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THE ELECTRICAL AGE

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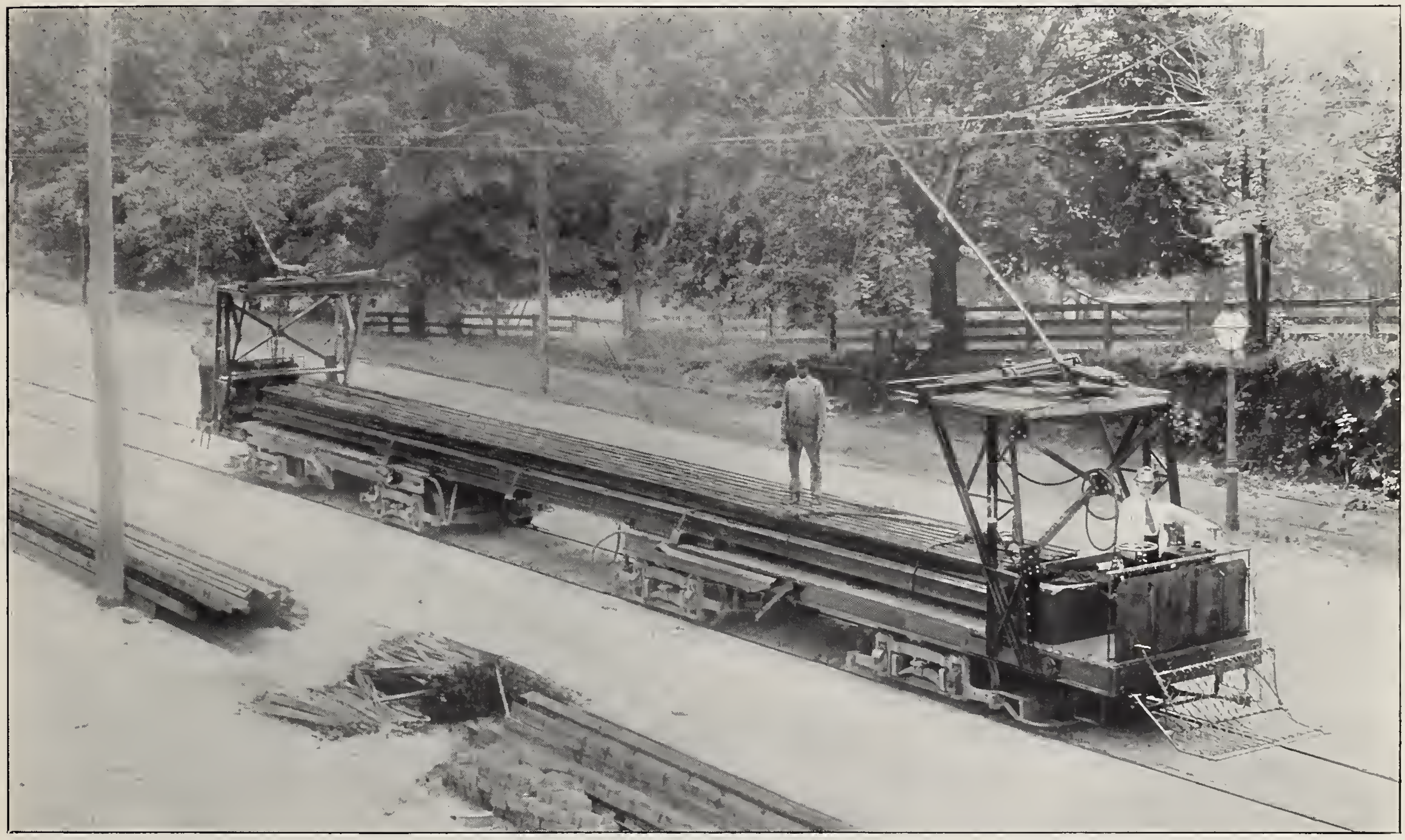
Trolley Current for Tool Driving and Other Uses

In Electric Railway Repair and Extension Work

By DAY ALLEN WILLEY

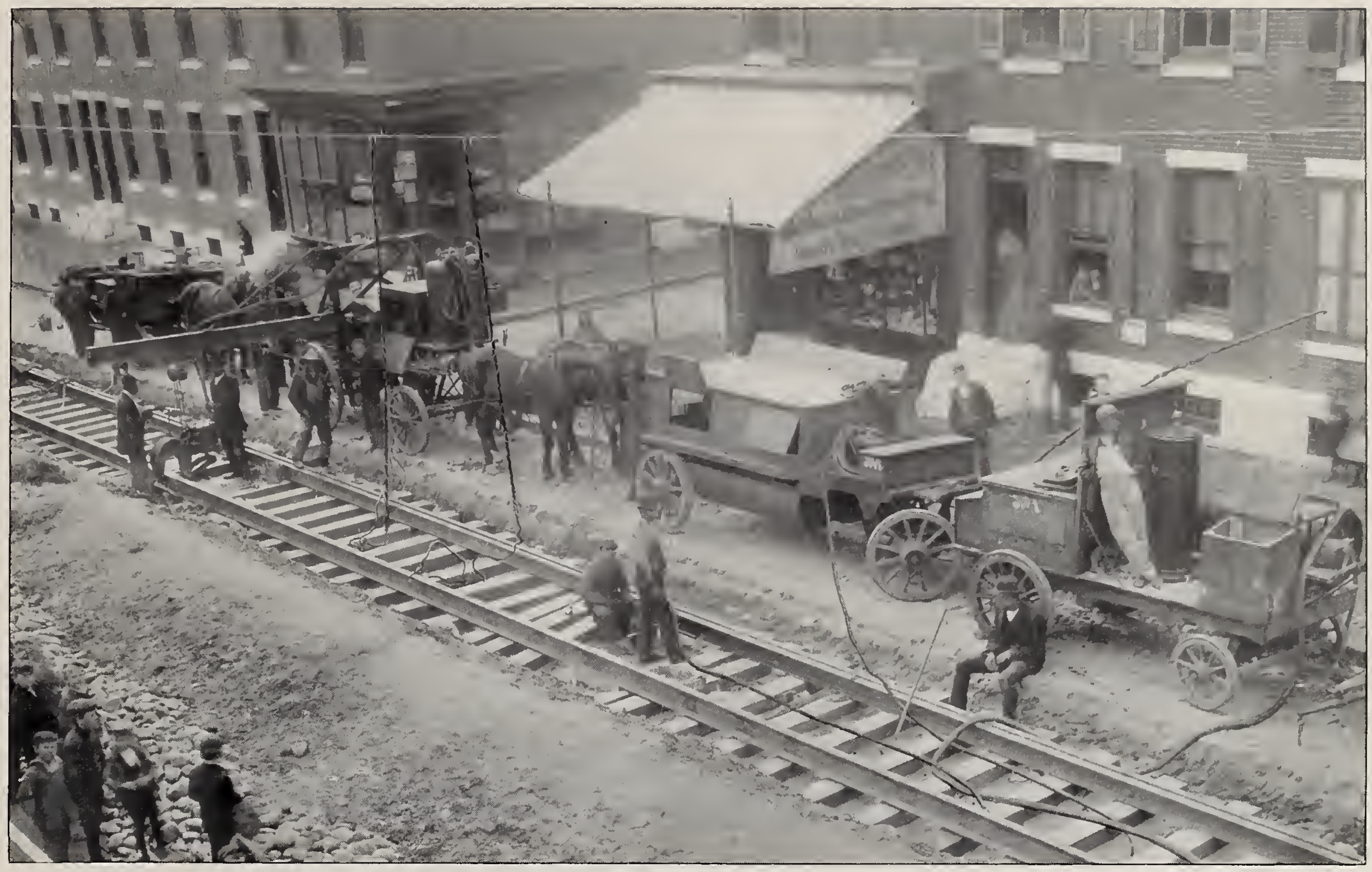


A SPECIAL CAR FOR TRANSPORTING RAILS FOR CONSTRUCTION WORK

IN spite of the diversity of street railway systems in the United States and the extensive mileage which they represent, it is perhaps unnecessary to say that the electric current generated for the purpose of operating them has thus far been utilized principally for furnishing motive power. In fact, the popular term "trolley current" has doubtless originated from the connection of the trolley wire with motive power almost exclusively. Engineers, however, do not have to be told that the current transmitted by the overhead, or even sub-surface system, can be employed in such a variety of ways that it seems strange for electric railway managers and engineers not to have before this considered the saving in expenses which might be effected by doing repair work, even building extensions to their lines, with the aid of the energy which propels their rolling stock.

The variety of power appliances which can be used in repair and construction on the ordinary street railway system, utilizing the electric current either directly or indirectly, has been demonstrated in the city of Philadelphia, where the expense account of one of the principal traction compa-

ROUNDING A CURVE. THE RAILS REST ON ADJUSTABLE PLATFORMS. SEE PAGE 7



PNEUMATIC TOOLS ARE HERE USED ON TRACK WORK. ELECTRICALLY DRIVEN COMPRESSORS FURNISH THE AIR SUPPLY, THE OPERATING CURRENT BEING TAKEN FROM THE TROLLEY WIRE. PORTABLE SAND BLAST, DRILLING AND RIVETING OUTFITS ARE SHOWN

nies has been greatly reduced by labor-saving methods of this character. In short, the company is so well equipped that it can perform practically every kind of work necessary in ordinary track-laying and renewal and overhead construction, including even street paving, with the facilities it possesses. Machines operated by electricity or compressed air are the principal agents. The compressed air may be called a product of the current, since all the compressors used on the line are operated by electric motors. The railway system referred to is that controlled by the Philadelphia Rapid Transit Company, which operates the greater portion of the trolley lines in the city and immediate suburbs.

Probably the most interesting apparatus is that used for rail laying. It includes a sand blast machine, power drills and riveters, as well as a portable outfit for melting metal at the scene of operation. As these appliances are closely associated with one another in the work, a brief description of the plan followed is essential in illustrating their importance. The first process in laying the rails is that of preparing them for jointing. In this work the sand blast has been found to be of much value in removing foreign matter from the surfaces of the rails where the jointing is to be effected. For drilling, a pneumatic machine is used, being applied to the side of the rail, and air is furnished in the usual manner by hose connection with the compressed air reservoir. Nearly all of the riveting, too, is performed by compressed air tools. After being clamped to the sections of rails to be jointed, the rail is held in position by a pivotal crane on the wagon containing the compressed air reservoir. The riveter is of the hydro-pneumatic type, working with an air pressure of 90 pounds, applied directly to oil in its cylinder. This, in turn, transmits the pressure to the plunger

A PORTABLE MACHINE FOR PUNCHING RAILS

A PORTABLE ELECTRICALLY DRIVEN DROP HAMMER, SHOWN BOTH ERECTED, READY FOR WORK, AND DISMANTLED FOR TRANSPORT. OPERATING CURRENT IS HERE ALSO TAKEN FROM THE TROLLEY WIRE BY FISH-POLE CONNECTION, AS SHOWN with which the dies are directly connected.

One of the essentials in track laying is a punch. The kind used on the Philadelphia Rapid Transit System is operated by hydraulic power, water and glycerine being employed. As it is frequently necessary to cut the rails at terminals and other points where short lengths are required, a cold saw forms part of the track-laying outfit. In this instance the electric current has been utilized directly, the saw being connected to an electric motor by means of a telescopic shaft and universal joints. This form of connection allows the motor to be placed at variable distances from the saw. All of the apparatus is so light that it can be placed on a wheelbarrow and trundled by hand along the line to the most convenient point. The saw is sometimes operated by compressed air.

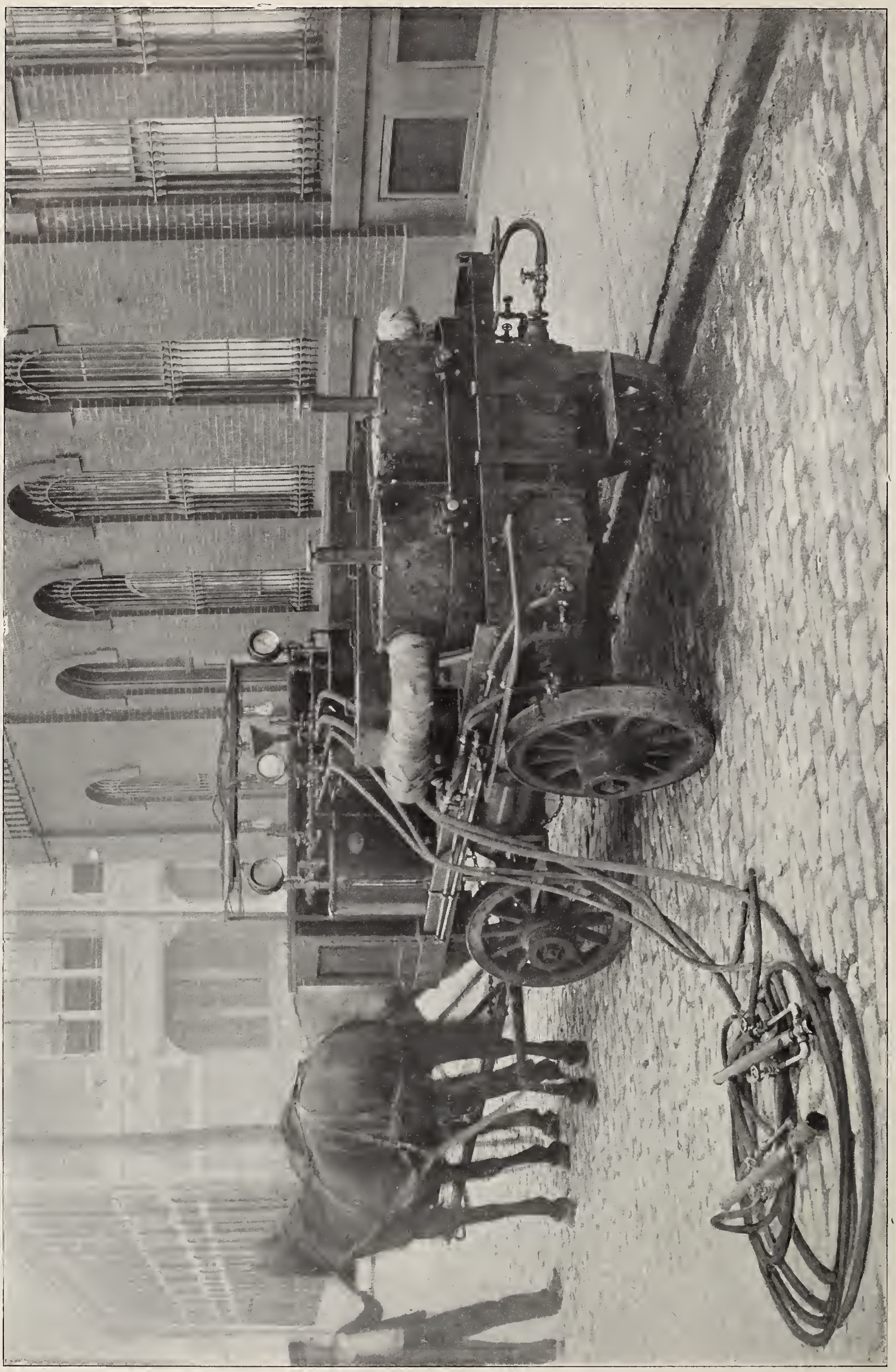
For several years the engineers of this company have been experimenting with different forms of rail joints. They have adopted the cast-weld joint and, for making it, as already stated, use a portable cupola outfit. At first a cupola having a capacity of nearly 1 ton of iron was used. The blower was operated by a 5-H. P. motor carried on the same truck. This apparatus, however, has undergone considerable change, and now a composite rail joint is made which has proved very satisfactory. The joint consists of a special form of fish-plate (see page 8) riveted to the web of the rail, but with zinc poured in between the plates and the web and into the space immediately underneath the rail head. The plates are heated by four oil-burning heaters before being placed in position. Oil is also used as fuel in melting the zinc, being fed to the furnace by means of an air jet. Two furnaces are sufficient to melt the quantity of zinc required and all of the apparatus is carried upon a single truck. To furnish compressed air for the melting furnaces and plate heaters, a compressor operated by an electric motor is placed on the truck. The air is delivered at a pressure of 20 pounds.

When a stretch of track is to be laid or relaid, the trucks containing the sand blast, drilling and riveting tools and melting furnaces, as well as a special truck provided with air compressors and reservoirs, are hauled to the locality, the sand-blast apparatus being in front and the melting furnaces in the rear. In this way one set of rails is being prepared for jointing while the work is being completed on another set; yet for all these operations actually less than a score of men are required. The air from the reservoirs is supplied by hose to the different tools, except the melting furnaces which, as already stated, have their own compressor. Even the crane for supporting the riveter and joint can be operated by air if desired. The air compressors in each case are direct connected to electric motors, taking current from the trolley wires.

GRINDING WELDED RAIL JOINTS WITH A PORTABLE MOTOR OUTFIT

Rail-laying, however, represents but one portion of the work necessary in street railway construction and repair. Various other devices, also worthy of note, are, therefore, found in use. For breaking welded joints of old rails a portable drop hammer has been found of great value. It is mounted on a

A HYDRO-PNEUMATIC RIVETING MACHINE ON TRACK WORK



A PORTABLE ZINC MELTING OUTFIT USED IN MAKING THE COMPOSITE JOINT MENTIONED ON PAGE 5

A PORTABLE AIR COMPRESSOR AND AIR TANKS FOR SUPPLYING PNEUMATIC TOOLS

special truck and hauled from place to place by another car. The drop weighs 1600 pounds, and the framework supporting it affords a fall of 17 feet, which has been found sufficient to break the heaviest joints, usually at a single blow. The movement of the drop is controlled by a winch operated by an ordinary street railway motor, so that the services of but one man are required, and he is generally the motorman of the car hauling the drop truck.

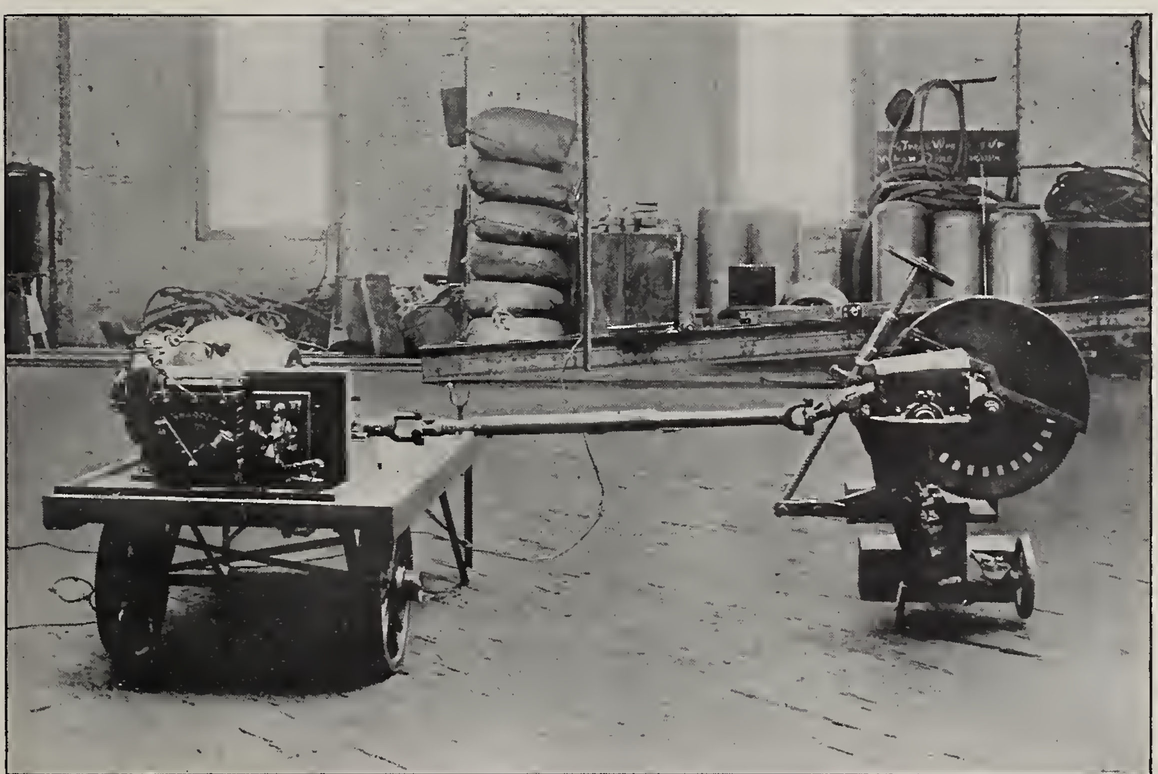
Where it is necessary to grind the joints after welding, an emery wheel is employed, operated by a 2-H. P. motor connected to it by a flexible shaft. The emery wheel and motor are carried on one of the trucks, and are of such small size that they can be easily carried in a wheelbarrow along the line and used where necessary. Current here, too, is taken from the trolley wire by a "fish-pole" joint, so that when the grinding is completed it is only necessary to lift off the pole and carry the apparatus to the next section of rails.

Night work, or any other operation requiring light, is carried on with the aid of incandescent lamps, using the trolley current. The fish-pole joints are set in movable standards and can be used singly or in series as desired, the lamps being placed in single or double rows in adjustable reflectors, as shown on page 7, so that the light can be thrown at the proper angle.

Track material, including the longest rails, is carried on a motor car of novel form, designed for this purpose. It consists really of two cars, each having its own set of trucks as well as its own trolley connection. Each truck supports a movable platform on which the load rests. In rounding a curve the platforms adjust themselves to the proper degree. Rails 62 feet in length can thus be carried to any portion of the city without difficulty and on routes containing the most abrupt curves on the system. Each rail car has a capacity of 20 tons and each section is equipped with two 37-H. P. motors. In loading and unloading the rails, a hoist is employed, operated by compressed air. By this means three men can do all the unloading.

A SAND BLAST OUTFIT, SHOWING SAND TANK WITH COMPRESSED AIR CONNECTION AND DISTRIBUTING HOSE

About the only apparatus which does not depend directly or indirectly upon the current from the overhead system is the road roller, and even this is carried from place to place hauled by a trolley car on a specially constructed truck. The charter of the company requires it to keep a certain portion of the pavement of the streets traversed by its lines in proper condition. For surfacing the macadam and



AN ELECTRICALLY DRIVEN SAW FOR CUTTING RAILS asphalt, a steam road roller of ordinary pattern, weighing 15 tons, is employed. The truck on which it is carried is provided with an inclined platform, so that when the roller is to be loaded or unloaded it is only necessary to attach this platform to the rear end of the truck, when the machine can be transferred by its own power and without other aid. (See page 10.)

Considering the extensive employment of the electrical apparatus here noted, only a small amount of power is required to operate it. All the main air compressors, for instance, are driven by a 500-volt motor of but 10 H. P. It is mounted directly on the frame of the compressor and drives through gearing. These compressors furnish all the power for drilling and riveting, as well as for the sand blast. The power required for the other apparatus, excluding the rail-carrying cars, is not more than 25 H. P. The use of the various appliances here described is due to H. B. Nichols, engineer-of-way of the Philadelphia Rapid Transit Company. Some of the apparatus is of his own devising and has been patented by him.

Wireless Telegraphy on the St. Lawrence

WIRELESS telegraphy is doing good service on the St. Lawrence route in reporting incoming and outgoing vessels, there being at least four Marconi stations between the Straits of Belle Isle and Quebec,—namely, at Belle Isle, Point Amour, Heath Point and Fame Point, distant from Quebec, respectively, 731 miles, 671 miles, 437 miles and 322 miles.

Commercial and social telegrams are accepted at any of the Canadian Pacific Telegraph offices in Canada, and are sent, prepaid, to the steamships equipped with Marconi wireless apparatus at a minimum rate of $2 for ten words and 12 cents for each additional word, in addition to the ordinary land charges. A somewhat curious feature of wireless telegraph operation noticed by some operators is that it is much easier to "hold" a station than it is to "pick" it up. On the chain of stations just mentioned one of the steamships of the Allan Line, the "Tunisian," on one occasion got into communication with Heath Point station at 40 miles, and held the communication for 140 miles.

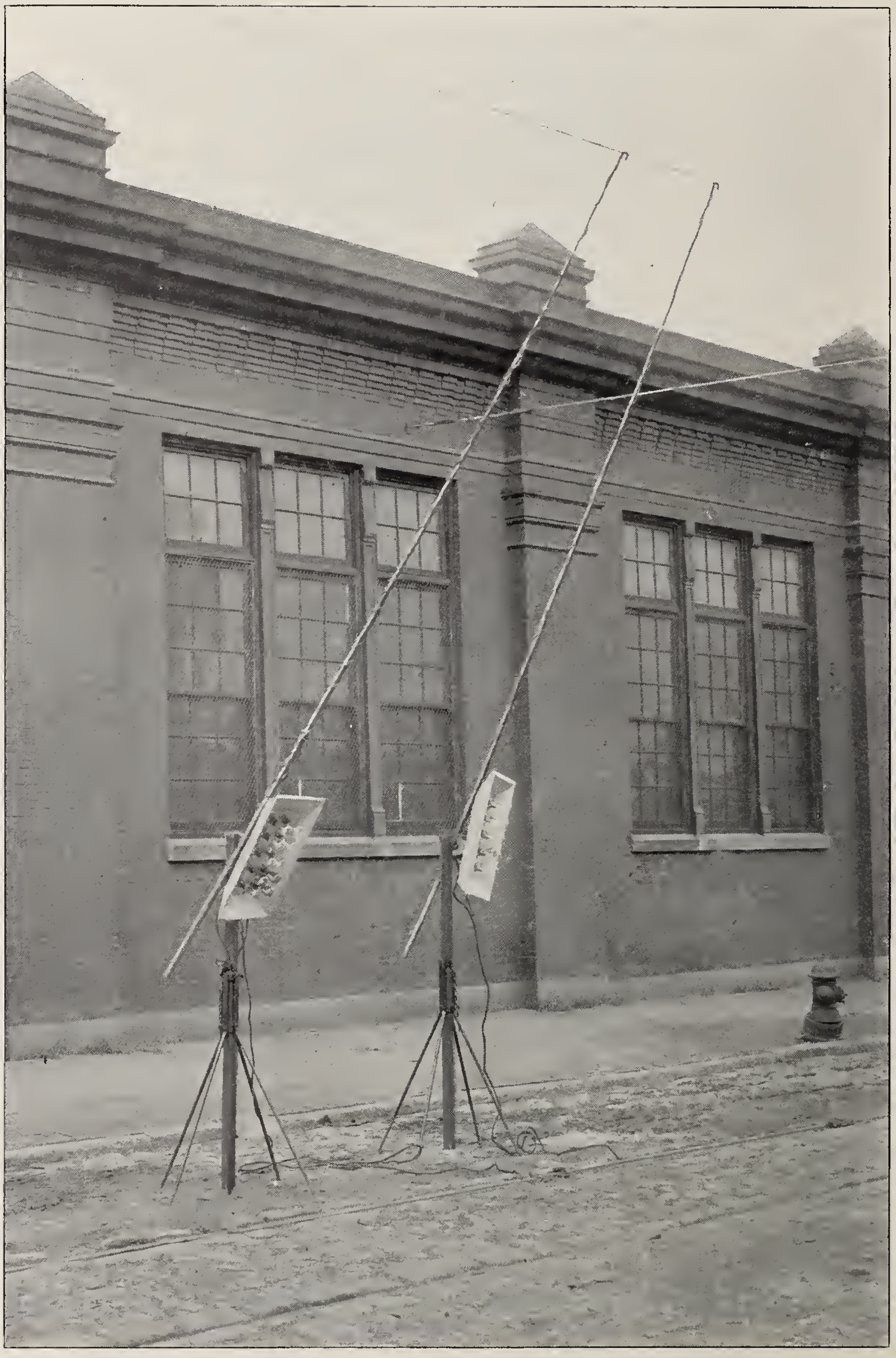
The number of persons employed in the electrical department of New York City is 131, whose aggregate salary is about $146,600.

Some Aspects of Electric Heating

By GEORGE HOWE

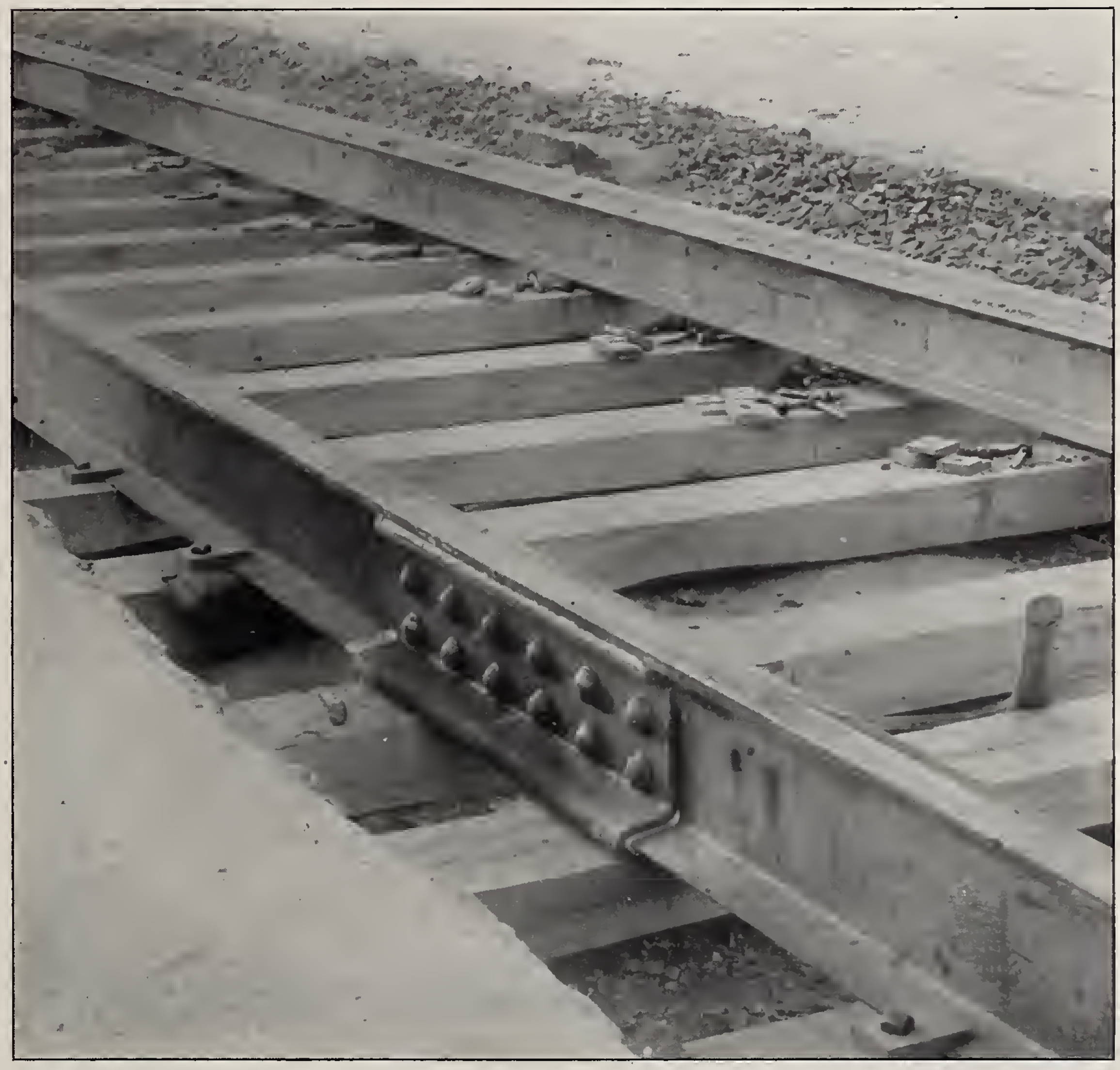
AT first glance an engineer would dismiss the question of electric heating as entirely uneconomical and impractical. He would maintain that it is absurd to transform the heat energy in steam into electrical energy through the medium of an expensive engine and generator plant, where, even under ideal conditions, at least 85 per cent. of it is lost, if this electric energy is to be immediately transformed back into heat. Why go to expense and trouble for the privilege of using six tons of coal where one would suffice? And in all truth, this argument is unanswerable. Where a large supply of heat in bulk is required, as, for example, in the heating of buildings, and the cost of its production per unit of quantity is the prime consideration, it were as wise to install electric heating as to construct a boiler with gold plates.

However, there are many special



FOR REPAIR AND OTHER WORK AT NIGHT, LIGHTS ALSO ARE SUPPLIED WITH CURRENT FROM THE TROLLEY WIRE BY FISH-POLE CONNECTION

DRILLING RAILS WITH A PNEUMATIC MACHINE. SEE PAGE 3



THE COMPOSITE RAIL JOINT DESCRIBED ON PAGE 5. NOTE THE BED OF ZINC BETWEEN THE RAIL AND THE SPECIAL FORM OF FISH-PLATE

heating problems, where cost per unit quantity is decidedly of secondary importance, where convenience, control, flexibility and simplicity are first to be consulted. It is here that the advantages of electrical heating make it not only very desirable, but in some cases almost indispensable. The electric heater, conveniently placed beneath the seats in a street car, thus eliminating the old-fashioned, clumsy stove, is a good example where its economy of space and convenience of location are sufficient to recommend it.

When steam heating is used, it is almost impossible to localize the heat or to keep it within ready control or to obtain high temperatures without considerable difficulty. Gas heating, which is much more expensive, was long ago resorted to for these purposes and until recently has been universally used. Now, every indication points to a complete displacement of the latter by electric heating in the near future—in fact, electric heating should be classed not as a rival of steam heating, but rather as the rival of gas heating, over which it possesses many distinct and obvious advantages. It is almost impossible to confine a gas flame so that it will not lose a considerable part of its heat to the surrounding atmosphere, or in a manner that it will produce a thoroughly uniform temperature in the object heated. Furthermore, the gas flame is dangerous, and largely augments the fire risk where it is used. It is inseparably associated with soot and dirt, and its fumes contaminate the air of the room in which it is being used. These defects do not exist with the electric heater, which, at the same time, possesses every advantage of a gas heater.

The electric glue-pot and the electric iron may be found in almost any up-to-date manufacturing establishment where these articles are used. In book binderies, printing offices, hat factories and a host of other industries, the introduction of electric heating devices is growing. In hospitals, too, the time-honored hot-water bottle is being displaced by the electric heating pad. In the modern hotel, the fastidious guest gives his orders to have his beefsteak done at such a notch on the electric broiler for so many seconds, and the chef spends his time in inspecting the adjustment of controllers on various cooking devices. At home we have the electric chafing dish, the electric tea-pot and the curling-tongs, the electric stove for more general use, the electric foot-warmer, and the electric shaving-mug.

The skill of inventors of electrical heating apparatus, in confining every single unit of heat to the accomplishment of useful heating without waste, has reduced their cost of operation to astonishingly small amounts.

The heating element proper consists in some cases of a high-resistance conducting paint; in others of fine wire imbedded in enamel; in others of open grids of metal; and in others still, of a thin, enclosed layer of hydrogen gas heated by fine, high-resistance wire, the gas being used for the purpose of distributing the heat from this wire uniformly over the object heated.

In any case, thorough heat insulation against loss is readily accomplished.

In fine, it may be said that electric heating has as many substantial advantages as it has inherent disadvantages. There are as many cases where its introduction would be advisable as there are where its use were mere folly, and excused only by ignorance or a total disregard of fundamental principles.

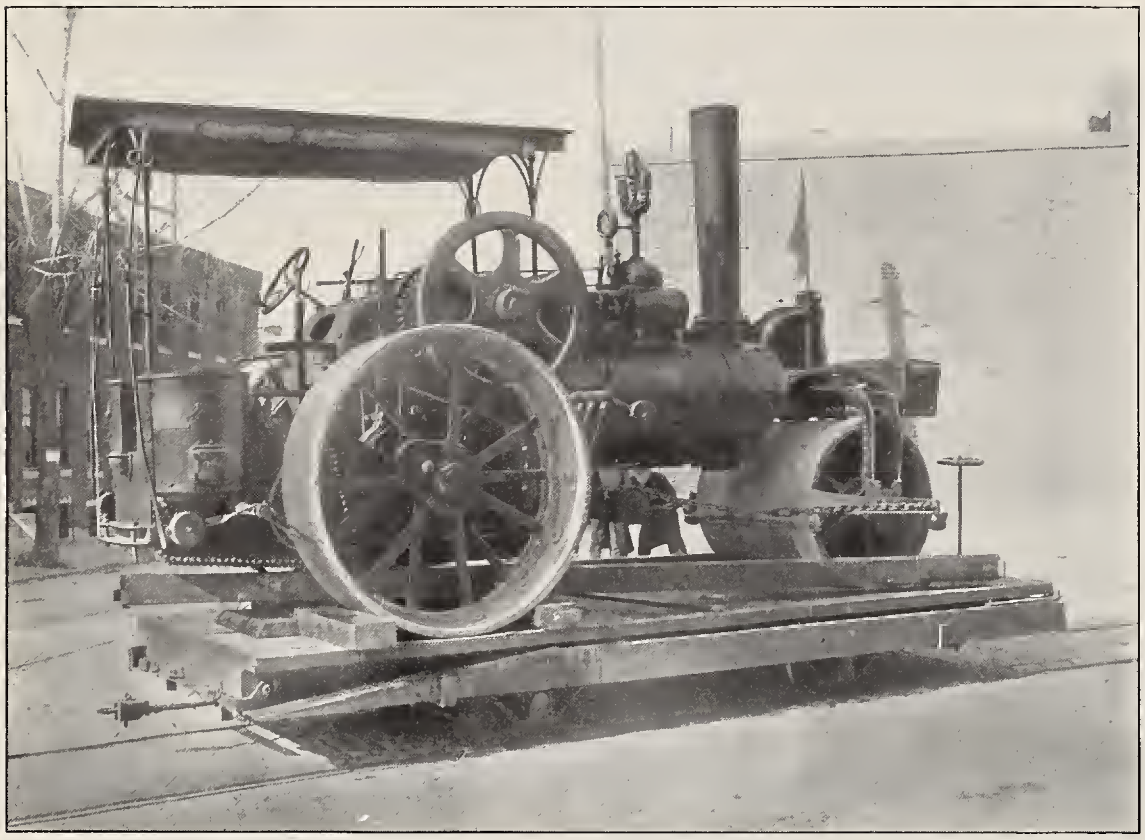
Lake Erie steam vessels are said to be suffering from the inroads of electric roads into their freight and passenger business.

Training Electrical Engineers

THE proper training of the electrical engineer is admirably set forth by Dr. Louis Bell in the January number of "Cassier's Magazine." The chief difficulty in laying judicious plans for training electrical engineers, he says there among other things, lies in the fundamental difficulty of saying exactly what one means by an electrical engineer. In popular apprehension he may represent almost any phase of technical expertness between a boss bell-hanger and the guiding genius of a great industrial organization.

The original conception of the electrical engineer was that of a fellow who designed and built dynamos, motors, arc lamps, and so forth; in short, a manufacturer of electrical apparatus, either as principal or accessory. The personage thus defined was a mechanical engineer with a smattering of electricity, and the more draughting and shop work he had, the easier would be his entrance of the factory.

The growth of the electrical art has radically altered the facts in the case, although the popular conception is little changed. The electrical engineer of the present day may require a knowledge of civil or hydraulic engineering, of chemistry or of general physics far more than he needs to make a pattern or to calculate the deflection of a beam. Handling men may be of vastly more importance to him than handling machines.



A ROAD ROLLER MOUNTED FOR TRANSPORT ON A SPECIAL TRUCK HAULED BY A TROLLEY CAR. SEE PAGE 8

TRANSFERRING THE ROLLER TO THE STREET LEVEL. SEE PAGE 8

Physiological Effects of the Electric Current

ACCORDING to "Electricity," of London, some new and interesting light has been thrown on the much discussed physiological effects of the electric current by Prof. Nernst. As is well known, a current of high frequency exercises no harmful effect upon the human body, however high the voltage. This immunity from electrocution dangers has hitherto been attributed to the passage of the current over the surface of the body, the skin acting as a species of shunt to the deeper tissues, and thereby protecting them from the prejudicial effects of a high-voltage current.

Prof. Nernst has been carrying out a series of investigations into this phenomenon at Bonn, and, as the result of some experiments on frogs, has formulated a new theory to account for the safe nature of high frequency currents—viz., that their harmlessness is due to the fact that each individual wave of the current occupies so small a period of time that the cellular tissues of the body remain unaffected.

The probable truth of Prof. Nernst's latest theory may be tested experimentally with an ordinary medical coil. An increase in the speed of the contact breaker or trembler, for a given voltage, renders the secondary current much less stringent in its shocking effect than when the trembler is set to vibrate at a low speed.

According to United States Consul Nason, at Grenoble, France, that city is to be lighted by electricity generated 27 miles away by the water-power from mountain streams and glaciers.

Notable Electrical Events in 1904

By WM. MAVER, Jr.

THE fourth year of the twentieth century can hardly be said to have produced any discoveries or inventions of a starting nature in the electrical science or art. The electric theory of matter in the realms of science and the invention of wireless telegraphy in the domain of art are of previous years, and nothing quite comparable to them in wide-spread public interest has been forthcoming in the year just closed.

In the general consideration of all that relates to the progress of electrical science, and in the development of electricity, and in its application to the needs of every-day life, however, the year 1904 has not been lacking. Perhaps one of the most noteworthy electrical events of the year was the meeting of the Fifth International Electrical Congress, held at St. Louis during the month of September. This was a notable happening, whether it be considered in the light of the social functions that preceded and accompanied the gathering of the members at St. Louis, or whether it be regarded in the light of its importance in the production of a mass of valuable papers on a multiplicity of electrical and related topics.

The Congress had a membership of 2100, over 400 of whom were foreign members. There were about 600 members of the Congress in attendance at its sessions. Over 500 papers were presented for discussion. The subjects of the papers embraced the theory of electricity, mathematical and experimental; the general applications of electricity; electrochemistry; electric power transmission; electric light and its distribution; electric transportation; the electric transmission of intelligence, and electro-therapeutics. An idea of the sort and quality of the papers brought forth may be gathered from a reference to some of the subjects specifically treated under those heads, for example:

"The Theory of Ionization by Collision" (Townsend); "High-Frequency Telephone Circuit Tests" (Kennedy); "Calculation and Tests of Alternators" (Blondel); "Electricity in Ancient Greece" (Preece); "The Energy Absorbed in Electrolysis" (Richards); "Transmission and Distribution Problems Peculiar to Single-Phase Railway System" (Lincoln), "The Effect of Steam Turbines on Central Station Practice" (Emmet); "Underground Electrical Construction" (Ferguson); "Central Station Economics and Operation" (Stott); "Modern High-Speed Printing Telegraph Systems" (Barclay).

The great benefits of the dissemination of knowledge concerning the various matters brought before the Congress, and the interchange of views in the discussions, no less than the opportunities for the making of personal friendships which the Congress afforded, will be more and more appreciated as time passes.

Another very notable event of the past year to electrical and other engineering interests in this country is the action that has been taken by several of the engineering societies to avail themselves of the very liberal gift of Andrew Carnegie toward providing a permanent engineering society headquarters for the advancement of the engineering arts and sciences in all their branches, and for maintaining a free public engineering library. Toward these objects Mr. Carnegie contributed the sum of one and one-half million dollars for the erection of buildings to be maintained and supervised by the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers and the Engineers' Club.

The societies named have entered into the work of carrying out the objects mentioned with creditable earnestness and vigor, and while the consummation of the plans outlined may take several years, and no doubt will entail some sacrifices on the part of the active workers, yet the realization of the plans will not fail to advance the best interests of all concerned.

The opening of the New York rapid transit subways will stand out preeminently among the accomplished applications of electricity on a grand scale to the uses of man in the year 1904. In the inception and construction of this great work, the capitalist, the civil, the mechanical and the electrical engineer jointly participated; but without the ability to employ a motive power that would not vitiate the air, that would lend itself readily to very high speed between stations, and to rapid, but gradual, acceleration and braking in starting and stopping trains, the building of this subway must, under the existing condition of things in New York City, have been held in abeyance indefinitely.

For the operation of the New York subways 60,000 mechanical horse-power, the equivalent of 45,000 electrical horse-power, are available, and provision is made to largely augment this amount at the main power house of the company, as may be required in the future.

Not only, however, is electricity employed as the motive power in this stupendous undertaking, but it is also the source of the illumination and heating of the cars and stations. Electricity is used also to operate the motors that compress the air used in the operation of the brakes. Further, it is utilized to promote the safety of passengers by the most approved methods of block signaling, and of automatically stopping trains without the physical or mental intervention of the motorman when trains get into dangerous proximity to one another on the same tracks.

The year 1904 is further notable in electrical annals for the extent to which electric locomotives of extraordinary power have been adopted and projected in the displacing of steam locomotives. The most important instance of this is perhaps in the plans now maturing for the electrification of the New York City terminals of the New York Central Railroad. For this work electric locomotives aggregating 2200 H. P. have been built and tested.

This power is distributed among four 550-H. P. direct-current motors, mounted directly on four of the axles of the locomotive. The total weight of each locomotive is 95 tons, and a speed of 60 miles per hour has been attained with a 500-ton train. These locomotives, of which thirty have already been ordered, have not been designed for extremely high speed, but rather for high acceleration, and tests already made have shown that drawing a train of eight cars weighing 336 tons, exclusive of the locomotive, a speed of 30 miles per hour has been reached in sixty seconds.

Another notable feature of 1904 in applied electricity has been the increasing development in this country and Europe of single-phase alternating-current railway motors and single-phase compensated railway motors. An important object of the work along these lines has been to obtain a more flexible system than is afforded by the direct-current motor; also to dispense with the rotary converters in sub-stations, to diminish the expense of copper in the transmission and feeder lines, and to permit of the use of higher potentials than are now considered practicable with direct-current motors, thereby to admit of greater distances between sub-stations with a given outlay for conductors.

The compensated motor has the further advantage that it is available for direct-current or single-phase alternating current, and can, therefore, be used in cities in which the direct-current system is already installed, and between cities where the single-phase alternating-current system at high potentials may be adopted.

As showing the already extensive use of the single-phase alternating-current railway motor, it may be noted that the product of one manufacturing company alone covers an output of 186 such motors, having an aggregate of 114,000 H. P.

It is not within the scope of this brief review to consider the relative merits of the direct-current and the single-phase alternating-current motor for railway purposes. But it may be remarked in passing that published estimates of the cost of construction of an interurban electric railway, about 60 miles in length, show an apparent advantage of $115,000 in first cost in favor of the single-phase alternating-current system, as compared with the direct-current system, the bulk of which amount, namely, about $75,000, is chargeable against the cost of feeders and trolley wires of the direct-current system.

The fact, however, that some of the most recent of the largest, but not the longest, electric railways have been, or will be, equipped with direct-current motors, indicates rather clearly that there still remain some questions to be settled satisfactorily in the consideration of this important subject—for example, the operating efficiency and reliability of the apparatus employed in the respective systems, it being apparent that a marked difference in this respect might speedily equalize the item of interest due to the added first cost investment of one system as compared with the other.

A further marked feature of the past year in connection with large electric steam power installations is the extensive and growing employment of steam turbines as the prime movers for electric generators, the advantages of which, such as economy in foundation and floor space, the absence of reciprocating parts and consequent comparative freedom from vibration, have frequently been pointed out in these columns.

The completed and projected use of electric water power has been another notable feature of electrical progress during the year just closed. In the vicinity of Niagara Falls alone plans are under way which, with the electric power already developed there, will aggregate 1,000,000 H. P.; and other parts of the United States and Canada, Mexico, South America, France and other countries are keeping creditable pace with this development, notably Canada, which easily stands next to the United States in electric water-power development.

Turning now to electrical telegraphy and telephony, it may be said of these industries that they have not shown any marked advance in the art within the past year. Yet as regards the extension of lines and improvements in practice, these arts, especially telephony, have not been at a standstill. In both cases much new territory has been occupied, and in telephony considerable progress has been made in the application of Pupin's inductance coils to long-distance circuits, with improved results in the operation of long-distance telephony through cables.

In telegraphy perhaps the most important work of the year has been the completion of the all-United States telegraph system in Alaska under the auspices of the Signal Corps of the United States Army. This system is made up of 1439 miles of land lines, 2079 miles of submarine cables, and a wireless circuit of 107 miles. On this line there are forty-eight stations, beginning at Seattle, Wash., and ending at Nome, Alaska, touching, en route, Sitka, Skagway, Fort Gibbon and Saint Michael. This line is open to the public, and will earn, it is thought, approximately $100,000 per annum in tolls on private messages.

In wireless telegraphy there have been no remarkable developments during the year. Experiments in the direction of long-distance overland transmission have been made in the United States, and signals have been transmitted a distance of about 300 miles between Chicago and St. Louis, but there appears to be no crying demand for the services of one wireless telegraph circuit for public use between large cities, even if the entire practicability of the system for long-distances overland had been satisfactorily demonstrated. The employment, however, of this beautiful system, which has not yet ceased to be wonderful, between ships at sea and ships and the mainland, and between points divided by sea or lake, where the use of cables is not economically practicable, is steadily and rapidly increasing. Among the more recent important instances of this nature are the five Marconi stations on the river and gulf of St. Lawrence, which cover, and it may be said, protect, a territory of nearly 1000 miles; and the De Forest stations at Bocas del Terro, Panama, and Port Limon, Costa Rica,—70 miles apart.

The eyes of the world were focussed on this branch of the electrical art during the past summer, while the steamship "Haimun," equipped with a wireless outfit and manned by the representative of a daily newspaper, was giving hourly accounts of the progress of affairs in the vicinity of Port Arthur,—a service which was continued until stopped by, or at the request of, one of the belligerents. The service continued long enough, however, to demonstrate that under proper conditions wireless telegraphy was a reality for practical purposes for distances of 100 to 150 miles over water.

Doubtless the very fact of its demonstrated utility will, for obvious reasons, involve its prohibition as a news gatherer within war zones by whatever belligerent may be in command of the sea, as in the present instance. Indeed, it is very probable that all nations will shortly require that no one over whom they have jurisdiction shall use wireless telegraphy anywhere without the special permission of the proper authorities, preliminary steps to which end have already been taken by at least two of the first Powers of the world.

Government Wireless Telegraph Installation

PLANS have just been completed in the Bureau of Equipment, according to "The Army and Navy Journal," for the establishment of a chain of wireless telegraph stations which shall extend from Cape Elizabeth, near Portland, Maine, to Galveston, Texas, insuring a complete line of communication between those two points. In this way a ship will be enabled to go from Portland to Galveston and remain constantly in communication with the shore.

The new stations include one in the mouth of Delaware bay, another at Diamond Lightship off Cape Hatteras, a third at Beaufort, North Carolina, a fourth at the Charleston Navy Yard, and a fifth on the upper Florida coast. There is already a station at Pensacola and one at Key West. Another will be established at New Orleans, and one at Galveston, thus completing the chain. The Bureau of Equipment will advertise for bids for the work. The type of instruments to be used has not yet been decided upon.

The Electrical Fire Hazard

By C. J. H. WOODBURY

An Address Before the Brooklyn Institute of Arts and Sciences

THE applications of electricity for illumination and the conveyance of power have outstripped the merely relative conditions of superiority to existing methods, and have also reached beyond precedents to the establishment of new expedients.

These vast enterprises have required the largest initial investments during the past twenty-five years.

The use of copper and consumption of supplies taxed all available resources. Not only have these enterprises utilized the output of the old copper mines, but have stimulated the search for further productive deposits of this useful metal.

The great usage of poles for aerial wires has been one of the elements threatening the forest supply.

The demand of electrical interests for a more economical generation of power at higher standards of accurate regulation has improved steam engines and water wheels, bringing out new types of both, which are also in other industries an advantage to users of power.

The organization of power-generating plants upon a scale whose solidarity inspired confidence in patrons that the product was to be of assured permanence, was of itself a new feature in construction.

New tributary industries to fill the gap in insulation between that of submarine cables and that of electric door bells, were established.

The continuous operation of these plants required mechanism whose high standard of construction has stimulated collateral lines of mechanical production and uplifted the character of such work.

Employment has been given to thousands upon thousands, particularly those of high-skilled artisanship. A new profession of electrical engineering has thus been established which has taken unto itself the best in the other branches of engineering, engrafting practical experience upon technical lore, for capital soon found that the useless labor of untrained minds was a most expensive venture.

The pre-eminent service, however, in this development was that rendered by the administrative leaders in these enterprises, who made all things possible by the force of their imaginations; this enabled them to comprehend the possibilities of the future and to endow with confidence the investment of capital in the applications of science for which there were not adequate precedents.

ELECTRIC ILLUMINATION

The introduction of electric lighting was never accomplished on the basis of cheapness, but on that of quality. Its advantages of brlliancy in illumination, revealing objects as at noonday, showing colors at their true value, applying the light without reference to the limitations of an exposed flame or the vitiation of air, are all of the highest value in artificial illumination and hitherto without precedent.

It was of great value in all manufacturing, because the perfection of the illumination enabled the production of as good articles under artificial light as by daylight, and this has obviated the well-known differences between summer and winter goods in textiles, as the latter, when made to a great extent under gas light during the short days of winter, contain a greater number of imperfections.

In some industries requiring accuracy as to color or delicacy in manipulation, the working day ended with the sunset.

Whether it be measured by hours or by results, in all cases the use of electricity has added to the working day, and it has aided both the product and the toilers in the benefits resulting from the absence of any vitiation of the air, as is the case to a serious extent by other methods of illumination.

While the sentimental uses of electrical illumination may not pertain to this consideration of the question, the fact cannot be ignored that its ministrations to the taste and comfort of humanity are contributions to the general good in the furtherance of happiness and contentment, even to the amelioration of the condition of the rich.

The concentration of electric illumination without regard to the disposal of the products of combustion, as in the case of other illuminants, has been of great value in emergency surgical operations at night, which could not otherwise be performed except by waiting until daylight.

ELECTRICAL CONVEYANCE OF POWER

The application of electricity to the conveyance of power followed that of lighting, but did not reach a full development until the production of large generating units in later years gave scope to its utilities on an economic basis.

This property of transferring energy without dynamic motion between the prime mover and the point of application to the machine has been of the utmost moment in the developments resulting from the removal of mechanical questions from the problems of power transmission.

It has given value to unused water powers and harnessed their energy to productive application hundreds of miles distant.

It has modified mill design to the fundamental purpose of construction purely devoted to the operative machinery.

It has changed the location of factories from that of an essential juxtaposition to the site of water power or coal supply, to those of freight facilities and centers of population available for labor.

THE GENERAL FIRE HAZARD

This reminiscent sketch, indicating the extent and permanence of these achievements of electricity, is presented to call attention to the immensity of the work whose wide range gives rise to great problems when viewed from any standpoint and in any direction.

These questions are so extensive that to treat any one of them equitably it must be considered conservatively.

Among these problems, subsidiary to the main questions of construction, operation and administration, is the relation of electricity to the fire hazard, for it is a principle in underwriting that every material possession subject to insurance is to its uttermost details also involved with question of fire hazard, both external and internal.

It would not be assumed by the lay mind that the stone reservoir which formerly occupied a portion of the park on Forty-second street and Fifth avenue, New York, was subject to a fire hazard, yet this structure was damaged over $50,000 by the burning of the Crystal Palace in 1856.

While diminishing the hazards of other methods of illumination, with their attendant mishaps from direct flame, the uses of oil, gas explosions, and carelessness with friction matches, it must be conceded that electric lighting cannot be claimed to be free from a hazard.

Electric motors, in displacing gas and gasolene engines, or isolated steam boilers with careless attendants, cannot be assumed to remove all fire risk merely because they displaced the burning of highly combustible materials.

In diminishing the use of these methods involving perilous hazard, there remains the possible electrical hazard. Electrical energy is normally converted into heat at high temperatures when it meets the resistance of arc or incandescent lamps; it also produces similar temperatures adequate to ignite anything combustible whenever sufficient electrical energy is diverted from its normal conductors of low resistance and meets with a path of high resistance, which latter converts into heat that portion of the energy devoted to the struggle for the maintenance of the circuit.

Virtually the whole of the precautions for the maintenance of conditions of safety may be summed in the provisions for adequate conductivity and efficient insulation, but in their applications these provisions reach practically to every detail of all electrical plants.

THE UNDERWRITERS' RULES

The early installations of electric lighting plants, whose circuits were upon uninsulated wires with earth return, caused numerous occurrences which naturally alarmed the underwriters. An investigation by a technical representative of a number of insurance companies and by those of the electric lighting interests was held, wherein the various incidents which had been the causes of fires were experimentally repeated, and new methods for the installation of plants prepared on behalf of the underwriters.

It was thus noted at the very inception of the commercial applications of electricity to interior lighting that the hazards could be minimized by arrangements which would improve rather than impair the operative conditions of the plant.

The feature of divesting a process of its dangerous elements initiated a new principle in fire insurance which has been widely extended in the technical treatment of various hazards, particularly those of manufacturing processes.

These electrical rules were extended along the lines of the advance of electrical applications, and various technical organizations, municipalities and local boards of underwriters, even individuals and manufacturers, prepared rules whose differences in unessential demands and deficiencies in specifications were sufficient to cause unnecessary vexation and frequent embarrassment, especially to the manufacturing and operative electrical interests.

In March, 1896, the National Conference on Standard Electrical Rules assembled in New York for the purpose of preparing a code, embodying specifications covering the conditions of safety in a manner equitable to all interests involved.

This convention was composed of representatives of underwriters, of those engaged in the manufacture and operation of all varieties of applied electrical apparatus, and also of several scientific organizations.

The various rules were diligently compared and their provisions criticised, and the reports of these meetings with an extensive correspondence containing suggestions were referred to a committee who prepared the National Electrical Code, which was adopted by the National Board of Fire Underwriters and promulgated by them.

Their committee of electrical specialists meet at stated times to make such amendments, generally by way of addition rather than alteration, as may be necessary to keep in step with the advancing conditions.

It is admitted that this code represents a wider consensus of opinion upon a question of science applied to the service of mankind than was ever concurrently given to any similar question.

These rules are anomalous in their functions. They set forth conditions governing methods of construction, installation and operation of electrical plants, and their specifications receive the utmost consideration from those to whom they apply.

Promulgated by the National Board of Fire Underwriters, they form in their applications the guidance of inspectors of voluntary associations of representatives of insurance companies, and do not rest upon any jurisdicition which has power to enforce compliance with their provisions in any manner comparable with the power of the law.

The work of the inspection corps is primarily suggestive in its nature, and as a division it is separate from the insurance rate making bodies, who, however, consider the electrical conditions in connection with other facts bearing upon estimates of risk.

In the consideration of the functions and jurisdiction of these rules, it must be remembered that there can be no exercise of authority without a corresponding measure of responsibility, and as these rules treat upon almost everything connected with applied electricity, the situation year by year becomes greater and more complex. There is an approach to problems which in the near future may need a stronger body than a voluntary organization, whatever may be the individual constituency of its members, to treat upon the large subjects arising from the congestion of various electric applications, and this administration of the National Electrical Code is being watched with interest, in comparison with that of the methods used under the authority of the law in various countries on the other side of the Atlantic.

It is no disparagement to the valuable work of the Electrical Committee in the advancement of standards of electrical installation and proscription of inferior methods to remark that in the confidence of equitable treatment, the electrical interests have co-operated with the underwriters in giving of their specialized skill towards the solution of the difficulties of hazard which have been raised. The improvements of their own apparatus have contained the suggestions of new rules. Slate switch-boards made by electrical lighting companies inspired rules asking for slate switch-boards; tubular fuses begat rules to match; telephone companies made protectors to defend their harmless plant, and protectors were demanded; power plants were equipped with circuit closers, and such devices became enruled. Study the evolution of these rules as one may, it will be seen that throughout the whole code the electrical interests were the pioneers in the means for the preservation of plant, and the maintenance of continuous service.

All electrical interests appreciate the value of a standardization of methods and expect a similar consistency in their application.

It is not necessary in this connection to specify in detail the methods of providing conditions of safety, as this would approach a paraphrase of the code, which is a manual of over one hundred pages, freely distributed to all interested persons, and is familiar in its details to those engaged in installation or manufacture of electrical apparatus.

Yet it may be worth while to refer to

some of the general methods to which it applies.

AERIAL LINES

The available routes for aerial lines are so limited that there are frequent instances of propinquity requiring every precaution to be taken to prevent cases of accident to poles or wires, such as would result from any contact between the high potential wires and those of other systems.

The action of town, county, or municipal authorities frequently require locations of these various lines to be so near together as to be incompatible with conditions of safety.

A United States court has compelled the separation of lines of poles carrying telephone and extra high potential wires to a distance equalling that of the highest pole, so that in case of a broken pole or wire, there could not be any contact between the two systems. While such separation accomplishes the desired result, yet there are many places where there is not sufficient available space for such diverse routes. The Niagara Falls power line has a separate right of way, as do numerous other electrical power lines.

In many instances, the owners of telephone and electrical power lines have mutually arranged to change their routes wherever necessary in order to provide sufficient distances between the several routes, and those agreements have been confirmed by the authorities; in other instances the permission for separation has not been granted.

Wherever these various lines approach each other more closely than already mentioned, it is necessary to use every possible precaution against breakdowns, by the adoption of extra heavy construction, thoroughly guyed and braced as occasion may require.

However much the lines may be separated in their general routes, it is inevitable that there should be cross-overs.

In such cases, it is desirable that the high potential wires should be above the telephone lines, as they are of larger diameter and therefore less liable to breakage; being also fewer in number there is the lesser chance of mishaps occurring. The telephone linemen are so accustomed to the innocuous telephone wires that they may inadvertantly neglect to observe the proper precautions for safety if the high potential lines were below.

In a cross-over, the best condition is when the poles at the ends of the cross-over span are so much above the lower span that a wire breaking at an insulator on the upper span would not be long enough to reach the lower span.

That the pole construction should be substantial and well guyed is an evident feature of these cross-overs.

The end wires on the upper line should be covered by wire loops, known as end-insulator guards, to prevent a wire from jumping over the end of the cross-arm in case of the breakage of an insulator or other mishaps sundering the relation of the wire to the cross-arm.

The wires at the ends of the upper cross-over span should be dead ended to double grooved transposition insulators, and the line completed by a loop to prevent overhauling in case of a broken wire.

In some instances where it is not feasible to make the upper span at such a great height as previously mentioned, a screen of wooden strips across a pair of suspension wires affords protection against a contact of the two lines.

A joint pole does not afford a desirable means for a cross-over, as the whole construction is confined to a single pole, but where it is used, the upper line should have a transverse frame supporting guard wires, and end guards to prevent contact in case of broken wires.

UNDERGROUND WIRES

The obvious obstruction which overhead wires presented to the operation of the fire departments early gave rise to a public opinion in favor of placing the wires underground. This was far in advance of the state of the art enabling telephonic transmission through cables, and required the development of a new art in the production of underground conductors whose wires should be insulated in such a manner as to permit telephonic transmission, and also the development of the continuously drawn lead sheath.

When this was accomplished the telephone wires were placed underground in cities, because the number of the wires was beginning to tax the possible pole capacity.

The largest pole line carried 250 wires, and single cables are now made with 1200 wires or 4 4-5 times as many circuits, and single underground conduits contain ducts for ninety cables, or over 400 times the capacity of the largest pole line.

Underground wires were not a refuge for safety from the troubles of overhead lines, for they have difficulties of their own. They are a target for pick and crowbar of laborers on other underground work in cities. Street rollers have crushed them, and strokes of lightning have not only wrought havoc with their wires, but fused them in the ducts. The insinuating leaks from gas mains penetrate ducts and manholes, where they cause destructive explosions.

In times past when attractive propositions of municipal action or other relations caused high potential wires to be placed with signalling wires in the same conduits, the electrical leakages of the former were the causes of numerous destructive crosses. The Supreme Court of New York has decided against this manner of joint use of a conduit system.

ELECTROLYSIS

The chemical effects of electricity are well known as a most active agent in industrial chemistry, particularly in electrotyping, where metal is removed from one mass and deposited upon another article. Electricity is used to make and to break molecular combinations in many lines of chemical industry, as in the manufacture of aluminium, sodium and other metals, also carbide of calcium, soda ash and other compounds.

In like manner with the single trolley railroad system the portion of the electricity passing through the earth between the moving cars and the ground plate at the central power station applies a portion of its energy in making various chemical changes in the earth, many of them to the serious detriment of underground pipes and electric cables.

Any impairment of underground water pipes to the point of rupture is certainly a live issue in the questions pertaining to fire hazards, and hardly less so is any injury to underground conductors connected with the fire alarm or the telephone systems which are essential features in the reduction of the fire loss, owing to the prompt manner in which they are able to summon the fire department.

These underground currents remove metal from such buried conductors, and also form caustic potash and other alkalies by the electrolysis of alkaline sulphates or chlorides.

If these are formed near to underground conductors they are not corrosively active upon them until the generating current ceases or is greatly reduced.

Metallic sodium has been formed by the dissociation of sodium hydrate in cement by currents of electricity, and such events have occurred in buildings where the presence of moisture caused the rapid oxidation of the sodium thereby producing sufficient heat to cause fires.

The magnitude of these underground changes may be noted from the large masses of these electro-deposited materials, sometimes a yard in diameter, which become attached to the ground plates at central power stations.

The method of preventing the destructive effects of electrolysis is to attach the positive side of the generators to the trolley wire so that the return current tends to build deposits upon the underground conductors beneath the area traversed by the moving cars. In the vicinity of the power house the destructive effects of the current leaving the underground pipes and cables for the ground plate would be more active than under any other condition of affairs, unless conductors reached to the ground plate from such of the pipes as were positive to the earth.

The arrangement of these connections is made from the data of surveys of the electric potential of various conductors to the earth; where it is negative, metal is not being removed from the pipes, and where the electric polarity is positive there is need of bonding to the ground plate.

New electric lines or bridges alter these conditions so that frequent surveys are necessary to preserve the conditions of electrical neutrality. The new East River bridge and the introduction of electricity as a motive power on the elevated railroads made many changes in the potential map of New York City, in which the lines of equal potential were drawn like the contour lines of equal elevation upon the map of a hilly country, the positive area near the power station being shown in a dark tint.

This line of treatment will stop further destructive results from return current if applied as already noted, but it is necessary that the work should be done properly, and a constant espionage maintained to reveal changed electrical conditions.

INSIDE WIRES

There is no department of electrical construction which is less properly the subject of amateur work than inside wiring, and none which has been the purpose of more misapplied industry, with the expected adverse results.

There is more constructive detail to the design and arrangement of inside wires than can be taken into consideration at this time. The essentials of wires of ample conductivity are established by a table of sizes, which limits the possible rise in temperature of any wire about 30 degrees Fahrenheit.

The selection of insulating material is based upon its exposure to water and dampness.

The possibility of contact with other conductors must be prevented by tubes or other methods of guarding, especially when passing through floors or other portions of buildings.

In manufacturing buildings, the wires may be placed upon suitable fixtures, but in commercial buildings and residences where they would be unsightly, they are drawn into pipes, run through the walls and floors. The modern architect leaves channels in the walls and floors for such tubes, as is done for water and steam pipes. These tubes are to protect the insulation from injury, but they are not insulators.

The switches in electrical systems are the subject of careful design, in order to provide that the several conducting parts will be of ample conductivity when closed, to convey without heating, the currents to which they may be subjected; their operation should be such that they cannot form arcs when opened.

The most important part of a lighting plant consists in the safety fuses, which are pieces of easily fusible metal introduced in the circuit, and of such dimensions that they will be melted by the heat resulting from an undue excess of current.

These safety fuses were first made for the purpose of protecting the filaments of incandescent lamps from destruction by slight increases in the current, and were afterwards applied for the broader purposes of protecting a whole system by opening the circuit whenever the current exceeded its normal quantity.

The heat at the instant of deflagration is sufficient to voparize a portion of the metal, and to throw around small drops in a state of fusion. This in itself would be a cause of fire if the fuses were exposed to combustible material, but for interior wiring it is necessary that they should be suitably enclosed.

The use of open fuses on the motors of street cars has been the cause of numerous fires in transit.

The first line of improvement was to enclose the fuses in tubes, and the violence of the deflagration would heat air sufficient to rupture the arc and add to the efficiency of the operation of the device.

This was followed by methods of reducing the volume of air by means of asbestos braid around the fuse, or filling the tube, except a small air space at the middle of the fuse, with a powder of refractory material, which would not be vitrified by the heat of the arc. These methods reduced the violence of the detonation and also permitted the more accurate calibration of these protectors.

FIRE ALARMS

Any allusion to the fire hazards of electricity would be seriously defective if it did not make mention of the work of the same agency toward the reduction of the fire loss, through the alarms given by the signalling systems.

The electric fire alarm, when first brought out, did not receive any serious attention until the city of Boston bought the territorial right of the patentee, and the results immediately became so valuable that similar alarms were installed throughout other cities.

The automatic fire alarm systems, in spite of their excessive complications, have been of great value in the concentrated large risks in cities and large manufacturing establishments.

Every telephone is a fire alarm, by which the unskilled can at once state to the fire department the details of place and condition of the occurrence.

There is a secondary hazard to these signalling systems, owing to the fact that in the extent and ramification of all electric wires there are liablities of mishap when through accident there is contact of the wires of different systems, and lighting or power currents are imposed upon the delicate apparatus of the telephone system.

PROTECTORS TO SIGNALLING SYSTEMS

At the ends of the telephone lines, destructive results from such foreign currents are prevented by apparatus which is subdivided into the various functions which it performs, for there has not been thus far any single device for defending the telephone instruments against the whole range of commercial foreign currents and lightning to which they are subjected.

The form of apparatus used by the Bell Telephone Companies, which are especially careful in this regard, consists of a device, which is threefold in its nature, inserted in each line wire.

The first element consists of a fuse made of an alloy which forms part of the circuit, and is contained in a tube of vulcanized fiber. These fuses will deflagrate when exposed to currents of seven to ten amperes, the capacity of the fuse being varied according to the type of the apparatus.

The next element consists of a pair of small blocks of carbon whose larger surface measures about one by one-half inch, and one of these blocks is connected to the telephone circuit. The corresponding block of the pair of carbons is separated from it by a perforated sheet of mica and is electrically connected with the earth. A small cavity in one of the opposite faces of the carbon is filled with a button of solder, such as is used in automatic sprinklers, and which melts at 160 degrees Fahrenheit.

The distance between these carbons, or the thickness of the mica, is .0055 inch, being such that electricity at over three hundred and fifty volts will pass from the carbon connected with the telephone circuit across this space to the opposite carbon and thence to the earth, thereby relieving the telephonic apparatus of electric tension exceeding three hundred and fifty volts.

Thus, if the foreign current exceeds the carrying capacity of the tubular fuse, its deflagration opens the circuit at that point. If, however, it is less in volume than the carrying capacity of the fuse, and over three hundred and fifty volts tension, it leaps across the thin space separating the carbons, and thence passes to earth. The resistance of the tiny arc in the space between the carbons is sufficient to slightly warm the carbons and cause the fusible metal to flow from its recess, fill the space between the carbons, and thus establish a conductor of low resistance to earth.

This diminished resistance generally causes a sufficient increase in the current imposed upon a line to cause the tubular fuse to deflagrate and open the circuit, if it did not do so on the first occurrence of the contact which imposed the foreign current on the telephone circuit.

At the subscriber's telephone installation, the fuses, and generally the carbons, are placed in the building near to the point of entrance; but in order that the wire leading to the ground shall be as straight as possible, because lightning does not like to follow turns and bends in a conductor, it is sometimes necessary to place the carbons at some other place along the route of the wires in the building. This separation of the parts is required very infrequently, on an average of about one telephone in twenty.

In order to protect the fine wires of the telephonic apparatus from injury by currents which are too small to operate the tubular fuse, and of too low tension to pass to earth through the carbon cut-outs, a third element, known as the heat coil, is employed; in this, a fine German silver wire which forms a part of the telephone circuit, will be heated by a current of one-sixth of an ampere to a temperature sufficient to release a conductor ordinarily secured by fusible solder, and which permits the current to pass to earth. This latter device is not used at the subscriber's end of the line in those modern types of telephonic apparatus in which the circuit is normally open, except when the telephone is in use, because such coils are an interference with the best conditions of telephone service by adding to the electrical length of the line; if a foreign current came in contact with the telephone line at a time when the instrument was in use, it would produce noises which would absolutely prevent the transmission of speech, and the user of the telephone would naturally place the receiver on the hook and thereby open the circuit.

The result of this protective apparatus has been so successful as to establish conditions of immunity in the Bell system of telephony against mishaps to the apparatus resulting from foreign currents and lightning after an experience of many years throughout the Bell telephone system. Such a telephone office appears to be, like a locomotive, the safest refuge in a thunderstorm. Notwithstanding the number and range of location of telephone central stations, it has not been possible to obtain information of any injury by lightning to any person in such a place.

Whenever the distribution of the telephone service is entirely underground, this system of protection is not necessary at the subscribers' instruments, but is in all cases installed at the telephone central office to protect the whole system against foreign currents imposed upon other parts of the system.

The whole telephone system has over 4,000,000 miles of wire, interlaced throughout the country, and in the communications which are daily traversing this vast network from the Atlantic to the westerly side of the Mississppi Valley, or the similar one at the Pacific Coast, exemption against the disturbances resulting from foreign currents throughout this vast territory is secured through these efficient protectors.

THE UNDERWRITERS' ELECTRICAL BUREAU

The whole foundation of fire insurance, which is said to be the second single tax in this country, is based upon a distribution of averages; and in this examination of facts which is the foundation of science, the allotment of the various losses both as to cause and amount is the subject of systematic tabulation, and these results furnish the basis upon which insurance rates are levied, for the old method of competitive guessing is a matter of the past.

The causes which contribute to the origin of fires are largely those of chemical reactions, while the resistances to fire are dependent upon construction and fire apparatus.

Thus the modern method of fire loss prevention is a technical proposition requiring the services of chemists and engineers.

The National Board of Fire Underwriters maintain a testing laboratory which contains the necessary facilities for making the various investigations required in this study of matters pertaining to the fire hazard.

It is here that the supplies and subsidiary devices of commercial electricity are put to their proper tests, and the results have great weight in furnishing additional features to the National Electrical Code. Their quarterly reports, containing lists of fires caused by electricity, and stating the deviations from the code which are supposed to have been the origin, is a compendium of exact information on the subject.

The Associated Factory Mutual Insurance Companies of New England were pioneers in the application of technical work to the reduction of the fire loss, a task whose beneficent results have extended beyond the mills which form the specialty of this combination.

The underwriters assume a great task in undertaking to maintain inspections over properties as widely extended and as numerous in detail as are the commercial applications of electricity.

The results show beyond peradventure that the electrical fire hazard is less than that in other methods of lighting and power transmission, while every telephone, being a fire alarm, the signalling systems are potent elements in the reduction of the fire loss.

While the diminution of the ratio of such fire losses appears to be due to this work, as the variable element in the problem, the question naturally arises, will the future permit its continuation to an extent which will be equal to the greater task of meeting the problems of depreciation of plant, and the congestion of the future to which the present applications of electricity are a mere preface?

If the work remains in hands which can exercise the responsibilities to a uniform jurisdiction, then it will be sustained by the dominance of an approving public sentiment.

A new device for driving a dynamo igniter on a motor car was exhibited at the Paris Automobile Show. A small turbine placed within the muffler is operated by the exhaust gases and drives the dynamo. From experiments made with a 6-H. P. car it is said that the exhaust was sufficient to run the turbine at 5000 revolutions per minute when idle, at 3000 revolutions per minute driving a dynamo at 10 volts and 5 amperes, and at 2000 revolutions per minute when driving the dynamo at 20 volts and 5 amperes. The weight of the complete apparatus is but 26 pounds.

Electrically Operated Unloading Machinery

For Steamship Wharves

By F. M. KIMBALL

AMONG the many radical changes which have been introduced to expedite the business of commerce and transportation during the past ten years, none is more interesting, perhaps, than the development of machinery and methods of hoisting and conveying merchandise in the process of loading and unloading cars and vessels. It would be quite impossible to handle the immense masses of coal, stone, ore, grain and other similar commodities which are usually shipped in bulk, with anything like the expedition which is now demanded by the necessities of consumption, were it not for the very ingenious and elaborate appliances which have been invented and constructed to meet the imposed demand.

At Cleveland and other Lake ports are to be found machines and structures of stupendous capacity, wonderfully automatic in operation and involving the outlay of vast sums in their construction, by means of which whole train-loads of coal may be discharged in a few hours and vessels carrying as much as 11,000 tons of ore discharged within five hours.

The power requirements of this class of apparatus are most excellently provided for by the use of electric motors. It is often necessary to have several distinct power units, all operating either singly or co-ordinately, in connection with one of these immense structures. The use of a single steam engine and boiler necessitates the transmittal of the motive power to various points by means of rope, chain or line shafting. In such a case the transmission is not only more or less irregular, but the control of the various movements and the application of power at different points either necessitates the presence of a number of men at the several stations, or the utilization of a rather complicated system of controlling levers at a central point, the manipulation of which is attended with a greater or less degree of mechanical difficulty.

The electric motor is particularly well adapted for use on these structures. It is light in weight for a comparatively large power output, it occupies small space, it may be installed in any position required by the general form or function of that part of the structure to which it is attached, it may be located at the exact point where the power is required, thus saving transmission losses and insuring maximum smoothness of operation, and all of the motors on such a machine may be very accurately controlled from a central operating point by switches and rheostats requiring little manual power to operate, and possessing the maximum of reliability in use.

In connection with the loading, unloading and conveying machinery used by the large trunk railroads and steamship lines at their elevators, coal pockets and docks, the use of electrically operated handling machinery is constantly growing. After the great flood in Galveston, when the Southern Pacific Railway Company erected the magnificent docks at their terminal yard, about twenty-five merchandise conveyors were installed on specially constructed gang planks or drops. These proved highly successful and, although they were not the first handling machines of like nature to be put into operation, yet, dating from the time of their installation, there has been a constant advance in the equipment of similar docks with machinery and appliances of the same general type.

It is not alone in the handling of ore, grain, coal, stone and similar raw material, that conveyors are found useful, but as well in connection with the handling of boxes, barrels and packages of all kinds, both at shipping termini and in and among factories and factory buildings.

An interesting illustration of one of the more special uses of unloading apparatus and conveyors is found in the equipment of some of the docks in the Gulf and Atlantic Coast cities where tropical fruits are received. The illustrations accompanying this article show the electrically operated conveyors with which one of the United Fruit Company's wharves in New Orleans is equipped.

The first illustration shows a general view of the wharf, with a banana steamer lying alongside. From an elevated framework there extends a skeleton boom, from which a "leg" may be dropped into the hold of the vessel. The boom and "leg" carry a succession of cylinders, over which passes a wide belt, whose sides are of flat link chain, separated by stretchers which support a loose canvas web. Power is supplied for operating the several parts of the mechanism, as well as for moving the belt, by General Electric motors of the induction type, of about 15-H. P. capacity. The wharf end of the belt delivers its load immediately in front of the door of the freight car to be loaded. After the first car is loaded the train is moved along periodically as one car after another is filled.

At this wharf upwards of seven million bunches of bananas are received each year. Formerly a large number of laborers were required to discharge the cargo. They "toted" the bunches out, one at a time, and in raising them from the hatches, lifting them from deck to deck, and passing them over the side of the vessel and to the cars, not only were the bunches frequently much bruised, with consequent deterioration in their appearance and value, but a large amount of fruit was broken off and lost as well. Under favorable circumstances and by hand labor, about twelve hundred bunches an hour could be removed from the vessel. By means of the one conveyor here illustrated, 5000 bunches per hour may be readily unloaded, without bruising or material loss of fruit, and by the use of three unloaders, one at each hatch, a minimum of 15,000 bunches per hour may be taken out.

The loose canvas belt drops naturally into pockets on the ascending side, and in these pockets the bunches are laid. At one operation and with one handling, they are thus conveyed from the hold up to the boom, and thence on to the wharf and landed in front of the car.

The second illustration shows the delivery end of the belt on the wharf in front of the train.

The unloader was built about three years ago by the Link Belt Engineering Company, of Philadelphia, under the patents of George J. Eddel-

AN ELECTRICALLY DRIVEN BANANA CONVEYOR AT NEW ORLEANS. THE CONVEYOR LEG IS SHOWN EXTENDED FROM THE WHARF INTO THE HOLD OF THE SHIP ALONGSIDE

THE BANANA CONVEYOR SEEN FROM THE WHARF SIDE, SHOWING WHERE THE BANANAS ARE LANDED, TO BE PASSED INTO FREIGHT CARS FOR FURTHER TRANSPORT ston, the construction engineer of the Alder-Weinberger Steamship Company, and Beverly J. Harris.

The whole structure is mounted on a ten-wheel truck, running on rails, so that it may be moved along the wharf parallel with the capsill, if so desired. The control is from a lookout tower, so located as to insure the attendant's having a full view of operations as they progress. All of the movements of the belt, the boom and the "leg" are controlled by the attendant without leaving his station.

The expense of operation and the maintenance of this machine have been most trivial in comparison with the saving in labor and fruit which has resulted from its use. Similar installations have been made at Mobile and several other ports on the Southern coast.

Storage and Discharge of Streams

By a Staff Correspondent

Minimum discharge of a stream is of prime importance for purposes of electrical supply, as the maximum and average discharges can usually be made available only by storage.

The reason for the great importance of the minimum discharge of a stream lies in the fact that consumers of electrical energy want it every day and every month. Such consumers cannot usually be induced to use large amounts of electrical energy when water is high and small amounts when it is low.

If the period of minimum discharge for a stream comes in the summer, when the demand for lighting is least, and the maximum discharge occurs in the winter, when the requirement for light is greatest, the maximum flow of water becomes important in so far as it meets the greatest need of light. For an electric system that supplies a large part of its energy for heating buildings, a stream with a maximum rate of discharge during the winter months might be very desirable, because in these months the demand for heat is at its height.

Storage of the discharge of a stream at any point may make the water flowing at one time of day available for power development at another time of the same day, and storage to this extent is often practicable. If the space for water storage is great enough, the discharge of a stream during one month may be carried over and used in large part for the development of power in another month, but no such storage capacity as this is available on most rivers. Where any such storage capacity does exist, it is usually in lakes that receive their water from a large part of the drainage area of the stream that forms their outlet, rather than along the main channel of the stream itself.

An excellent example of a storage capacity of this sort is found at Sebago Lake, in Maine, where the lake drains an area of 470 square miles out of the 700 square miles drained by the Presumpscot River, its outlet. This lake has a water surface of 50 square miles, or more than 10 per cent. of its drainage area, so that if the annual run-off, which corresponds to a water depth of 21 inches over this drainage area, were stored, it would raise the lake level only 16.4 feet.

For more than a decade the annual range of elevation of the surface of Sebago Lake has been between 5 and 6 feet, showing that approximately one-third of the water flowing into the lake annually is stored from the wet to the dry season. This storage gives an unusually uniform discharge over the stone dam that marks the outlet of this lake into the Presumpscot River. Thus, for 1897, the lowest average discharge for a month was 545 cubic feet per second, in April, and the highest was 1110 cubic feet per second, in August.

Where the storage of water is carried out in one or more lakes that feed a stream, as in the case just cited, and power is developed by falls along the river below, the heads of water on wheels vary but slightly as the stored water is drawn off. A storage that does not materially vary the available heads of water on the wheels is very desirable, because not only the power of a turbine wheel, but also its speed of revolution, varies with the head of water under which it works.

If the use of stored water causes a large reduction of the head on the wheels, the electric generators connected to these wheels will, as a rule, be unable to carry their full loads, the frequency of the main current will be changed, and the exciting current may not be able to keep up the line voltage.

Where the storage of water for an electric plant is directly behind the dam that maintains the head for the wheels, it is usually impracticable to draw off more than a small part of the stored water, because of the resulting variations in head, power, speed and voltage, as just mentioned. Such a storage of water behind the dam that creates the head on the wheels cannot usually amount to more than the flow of the stream during a week, and is more often sufficient to hold the discharge of water for less than one-half of this time. From a storage of this latter sort the operation of a fully loaded electric station during a single day might cause a serious reduction of head, if the flow of the stream were greatly diminished.

As a rule, the storage of water directly behind the dam that creates and maintains the head on the wheels merely suffices to hold the discharge of the stream so that it does not escape during those hours of each day when electric loads are least, and may be utilized during those hours when such loads are greatest. For storage from month to month, and season to season, recourse must usually be had to lakes or artificial reservoirs that do not create and maintain the principal part of the head of water on the wheels.

An illustration of many of the foregoing facts may be noted in the hydraulic development for the electric station at Spier Falls, on the Hudson River. By means of a dam at that point, the surface of the river was raised about 50 feet, and the electric station was located near one end of the dam. The storage reservoir thus created extends several miles up stream and is ample to provide for hourly fluctuations of load. For storage between seasons, reliance is placed on a number of lakes many miles up stream in the mountains.

The utilization of electric power in Italy has grown apace since 1890. At that time the only important plants were situated at Milan, Rome, Genoa, Turin and Naples. It is improbable that the total electric motive force available in Italy in that year exceeded 20,000 H. P. To-day electricity in Italy provides a total motive force of over 200,000 H. P. Milan alone disposes of 20,000 H. P., and the large, new hydro-electric station at Vizzola, near Milan, distributes 18,000 H. P. to various points in the provinces of Milan and Como. The central station at Genoa generates and distributes over 8000, and those of Rome and Naples over 10,000 H. P. respectively. The new plant at Cellina will shortly be in a position to distribute a motive force of about 18,000 H. P.

The first electric railway in Nevada was recently opened between Reno and Sparks, in that State.

The Electric Motor in Illinois Farming

By GEORGE L. CLARK

A HALF century ago, when the route for the first railway was being surveyed in Kane County, in Illinois, a large number of the prominent farmers in that part of the State held a mass meeting to protest against the coming of the steam locomotive. The speakers argued that the railroad would decrease travel along the toll highways to such an extent that the revenues of the companies who maintained the "plank" roads would be greatly reduced, while the roadside inns, so numerous at that time, would also be affected.

Despite the objections of the rural folk, the ties were laid, the rails spiked to them and locomotives were soon hauling trains over the prairie. Then came the era of electrical transportation, with the result that this part of Illinois contains literally a network of lines operated on both the overhead trolley and the third-rail systems.

This brief history is worth noting, since the coming of the electric railroad has not only changed the methods of travel, but has also inaugurated a new system of carrying on farming work. The farmers have recognized the fact that electricity can drive many of their machines, performing the labor so quickly, yet economically, that those who have availed themselves of it have been able to reduce their expenses in a large degree.

Along the electrically operated lines extending into the county in question are the Aurora, Elgin & Chicago and the Elgin, Aurora & Southern. The first road mentioned is notable on account of the high speed maintained over it, and because it represents the most modern type of interurban electric railway. The third-rail system is used on this road. The Elgin, Aurora & Southern is operated on the overhead system.

Both of these lines pass through some of the largest farms in the county, and consequently, by merely stringing a few hundred feet of wire, a supply of electricity can be secured for use at convenient points on any of these farms. Within the last year the advantage of utilizing this power has so forcibly impressed itself upon the people of Kane County that at present nearly fifty of the most extensive farms within its limits are dependent almost entirely upon the current from the trolley or the third-rail systems to operate the various machines used on them.

While such staple crops as grain and fodder are produced in large quantities, a specialty is made of dairy products, and it may be said that the county has a reputation for sending to market more milk, cream, butter and cheese than any other place of equal area in the United States. The county seat, Elgin, has a national reputation for the large quantity of cheese and butter manufactured there. An opportunity has therefore been given to demonstrate the advantages of the electric motor in an unusual variety of operations, for it has been introduced with the idea of taking the place of animal and manual labor as far as possible. For example, wood for fuel is cut into the proper lengths by motor-driven saws, and the tanks from which water is secured for the gardens and for supplying the live stock are filled by pumps electrically operated.

In the dairy a motor drives the apparatus which separates the cream from the milk, and turns the butter maker and the ice-cream freezer. In the barn electricity drives the corn husking machinery, cuts the hay, corn stalks and other fodder for the horses and cattle, and drives the fanning mill which removes the dust from the grain. As the farm wagon is driven up to the door filled with wheat, vegetables or other products, it is unloaded by means of a rope and pulley attached to a bag or basket, the motor hoisting and lowering the receptacle so that the only work required of the farm hand is to empty it. In the same manner hay is carried from the wagon into the barn loft. The machinery which has recently been invented for peeling and pulping potatoes and slicing apples is also operated by motors, and on a number of the farms they have been placed in service successfully for driving plows and cultivators.

The motor is generally placed in the barn or other building, but it may also be used out of doors at any place on the farm which can be reached by wires. Since it is of such weight that it can readily be hauled on a wagon into the field, garden or orchard, it is only necessary to carry along sufficient wire to allow of its application to nearly every operation which the farmer performs. Thus it is that the application of electricity in this portion of the United States has been so thorough and so diversified that a correct and complete estimate can be made of its advantages as compared with the methods in common use. It may be needless to say that those who have adopted it have done so for purely business reasons, believing that the motor would be more economical than human or animal labor. In a number of instances records have been kept showing the comparative expense which has been entailed.

One of the most extensive farms in Kane County is known as the Lord farm, which was among the first on which electricity was employed as far as possible in place of other power. An itemized account of the expense for the first year follows:—

Cost of installation of electric motor..........	$500
Cost of power furnished..........................	30
Cost of repairs, etc., one year.................	10
Total cost of electricity, first year......	$540

The itemized expense for performing the same amount of work during the preceding year was as follows:—

Wages of one farm hand one year, at $25 per month	$300
Cost of board and lodging, at 50 cents per day	185
Cost of team of horses, at $125 each...........	250
Cost of feed for same, using the fodder of five acres of land	200
Cost of shoeing, fee of veterinary surgeon, repairs to harness, etc., one year..........	25
Total	$960

It will be noted that no less than $420, or nearly 78 per cent. of the total expense of installing and maintaining the electric plant, was saved during the first year. This amount, however, includes the outlay for the motor itself which, of course, can be utilized for a period of years before it would be necessary to purchase a new one. Therefore, for the second year the allowance should only be made for the depreciation of the motor. If this were placed at 15 per cent., the total cost to the farmer would be but $115. In the second year's account, however, allowance may be made for the cost of the horses in order to make a fair comparison, but after this is done a balance is left of nearly $600 more than the expense of motor service. Such is but one illustration of the economy in the use of electric power as secured by the farmers in the county referred to.

On the Kenyon farm, where the

motor has been used very extensively, power has cost but $4.70 per month on the average—less than on the Lord farm. On the Bosworth farm the cost has been $6.46 per month. On this place also the motor has been in general use, but it should be stated that the service is required only about six months during the year, so that in calculating the expense the cost of the electric current during this period only need be estimated. On such a basis the expense for the year on the Kenyon farm, for example, does not exceed $30, while on the Bosworth farm it amounts to less than $40. This estimate is based on a charge of 4 cents per kilowatt-hour, the uniform rate charged by the electric companies for agricultural service.

A brief outline of the method of utilizing the electric current may further explain why it has come into such favor with the Kane County farmers. As already noted, the motor may be located at any place and connection made with the electric railway line, the power secured being much greater than that generally available where horses are used—still another advantage. On nearly all of the farms a single motor of 15 H. P. is used, which costs the farmer only as much as he would be obliged to pay for four horses or mules of a fair grade. So little skill is required for operating the motor controller, that on most of the farms boys are employed for this purpose.

It is perhaps fortunate that the introduction of the electric current in connection with agricultural pursuits has been made in this section of the United States, since it is one of the wealthiest farm territories in the world. Kane County has an area of about 540 square miles, but within its boundaries resides a population of nearly 100,000, and on account of the wealth it represents the average amount per capita is nearly $1000. In other words, this county contributes nearly $100,000,000 to the assets of the State of Illinois.

The fact that the motor has made its appearance on some of the most extensive farms in the county and has accomplished the results described indicates the vast possibilities of its employment in other portions of the United States. It is a question if European farmers have not made more progress than Americans in the substitution of electrically operated mechanism for the more expensive and slower methods. The tourist in France and some portions of Germany may see what have been termed "electrical farms," where the electric motor is utilized in all of the principal operations. With the rapid extension of the interurban railway in the United States, however, the electric current, it may be said, is brought to the gate of the farmer, while he himself can step from the car in front of his own door.

Not only in the Central West, but also in New England, Central and Western New York, Pennsylvania, and even on the Pacific Coast, the trolley and third-rail systems are ramifying the rural districts. While the success which has attended the operations in Kane County is as yet but little known outside of that vicinity, it is safe to say that it will soon be so to thousands of farmers who are also so situated that they can take advantage of the labor and time-saving properties of the electric motor. When it is appreciated, it is not improbable that another great change will be effected in agricultural pursuits as far reaching as that which resulted from the invention of the harvester.

Book News

Self-Propelled Vehicles

A Practical Treatise on the Theory, Construction, Operation, Care and Management of all Forms of Automobiles. Second edition, 1904. By J. E. Homans, A. M. Size, 8 x 5; pp. 650. Publishers, Theo. Audel & Company. Price, $2.

Mr. Homans' book is intended to give practical information to those not having the time or inclination to study the mechanics of anything except their own automobiles. It furthermore is intended to give principles of theories involved in automobile designs of various types, and to explain their construction and operation, and to do this briefly but explicitly. It illustrates the constructions used on various automobiles of 1904. A large portion of the book is of direct interest to owners of vehicles, while the balance is particularly interesting to the more technically inclined, or students of the art.

The first edition of this book appeared in 1902, and gave the impression of championing the steam-propelled road vehicle. A material change is evident in the present second edition, reflecting most markedly the transposition in importance of steam and gasoline automobiles which has taken place in the past three or four years. A large number of what may be considered typical American gasoline cars of 1904 are fully illustrated and described in the five hundred illustrations contained in the new edition. A few modern foreign machines also are illustrated, and several parts of the book contain snatches of ancient and the more modern automobile history.

The contents might be summarized as briefly the theory involved in the different classes of automobiles, namely, steam, electric and gasoline; general discussion of different forms of constructions of the principal parts of vehicles; and brief details of the typical vehicles of the latest construction. The book is well indexed.

Maxwell's Theory and Wireless Telegraphy

By Frederick K. Vreeland. Published by the McGraw Publishing Company. Cloth. 255 pages. 145 illustrations. 6 x 8½ inches. Price, $2.

This book is divided into two parts, the first of which is a very good translation of H. Poincaré's work, "Maxwell's Theory, and Hertzian Waves"; the second part is devoted to an essay on "The Principles of Wireless Telegraphy," by the translator and author. The avowed object of Part I is to give a physical treatment of Maxwell's theory and its application to some modern electrical problems, from which to derive a practical understanding of the essentials of wireless telegraphy.

The subjects are treated in everyday language, and mechanical analogies and diagrammatic illustrations are employed in place of mathematics to simplify and elucidate the explanation of what are usually considered rather abstruse problems. Among the subjects thus treated, for example, are electrostatic phenomena; Maxwell's theory; Hertz's oscillator; imitation of optical phenomena, and wave length and multiple resonance. Students unfamiliar with the French language will appreciate the translator's pains to place Poincaré's work within their reach, in virtually its original shape.

On page 94 and elsewhere in the translation occurs the expression "Thin films." Without having the original before us, we cannot be certain as to the accuracy of this translation, but we should say that the expression belongs in the same category with "hollow tubes," "mental acumen," "acumen of mind," "slow speed," and the like, against which Messrs. Lockwood, Maver and Crocker, respectively, have inveighed.

In Part II Mr. Vreeland gives an interesting and important addition to the literature of wireless telegraphy, especially as relates to the development of the art in its essential features—as the author explains. In this part of the work chapters are devoted to the grounded oscillator, the propagation of grounded waves, the receiving apparatus, selective signaling, etc., all of which subjects are treated in a clear and comprehensive manner. It is a curious fact that on page 189 the author claims the credit for the development of the electrolytic detector, which is now a bone of contention between Fessenden and De Forest. In the index this is termed the "Vreeland Electrolytic Detector," so that we are not left in doubt as to the author's claim. The discovery of this detector is already credited to Schloemilch and to Pupin, as well as to the others named, and unless an authoritative decision is shortly given on the subject, there may soon be as many claimants for the discovery of this device as for the authorship of "Beautiful Snow."

The work is not intended as a handbook of the subject, and consequently no attempt is made to describe the various systems of wireless telegraphy that have been invented, that being left for others. The interested reader will, however, find much information of value within its pages. The typography is excellent and the diagrams are well designed and reproduced.

The Up-to-Date Hardwood Finisher

By Fred T. Hodgson, architect and editor of the "National Builder." Published by Frederick J. Drake & Company. 209 pages. Illustrated.

In this book the author has extended the limits of his manual on "Hardwood Finishing," prepared about twelve years ago, and added more to the subject of wood preparation. The title is somewhat misleading, as the book gives general instructions in finishing woods of all kinds—hard and soft. Directions are given also for finishing the raw wood, making it ready for the finisher or varnisher and polisher, together with formulæ for mixing the materials and applying them to the prepared wood. Descriptions are given of the tools required, methods of using and how to care for them.

Scientific American Reference Book

Compiled by Albert A. Hopkins and A. Russell Bond. Published by Munn & Company. 516 pages. Illustrated. Price, $1.50.

This book is the result of the queries of three generations of readers of the "Scientific American," and covers a wide range of topics, as evidenced by the subjects of the chapters. In Part I., covering 398 pages, are included the progress of discovery, shipping and yachts, navies, armies, and railroads of the world, population of the United States, education, libraries, printing and publishing, telegraphs, patents, manufactures, departments of the Federal Government, post office, international institutions and bureaus, mines and mining. Part II. devotes 44 pages to geometrical constructions, machine elements and mechanical movements. Part III. treats of chemistry and astronomy in 22 pages. Weights and measures in Part IV. take up 36 pages. The work has been made as non-technical as the subjects treated of will admit, and is intended as a ready reference book for the home and the office. Many statistics are presented in the form of illustrations and diagrams supplemented by figures, after the manner of treatment familiar to the readers of the "Scientific American." Thus a comparison of the railways of the world is shown in one case by locomotives of characteristic designs of the principal countries, and the size gives the relation of the number of miles of track in the various countries.

Alternating-Current Engineering Practically Treated

By E. B. Raymond. Published by the D. Van Nostrand Company. Cloth. 240 pages. 102 illustrations. 4 x 5½ inches. Price, $2.50.

There is a class of text books which among self-taught students are known as "the well-known manner" books, from the fact that at the critical point of an explanation the author ends it by saying "and the result is obtained, or the operation occurs, in the well-known manner," that "manner" being exactly what the student is most desirous of knowing. The book before us is not of that class. Indeed, it stands out, as comparatively few technical books do, as one in which the author evidently takes pains to make the "well-known manner" unavoidably clear to the student. For example, where the author is defining impedance, he states, "the reciprocal of the impedance is called admittance. Thus the admittance is the current flowing in a circuit with one volt applied. Thus admittance times volts = amperes." Again, further on, he says, "One property of great importance is a value called its square root of mean square; that is,

$$\sqrt{\text{mean square}},$$

which is, as the name implies, the square root of the average of the squares of all the values."

On the other hand, the author is not always conventional. On page 9 he states:—"It was discovered some time ago that if a wire were moved to cut across the magnetic flux which has been described, etc." He might have said, conventionally, "In 1832 Faraday discovered, etc." But authors of text books, like other authors, must be allowed to tell their stories in their own way.

The subject matter of the book is divided into two parts. The first part treats of "The General Subject of Magnetism and Alternating Current"; the second treats of "Modern Alternating-Current Apparatus." In the first part, magnetism, permeability, electromotive force, self-induction, impedance, hysteresis, and other related subjects are discussed. In the second part, transformers, alternating-current motors, the repulsion motor, the alternating-current generator and other types of alternating-current apparatus are considered, together with a chapter on testing.

The author, in his position as director of the students' course in practical engineering in one of the largest electrical manufacturing concerns of this country, has had excellent opportunity to ascertain the needs of students and, as he states in his exemplary brief preface, has had impressed upon his mind the necessity for a general treatise on alternating-current engineering, presented in a simple and practical way, and the book under consideration is the successful outcome of his endeavor to supply such a treatise. If we have any suggestion to make, it is that the title might quite appropriately have been "Alternating-Current Engineering, Simplified and Practically Treated."

While mathematics are employed in the book, they are not at all complex, and the graphic method has been followed in the illustrations, which, by the way, are well executed. We can cordially recommend the book as a text book to students, and as a work of reference for the library of the electrical engineer.

Notes on Track Construction and Maintenance

By W. M. Camp. Published by the author. Second edition, revised. Size, 6½ x 10 inches. 1214 pages and 620 illustrations. Price, $3.75; cloth, bound in two volumes, $4.

The author, the editor of the "Railway and Engineering Review," has treated the construction and maintenance of railroad track from the standpoints of both the trackman and the engineer. This would seem to be the logical method of handling the subject, as a thorough trackman must necessarily be able to understand some of the principles of engineering, and a knowledge of some of the important details of track work is essential to the qualifications of a track engineer. The book is addressed to those who are in need of a thoroughgoing treatment of details as well as of general principles. The descriptive matter and illustrations treat of work, methods or appliances in actual service, and the discussions of practice are based upon experience.

The general scope of the book includes information on the track proper, such as materials, laying, ballasting, curves, switching arrangements and appliances, maintenance, double-tracking, track tools, work trains, miscellaneous and organization. Supplementary notes and tables occupy 60 pages, and an index of 18 pages concludes the work. One particular object in view has been to cover as widely as possible the development of labor-saving machinery in connection with track work.

Moody's Manual of Corporation Securities. Fifth Annual Number, 1904

By John Moody, editor. Published by the Moody Publishing Company. 2370 pages. Price, bound in cloth, $10 per copy; in flexible leather, $12 per copy.

This annual statistical publication is a reference book for American investment securities of every nature, embracing information on practically all the industrial, gas, electric light, electric railway and steam railroad corporations in the United States, Canada and Mexico. Each corporation is described as to statistics and property owned and controlled, capitalization and bonded debt, dividends paid, financial condition and earnings, officers, managers and directors, location of plants, offices, etc. The statements vary in fullness, according to the size and importance of the corporation involved. The volume is likely to be particularly useful to the banker, broker, corporation lawyer and general investor, as well as to all who are in any way interested in corporation finance or the general evolution and growth of twentieth century industrial conditions.

The Canadian Niagara Power Company

On January 2 the Canadian Niagara Power Company opened formally its new power house in the Queen Victoria Niagara Falls Park by putting into operation two 10,000-H. P. units of its first installation of 50,000 electrical H. P. The company is the pioneer in the development of Niagara power on the Canadian side for commercial purposes. Its contract with the Ontario Government called for a development by January 1, 1905, involving the construction of a tunnel with a capacity for the discharge of water producing 100,000 H. P.; a canal or intake from the river with a capacity for 50,000 H. P.; a wheel-pit with a capacity of 50,000 H. P., and 20,000 electrical H. P. ready for sale and transmission on or before the date mentioned. The works have been constructed on a larger scale than are called for by the requirements of the contract with the Government, so that now the company has a canal, tunnel and wheel-pit complete for the development of 110,000 H. P. Five electrical units of 10,000 H. P. each are being installed, two of which were put into successful operation on the date above mentioned. The other three will be ready for commercial use also by May 1 of this year, and there will be room in the completed wheel-pit for six additional units of the same size which can be quickly installed as the demand may require such installation.

Each unit is composed of a 10,000-H. P. turbine wheel designed and built by Echer, Wyss & Company, of Zurich, Switzerland, placed in the bottom of the wheel-pit and connected by a vertical shaft with a 10,000-H. P. alternating-current generator made by the General Electric Company, of Schenectady, N. Y. The water is led to the turbines from the canal penstocks 10 feet in diameter, and after passing through the wheels is discharged through a short tunnel whose portal is at the water's edge, in close proximity to the Horse Shoe Falls. The tunnel is driven through solid rock and lined throughout with concrete and specially burned brick.

The company is owned by the Niagara Falls Power Company, whose two power houses on the American side, containing an installation of 105,000 H. P., have been completed for some time. The power house of the Canadian Company is connected with these two power houses on the American side by cables laid in conduits through the Canadian Park and the city of Niagara Falls, crossing the river on the upper steel arch bridge of the International Railway Company just below the American Falls. Every power customer, therefore, of these two companies, whether he be on the American or Canadian side, has the assurance of continuity of supply of power given by these connections, and the plants on both sides of the river will be operated as one plant.

The first large block of power from the Canadian power house probably will be run for transmission to the city of Toronto for use there for railway and lighting purposes. This power will also be available for transmission to the United States in connection with the customers of the Niagara Falls Power Company. Should the Canadian demand require it, one-half of the 100,000 H. P. is available for Canadian uses. This international development under a single direction may be expeditiously enlarged from its present output by the installation simply of the additional units of machinery for which the Canadian works are prepared. It may be still further enlarged by the exercise on the part of the American Company of its already acquired rights to a further development of an additional 100,000 H. P.

The National Electric Light Association Question Box

HOMER E. NIESZ, editor of the "Question Box" for the Denver-Colorado Springs meeting of the National Electric Light Association, has sent out over 7000 letters to companies and individuals in the electrical field asking them to submit questions to be grouped under the following headings:

Buildings.
Water Wheels, Water Power, etc.
Feed Water, Heaters and Pumps.
Fuel.
Boilers and Mechanical Stokers.
Forced Draft, Blowers, Stacks.
Piping, Condensers, etc.
Engines.
Turbines.
District Heating.
Generators and Exciters.
Storage Batteries and Boosters.
Switchboards, Instruments and Station Wiring.
Belts and Shafting.
Oil and Waste.
Overhead Lines.
Underground Lines.
Transformers.
Lamps—Arc, Incandescent, etc.
Heating, Battery Charging and Power.
Meters.
Advertising.
Contracts and Rates.
Accounting and Statistics.
Management.
Miscellaneous.

Mr. Niesz not only desires questions from those seeking information, but he appeals to the missionary spirit in those who have solved difficulties for themselves, and asks them to send questions to which they have found solutions, together with the replies, for the benefit of others.

There is practically no limit to the benefits to be thus gained.

Prices of Water Power

By a Staff Correspondent

ELECTRIC power is now so generally developed by water that the prices at which water power as such is sold are valuable as an indication of the cost of the former. The prices of water power vary much with its location, the cost of development and the amount sold at one time.

An early sale of water power was that at Lockport, N. Y., in 1825, when the State conveyed the right to use the surplus flow of the Erie Canal at that place for the development of power, at a yearly rental of $200. This surplus water is that part of the supply from Lake Erie necessary to feed the canal east of Lockport, and as the canal changes its elevation by 58 feet at that point, the water has that amount of head. In this way about 2625 horse-power is now developed. The payment of $200 per year amounts to 7.6 cents per horse-power per year for the amount of power just named. A number of large factories use this water power at Lockport, and the prices paid for it range from $12.50 to $16.67 per year per horse-power.

Large amounts of hydraulic power are sold at Niagara Falls, N. Y. for $8 to $10 per horse-power year, the purchaser drawing the water from a canal and supplying his own pipes and wheels. At Oswego, N. Y., two canals, one on the east and the other on the west side of the Oswego River, supply water for power purposes. The river at this point has the Lake Ontario level, and the canal on its east side maintains a head of 18 to 20 feet—usually the latter.

A "run" of water from this canal is fixed at 11.75 second-feet, and is sold for $350 per year when first class, $250 to $300 when second class, and $150 to $200 per year when surplus. When the water supply is not sufficient for all users, the surplus runs are first shut off entirely, then the second class, and lastly, the first-class runs are reduced proportionately. No land goes with the water at the rates just named, and the users of water power erect and maintain their own pipes and wheels. On the basis of $350 for a first-class run of water under a head of 20 feet, representing 26.5 horse-power, the annual price is $13.20 per gross horse-power of the water.

A "run" of water from the canal on the west side of the Oswego River is about 33.3 feet per second under the head of 10 feet, and is sold for $250 to $300 per year. The full power of a "run" on this canal is thus 37.4 horse-power, and at the higher rate just named its price is $8.02 per horse-power year. As good wheels will deliver only about 75 per cent. of the total power of the water, in any case, the price per gross horse-power must be increased by at least one-third to determine the net cost of mechanical power. On the west side of the river the supply of water seems to be more variable than that on the east side, and factory sites on the latter side have the advantage of clear water transportation to the lake. These facts, with the greater head of water on the east side, seem to be the cause of the higher price of power there.

In Cohoes, N. Y., a large amount of power is developed by the Mohawk River and is sold by a company that owns the canals and main raceways and all of the adjoining land. Purchasers take the water at the face of the raceway and maintain their own head gates, flumes and wheels. The lease of water carries with it land for a factory site, and the price for both land and water is $200 per mill-power per year. A mill-power in this case consists of 6 cubic feet of water per second under a head of 20 feet, and thus amounts to 13.52 horse-power. The price per gross horse-power at the rate named is $14.79 per annum.

At Lewiston, Me., the Androscoggin River falls 50 feet and has a capacity of about 15,000 gross horse-power. The water power company there sells the use of water under the head just named for $6.66 to $16.66 per gross horse-power, the older mills having the lower prices.

In Holyoke, Mass., the entire flow of the Connecticut River is controlled by a company that maintains a dam and canals and owns the adjacent land. The water power and land are leased together in varying proportions, according to the wants of tenants. A ruling price for the use of water and land adjacent to the canals in Holyoke is $1500 per permanent mill-power per annum, and in some cases a bonus or lump sum of money at the start is exacted in addition to this rent. Each mill-power is defined to be 38 cubic feet of water per second under a head of 20 feet, which represents 85.6 gross horse-power. The price per horse-power, neglecting the land and bonus, is thus $17.52 yearly.

Three corporations have been authorized by the government of Ontario to develop electric power by diverting water from the upper Niagara River and discharging it below the falls. Annual rentals are paid by these companies, the payment in each case consisting in part of a fixed sum and in part of a sum that varies with the amount of power developed. Each company is limited as to the amount of electric power that it may develop, but there is no set limit to the volumes of water that may be used to develop the power. The companies are building and must maintain all of the works necessary for the development of power, as the payments made to the Ontario Government cover simply the right to occupy land in the Queen Victoria Niagara Falls Park and to divert the river water.

The heads of water available at the three sites selected in the park vary from about 150 to 210 feet. One company has the right to develop a maximum of 100,000 electric horse-power, and is bound to pay a yearly rental of $15,000 without regard to the amount of power actually developed. Besides this fixed sum, the company in question must also pay in each year to the government from 50 cents to $1 per horse-power, according to the amount developed above a certain minimum.

Another of the companies on the Canadian side of the falls has the right to divert sufficient water to develop 125,000 electric horse-power, and is bound to pay a fixed yearly rental of $15,000, without regard to the amount of power actually developed. If this company generates no more than 10,000 electric horse-power, no further payments are exacted of it. For each electric horse-power above 10,000, but not over 20,000, an annual payment of $1 is to be made, for each horse-power above 20,000, but not above 30,000, an annual payment of 75 cents; and for each horse-power above 30,000, an annual payment of 50 cents. The rental paid by this company amounts to $1.50 per horse-power when 10,000 is developed, $1.25 per horse-power when 20,000 is developed, and to 64 cents per horse-power per annum when the maximum authorized amount of 125,000 horse-power is developed.

The third great company on the Canadian side of the falls is authorized to divert enough water to develop 200,000 horse-power, and must pay a fixed rental of $30,000 yearly. In addition to this rental, annual payments must be made of $1 for each electric horse-power generated between 20,000 and 30,000, 75 cents for each horse-power between 30,000 and 40,000, and 50 cents for each electric horse-power above 40,000. When this company generates 20,000 horse-power its water rental amounts to $1.50 per horse-power yearly. When 40,000 horse-power is developed the rental per horse-power will be $1.1875 yearly, and with the maximum development of 200,000 horse-power the rental drops to 63.75 cents per horse-power year.

In the case of at least one of the corporations just considered, the lease of power and of the right to occupy Queen Victoria Park runs for a period of fifty years, subject to the right of the company to vacate its plant on three months' notice. After this period of fifty years, the company has the right to three successive renewals of twenty years each, but on these renewals the government may have new rates for power fixed by arbitration.

Long Distance Wireless Telegraphy

According to "The Electrical Engineer," of London, a message by wireless telegraphy has been transmitted from the Marconi Company's station at Poldhu to a station belonging to the Italian Government at Ancona. It was addressed to Admiral Mirabello, Italian Minister of Marine, who has taken a great interest in wireless telegraphy. The station at Ancona is a small one, and was not originally intended for long-distance work. The mileage between Poldhu and Ancona is about 1000, and almost entirely over land, and in order to reach their destination the waves had to pass over nearly the whole of France, and a considerable portion of Italy, including the highest mountains of the Alps.

Electric engineering is a living, growing subject. Even the best men, says Dr. Louis Bell, can hardly keep pace with it, and the young engineer needs an athlete's training in the fundamental exercises that give speed and endurance. Beyond this, thoroughness and initiative are the watchwords of the profession.

Electric Mine Hoisting

In a letter to "The Electrical Review," of London, Sydney F. Walker enumerates the following causes of the great waste of steam in steam hoisting engines for mines:—

1.—The very large amount of condensation that takes place, owing to the fact that the engine is standing for a large portion of the twenty-four hours, but must be ready to hoist at any minute, that it stands between each wind, even when hoisting is at its busiest, and that even for a portion of the wind itself, the steam is cut off from the engine.

2.—The fact that the boilers must generate sufficient steam to meet the heavy demands made by the winding engine, without seriously lowering the pressure of the steam supplied to other engines on the same service.

3.—The large amount of work done at each wind during the acceleration period, and the demand for steam for braking at the end of the wind.

4.—The necessity for provision for lifting the full length of the rope at the commencement of the wind, while this length is not only continually decreasing as the wind proceeds, but the descending rope is continually lengthening, and the descending cage is continually acquiring momentum throughout the wind, though no benefit is obtainable from this fact, beyond shutting off steam at a certain portion of the wind, and thereby leading to additional condensation.

Mr. Walker says that if the whole of the steam properly chargeable to the hoist were divided over the actual brake-horse-power expended in winding, the amount would be startling. As far as his experience goes, there are not many winding engines in use that wind for even 125 pounds of steam per indicated horse-power.

With electric winding, in place of the colliery boilers being obliged to be kept going all night for the winding engine, the fan engine, and possibly the electric light engine, with the necessary waste of steam during the interval between the winds, the winding and other engines go in with those of other collieries, or other works. It is hardly necessary now to repeat the argument that economy is realized by generating power at a central station and distributing, from the fact that, in any works all the machines are never at work together, and so the power that would have been used for the machines that are standing in any particular works can be used to drive machines in other works. Putting the winding engine on the electrical supply, instead of keeping one or more boilers going for it, enables that economy to be realized.

The reasons why colliery managers are not eagerly in the race for electrical winding engines are reasons of economy.

There are two economical laws which rule in these cases. Whenever a new machine is contemplated, the outlay is economically sound only when the saving in the cost of the process of which it is to form a part, or alternatively the increased selling value, is sufficient, during the useful life of the new machine, to pay all costs of installation and leave something over. By costs of installation are meant the cost of the machine and of fitting it up, with any contingent costs such as those sometimes incurred in learning to use a new machine, and from the total sum may be subtracted any amount realized by the sale of the old machine.

The other economic law refers to mines more particularly, and it states that the whole of the cost of opening the mine, of working it, and of puting the mineral on the market, together with a certain interest on the capital outlay, must be repaid within the period of the life of the mine.

It will be seen that these two laws have a very important bearing upon the question of the introduction of any new apparatus. German collieries have a longer life before them than the generality of British collieries, and hence they have greater inducements to expend large sums upon apparatus which, after all, though they promise very well indeed, are still new; and the mine owner is wise to allow German mine owners to experiment, instead of doing so himself.

Apart from this also, though it is practically certain that mines will, one and all, be worked by electrically driven machinery, it is by no means certain that a simple mechanical solution of the winding problem may not be more economical. Thus it has been proposed to work mine shafts on the elevator principle, with either an endless rope or chain continuously running in the shaft. As the rope or chain might be driven by electric motors, it appears to me that this arrangement at least offers a good possible solution of the problem.

The elements which, in the broadest sense, limit the distance to which power can be economically transmitted, are two—the cost of power at the generating station and the price which can be obtained for the delivered power. The difference between these two elements must cover the cost of transmission, the interest on the investment, and the profit.

From the World's Technical Press

Exhaust Steam Turbines in Steel Works

IT is now a good many years, says "Engineering," of London, since Druitt Halpin proposed a system of thermal storage for rendering available for power purposes steam produced at times when it could not be immediately utilized. The proposal as made had special reference to reducing the boiler capacity needed to carry the loan on an electrical station at the time of maximum demand. The principle is, however, available in other circumstances, and in a paper read before the West of Scotland Iron and Steel Institute, J. P. Mitchell described the plant by which Prof. Rateau has rendered available the very large quantities of exhaust steam now wasted at large collieries and iron works. It should be noted that it is more economical to use this steam in a turbine than it is to merely fit the engines with a condenser, since, when it comes to dealing with steam at low pressures, the very best reciprocating engine is easily distanced by even an inefficient turbine. The difficulty to be met lies, however, in the fact that at rolling mills and steel works the supply of exhaust steam is very fluctuating and, although the waste may represent 1500 H. P. or more, some method of thermal storage is essential if this is to be commercially available, as the demand for power is a constant and not a fluctuating one, or at least such fluctuations as exist cannot be expected to synchronize with those in the supply of exhaust steam. Three patterns of thermal stores, or regulators, are used by Prof. Rateau. In the one case the regulator consists of a large vessel filled with cast-iron trays containing water, in which is stored up the surplus energy received at times of large supply of exhaust steam, to be evaporated off again at times when this is deficient, so that a supply which is practically steady is supplied to the turbine. In another pattern the vessel is filled with masses of scrap iron. In both these cases the large quantity of metal present greatly facilitates the rapid interchange of heat. In the third pattern the heat is stored in water, as in the Druitt Halpin system, but to insure a rapid interchange of heat between the steam and the water the exhaust steam is introduced below the surface of the latter, into which it escapes by a series of small orifices so arranged that the water is kept in a state of constant agitation. With a steam supply at 29.4 pounds absolute per square inch and a vacuum of 25 inches the consumption in the turbine per electrical horse-power is only 20.1 pounds, while with steam at 14.7 pounds absolute and the same vacuum it is 26.5 pounds per electrical horse-power hour.

The Care of Switchboards

WHILE in most electric central stations systematic attention is devoted to the cleaning of the buildings and mechanical plant, and some effort is made to keep the electrical running machinery in good order, only superficial notice is often taken of the condition of the switchboard.

An instance of this, says the London "Electrical Review," came under our notice at a station whose switchboard was of the "flat-back" type. The marble front was beautifully clean, the glass and brass of the instruments were brilliant in their polish; but the engineer was unwise enough to show us the back of the board. A heavy coating of dust lay on the bus-bars and cables, a mop and pail of water stood in one corner adjacent to a resistance frame, and balanced on the angle-irons of the frame work was an assemblage of pint-pots, cups and parcels of food, this portion of the board being evidently reserved as a pantry by the switchboard attendants. This laxity is all the more astonishing because the board is the point of assemblage of all the power developed by the plant in the station prior to its departure to the feeding-points of the system.

The reason for such neglect is probably that, with a continuous supply, the board is never entirely available for overhauling and cleaning. Parts which are in operation, or regarded as "spare," are exempted from strict examination owing to the risk of life or other causes. The danger of this is, however, apparent to anyone who has had the opportunity of seeing what dust can do in increasing leakage, and noticing the effect of loose connections in increasing the drop of volts in a bus-bar.

A switchboard should be subjected to a detailed examination as often as, and of as severe a nature as that of the rest of the plant, which, though perhaps occupying more space, is, after all, only of the same power-capacity as the board. This should be undertaken by the engineer in charge, and he should be particularly on the alert for loose connections. It is not a wise policy to wait until a screw drops out and an open circuit is formed before making an anxious investigation and a penitential report. A half-hour spent with a spanner and screw-driver, say once a week, may save the credit of the station. It must be remembered that in a power house there is nearly always vibration constantly tending to jar connections loose. Alternate expansion and contraction of metal parts by heating as current is passed through them or interrupted aids vibration in making these parts work loose.

Dust in an engine room is usually rather oily, and where it touches it sticks. Moreover, parts charged to a potential differing from that of earth attract and retain light particles of dust. In some stations a small portable motor-driven air-compressor is used in order to blow the dust off electrical fittings, and the introduction of such appliances should not be discouraged. But it is not safe to rely on this method, partly because the general application of an air-blast tends to diminish the detailed examination of the insulating part of the board by the attendant, and partly because oily dirt is not moved by a current of air. The blast should be followed by a careful wipe-over by an intelligent human being armed with a piece of dry, soft rag. Waste is not to be recommended, as it leaves fluff and loose strands lying about. In applying an air-blast, particular attention should be paid to resistance-frames and other inaccessible parts. It is not desirable to have the pressure of the air higher than 60 pounds per square inch, as cases have come within our knowledge where mica insulation has been stripped away by too great a blast of air. Where it is impossible to draw links in order to make a certain part of the board "dead," a feather brush mounted on an insulating handle may be used on systems at ordinary pressures of supply.

On many boards oil-break fuses are used, which have an occasional trick on breaking of distributing their oil fairly impartially over the surrounding apparatus. Oil is in itself an insulator, and, therefore, although it looks untidy, it is safe. But a streak of oil is a resting-place for all passing dirt, and if it is not soon removed the insulating properties of the board may be greatly reduced. On any board where oil is used, care must be taken that none gets upon insulation composed of rubber or wax, as they become deteriorated by its action.

It may not, perhaps, be out of place to draw attention at this point to the careful examination of fuses. Metal-strip fuses, it is notorious, deteriorate in course of time, and should be systematically replaced. A rough method of checking their behavior is to test their temperature when on full load. When a particular fuse has an unusually high temperature, it should be marked for removal at the earliest possible opportunity. Quite apart from this, however, a fuse should not be allowed to remain in use for more than a year's running. Where oil-break fuses are used the level of the oil in them should be examined daily. Some types are constructed to break in air, the fused ends being then plunged in oil; other makers prefer to make the arc in the oil itself. In either case the oil must not get too low. Metal-vapor bridges a very wide air space, and hideous results may follow from the improper breaking of a fuse.

It is an unfortunate phenomenon in central station practice that many parts of the plant, originally put up as temporary plant, become by their good conduct permanent institutions. This is very much the case with switchboards, where opportunities of reconstruction are rare. Teak—a very slow burning wood—has been used for this purpose. It is oily, and so resists moisture. It should, however, be watched with an anxious eye by the engineer in charge. Asbestos, from some points of view, is better—it will not burn. But it absorbs any moisture it can find, and hence its insulating properties are diminished. If asbestos is used, it should be painted with some insulating varnish to remove this danger. The same remark applies to slate, whose enamel has been damaged by an arc. Precautionary measures of this description are worth any amount of brilliant evolutionary operations with burning switchgear in order to save the lights.

One of the functions of the switchboard is to register the amount of energy generated and distributed. The switchboard attendant is supposed to take a record every quarter or half-hour of his indicating meters, and to register the readings of his integrating meters at the end of his shift. If these meters are out of order, the proceedings become a solemn and arduous farce. The engineer should at least know how to adjust the zero of his indicators, and should do it. He should also check his machine meters against his feeder meters, one voltmeter against another, pretty frequently, and report faulty instruments. He should time his integrating instruments against his ammeters, and make sure there are no shunt current errors, friction losses, and so on.

It is, of course, impossible to enumerate all the points which require supervisory routine. Different types of switchboard develop various tendencies to failure, which have to be particularly watched. It is, however, safe to say that the engineer in charge will find that a conscientious scrutiny of his switchgear from time to time will amply repay him.

A Railroad Operated by Telephone

IN a letter to "The Railway Age," L. L. Featherstone, secretary and superintendent of the Gulf & Interstate Railroad, of Texas, describes the operation of 70 miles of the road by telephone exclusively. "We consider the telephone far superior to the telegraph in handling trains, he says, especially on a short line. In the first place, the employees are directly connected with the business they desire to be informed on, can communicate directly with the party from whom they want advice, and in this way can more thoroughly understand what is required of them than they could if forced to use the telegraph.

Trainmen can all carry a telephone box on their trains and in case of accident they can cut in anywhere on the line and fully report the trouble to those interested. Besides this great advantage, the section men can have a telephone in every section house and receive instructions at any time of the day or night, when, on the other hand, they could not be reached by telegraph possibly for several hours. The cost of maintaining the telephone is nominal, and the cost of the operators in most cases is nothing at all."

Vulcanizing by Electricity

IT is common knowledge, says "The India Rubber Journal," of London, that under certain circumstances the raising of heat by electricity for the vulcanization of rubber can be made as economical, or even more so, than by other means. It is obvious also that this heat is more under control than any other form. On investigation it will be seen that the means by which this heat can be applied are less cumbersome and more adaptable than heating by hot air or steam or water, at least in many cases. The vulcanizers for tire repair work at present in use, while admirable of their type, appear to be inconvenient. The heat required is wanted only at infrequent intervals and for short periods, and as a consequence a large amount of gas is used for very little heat. It is essential also that the portion of the tire heated (other than the repair) should be as small as posible, and this is rather difficult to adjust. In some experiments made with the electric vulcanizer these disadvantages disappeared. The proper temperature was quickly reached, and was maintained with very little variation for almost any length of time. The amount of surface heated could be very easily arranged for, and the whole apparatus took up a very small space. In brief, the method was less expensive, more efficient, much safer, and much quicker than the old.

A Mexican Substitute for Rubber

WRITING under recent date from Durango, Mex., United States Consul Le Roy says:—

It has been known for some years that a shrub called the guayule, which grows on the arid northern plateau of Mexico, gives an extract possessing the appearance and qualities of rubber. Either because sufficient attention has not been drawn to it, or because of failure to find a satisfactory process for extraction, nothing worthy of mention has hitherto been done with this plant, which is found growing particularly in the eastern part of Durango State, along the Mexican International Railroad.

Within the past two years New York rubber manufacturers have developed a process for the utilization of the plant. Under the name of the Anglo-American Company, they have obtained a concession from the State of Coahuila and are about to build a factory for the extraction of rubber from the guayule at Torreon. Plans for the factory are completed, but the contract for its erection has not been awarded. The new Mexican company is understood to be associated with the Continental Rubber Company of New York.

Oil for Transformers and Switches

In "The Electrical Review," of London, E. K. Scott summarizes his observations on the use of oil for transformers and switches in the United States.

It will be remembered, he says, that the early experience with oil transformers in Great Britain was not satisfactory, and possibly this as well as the fact that we do not require transformers of very large size, are reasons why oil is so seldom used.

The oil employed in America appears to be in all cases a special refined mineral oil free from water and acid. Rosin oil, which we have used in England, does not appear to be a familiar term to American engineers, at any rate, those the writer asked had never heard of it.

Presuming the oil to be neutral, water is, of course, the principal drawback, and not only must such oil be specially treated to thoroughly free it from water, but special care must also be taken to see that water does not get in afterwards. Many failures have been traceable to water getting into the barrels during transport, and the only reliable way is to forward the oil in watertight drums.

There are various methods of drying, but perhaps the best one is to place the oil in a large tank having a resistance coil suspended in the center. After the current has heated up the oil, air is blown through it from a motor-driven compressor, the air having been first thoroughly dried by passing it over chloride of lime. As the small bubbles pass upwards through the oil they take up any moisture that may be present. In the case of a very large tank, it is as well to also agitate the oil mechanically, so as to insure all of it coming into contact with air.

After drying, a flashing test is made, and this, of course, varies according to the voltage to be employed. It may be taken, however, that no oil is considered satisfactory which will not withstand at least 30,000 volts alternating between two flat surfaces $1\frac{1}{4}$ inches in diameter and 1-5 inch apart. After passing the test, the sooner the oil is placed in the transformer case the better, and for this reason some power companies dry the oil themselves in the main station or substation, as the case may be.

After the oil is in position trouble is not yet over, for water-cooling coils are necessary to keep the temperature of the oil below 100 degrees C. Such coils are apt to give a good deal of trouble if the water contains any mineral matter, because sediment is deposited on the inside of the piping, and in some cases has to be removed every day or alternate day. This may be effected by blowing air through the coils and so stirring up the deposit that it runs off with the water. Of course, the piping must be arranged for the water to enter and leave at the lowest point, so that everything can be drained away.

In case the water is very bad, an obvious way out of the difficulty is to circulate the oil instead. Thus a small centrifugal pump could force the oil through coils immersed in running water situated outside the transformer case. As natural circulation would do much of the work, quite a small pump would suffice; indeed, one pump could serve several transformers.

It is clear that every care must be taken to keep the temperature of the oil within limits, because if once the flash point is reached, the resulting fire would be disastrous. As a safeguard, many transformers are fitted with a thermostat adjusted to open a closed circuit alarm at 100 degrees C.

Whatever may be the final decision of engineers as to the use of oil in transformers, there seems to be no two opinions as to its being a necessity for extra high tension switches. Practically every station which the members of the Institution of Electrical Engineers saw in the United States and Canada was equipped with such oil switches, and certainly the bricked-in switch-chamber with keyboard pneumatic or electric control does seem to be the latest thing in high-tension switchboard design. Flare switches, so much used on the Continent, are dangerous by comparison, and have the objection of setting up a considerable increase of pressure on the system. Oil on the other hand, shuts down the arc before the pressure has time to rise.

Besides the danger of fire, there is just one other point which may give trouble in countries where cold is extreme; it is that the oil may become thickened. As a cure for this one company recommends mixing tetrachloride of carbon with the oil.

Railroads at High Altitudes

According to "The Railway Age," when the electric railway to the summit of Mont Blanc is completed, that point will be the highest in the world reached by a railway. Its altitude is 15,776 feet. At the present time the highest point is Pike's Peak, 14,147 feet. Next to this come the crossing of the Andes in Peru by the lines from Lima to Oraya, and from Mallendo to Puno, at altitudes slightly less. The highest point in Europe now reached by a railway is the summit of the Gornergrat—10,290 feet—in Switzerland, and there is under construction at the present time in the same country an electric line which will reach the summit of the Jungfrau, at a height of 13,670 feet.

Systems of Charging for Electricity

In a paper on "Methods of Charging for Gas," read by Frank W. Frueauff before the recent annual meeting of the American Gas Light Association, he described several methods of charging for electricity, which were well adapted to charging for gas.

Probably up to ten years ago charging at a uniform rate per kilowatt-hour on a meter basis was considered good practice. Discounts were made for large quantities of consumption, and were considered advisable. Meter charging, however, was unsatisfactory because of meter losses, a minimum charge of $1 or $1.50 to each customer being made, regardless of the number of lamps installed, to offset these losses.

The first radical departure from meter rates came with the introduction of a system proposed by Arthur Wright, of Brighton, England. This system as used in America is as follows: A demand meter is used which registers the maximum demand made on the station during the month. If this demand meter indicates a maximum of twenty lamps, the consumer is charged, say, 20 cents per kilowatt-hour for the consumption of the maximum for the first two hours, or a fractional part, and for any excess current a charge is made at a much lower rate, even as low as 5 cents per kilowatt-hour.

This system, while a step towards greater equity in charging, has the disadvantage that all consumers below a certain time factor of burning pay the same rate per kilowatt-hour, and yet it is evident that the consumer, having a 2-hour maximum demand, can be supplied at a lesser rate than the one having a 1-hour demand. Another inequity is that one consumer's maximum may only average one-half hour per day for eleven months, with a maximum demand for six hours in the twelfth month. He will thus receive a marked discount during this month, although he has not averaged two hours per day consumption for the entire year, while another consumer may average slightly less than two hours per day in every month of the year, and yet the total use of his equipment will exceed the use of the equipment of the other consumer.

In the Kapp system, a meter is required having two dials and a clock. The clock is used to operate mechanism which will put one dial in plane with the meter during given hours of the day, and the other dial the balance of the day, one dial registering all current consumed during the peak period, say from 5 o'clock in the evening to 11 o'clock at night, and the other dial registering the current from 11 o'clock at night until 5 o'clock the following evening. The current registered on the first dial is charged for at the rate of, say, 20 cents per kilowatt-hour, while the current registered on the second dial is charged for at the rate of 5 cents per kilowatt-hour, the idea being to put a premium on daylight or unusual hour consumption.

This system of charging, like the Wright demand system, has the disadvantage of not distinguishing between expenses which are of a general fixed character and those which may be known as "consumer expenses." It is evident that one man having sixty lamps and using, say, 1000 K. W.-hours per year can be taken care of with less expense to the station than two consumers having 30 lamps each and using 500 K. W.-hours each, or a total of 1000 K. W.-hours per year.

In another system, introduced by Henry L. Doherty, four factors of expense are recognized. Broadly, these four factors may be first stated as two factors. The first factor includes those expenses proportional to output and their nature is determined by whether or not they vary in proportion to the output. The second factor embraces the fixed expenses, and, broadly, these expenses do not vary proportionately to output, but vary according to some other factor. These fixed expenses are designated as:—

1. Expenses incidental to each consumer regardless of other expenses, such expenses as the reading of meters, maintaining the meters, collection, office expenses, bill making, etc., being included in this head.

2. Fixed expenses caused by the distance from the station (included here would be the line and pole investment).

3. Fixed expenses caused by maximum demand, being those expenses occasioned by investment for capacity and those which are peculiar to the general operation of an electric light plant.

For reasons of expediency the author excluded the factor of distance from station and based his method on charging of three general factors:

1. Consumer expenses.
2. Capacity expenses or maximum demand and
3. Output expenses.

The consumer expenses consist of the reading and maintaining of meters, the shunt losses of the meters and all other expenses which vary directly with the number of consumers the station must supply. The second factor, "maximum demand," is charged for as a distinct item in addition to the charges made to each consumer, on the theory that this is what fixes the amount of the investment, the amount of the core losses and those other items which are in no way related to the consumer expenses, nor to the output expenses, and yet are directly related to our maximum demand, and to our general expenses. No distinction is made of the time of day his maximum demand is required.

To these two charges a charge is added representing the consumption of current, and this charge covers all items which vary in proportion to consumption, consisting of boiler fuel, boiler room, labor (above a certain minimum), lamp renewals, arc carbons, etc. This charge per kilowatt-hour is very small, and, presumably, for the average consumer, the sum of all the charges will be about equal to the charge that would be made on a meter basis if all current was sold on a meter basis, except that the effect is such that there is a tendency to diminish the expenses to the station per kilowatt-hour sold.

This plan has not generally been adopted, but its announcement had a marked effect on central station business and stopped the spread of other methods. It has caused the central station managers to recognize the nature of their business and the distinction between the different classes of expense and the profitableness of different consumers, and has frequently been used as a means of computing what constitutes just discrimination and also what justifies such discrimination. Instead of bringing about uniform methods of charging as advocated by the writer, it has, perhaps, had a tendency to encourage further discrimination by pointing out the different expenses to the station in supplying different classes of consumers.

Electric Conductivity of the Human Body

INVESTIGATIONS into the electric conductivity of the human body show singular variations in this conductivity due to the psychical or physiological condition of the subject of the experiment. The magnitude of the resistance was found to be sensitively dependent upon the hour of the day, the place of measurement, and even upon the character of the subject's last meal. A noise, or the presence or absence of other persons, has a marked effect. Any internal or external psychical influence will result instantly in an oscillation, often of great magnitude, in the value of the resistance, sometimes reducing it to as little as 20 or 30 per cent. of its normal value. Nervous persons and strong smokers and drinkers were found to have an exceedingly low resistance. The average value found for the resistance, as measured from hand to hand, was about 3000 ohms.

Municipal trading has assumed an important aspect in Sicily. According to a consular report, the town of Palermo some time ago assumed a monopoly of the undertaking business and the cemeteries. Now it bakes its own bread. The bulk of the production is sold direct to the public by the servants of the municipality, but the retail dealers are also disposing of it at a small profit.

A circus now making the circuit of the Pacific Coast has in its equipment two gas-engine-driven alternators, furnishing current for thirty-six 6-glower Nernst lamps used in lighting the tents at night.

A private car on the Lake Shore electric road recently made a fast trip between Toledo and Cleveland, a distance of 111½ miles, the actual running time being two hours and one minute.

Niagara Power

By ALTON D. ADAMS

NIAGARA RIVER develops eight and one-half million continuous horse-power. This rate of work is entirely beyond human conception, but some faint idea of it may be got by reference to the amount of coal that would be consumed to develop energy at the same rate. If 2 pounds of coal were burned per horse-power hour, the weight consumed in that time, to equal the work of Niagara River, would be 8500 tons. Continuous work for one year at this rate would require 74,460,000 tons of coal, or more anthracite than the United States produced in the year 1900, when the entire output was 57,464,235 tons.

In 1902, the total horse-power of steam engines in the electric railway stations of the United States was 1,298,133, and in electric lighting stations, 1,379,941, so that the continuous power of Niagara River is more than three times that of all these engines combined. Allowing for all necessary losses in the development of the power of the river, it is more than sufficient, could it be transmitted, to displace every steam engine in central electric stations and railway plants in the United States to-day.

This prodigious power, except the relatively small amount that is devoted to useful work, is now continuously expended in carving a deep, narrow channel through the strata of rock, about 20 miles wide and more than 300 feet thick, that separate Lakes Erie and Ontario. Already the strong hand of the water, armed with stones and silt, has carved the great canyon of the lower river, about 6 miles long, from Niagara Falls to the foot of the escarpment at Lewiston and Queenston.

In many thousands of years to come, if the work of the river is not interrupted, the 14 miles of canyon that remain to be excavated between Niagara Falls and the foot of Lake Erie will be completed. Then that lake will narrow down to a river and the falls will be transferred to Detroit River.

At present the energy liberated by the falling water, having done its work of excavation on the rock of the river bed, is transformed into heat, and raises the temperature, if ever so little, of the water, the sides of the canyon and the surrounding air.

The foregoing estimate of Niagara power is based on the fall of 327 feet between Lake Erie and Lake Ontario, and on the discharge of 230,000 cubic feet of water per second by the river at the International Bridge, a little below the falls, as determined by the United States engineers for mean Lake Erie level. With these figures and the weight of 62 pounds per cubic foot for water, it appears that the river develops 4,663,020,000 foot-pounds of energy per second in its course of 27 miles between the lakes. This represents a rate of work equal to 8,478,000 horse-power.

Allowing for a loss of 20 per cent. in the friction of river bed, canals and water pipes, 25 per cent. in water-wheels and 16 2-3 per cent. in the combination of electric generating and distributing apparatus and lines, the Niagara River is thus capable of supplying 50 per cent. of all its energy, or 4,478,000 horse-power, for useful work, if its entire fall between Lakes Erie and Ontario is utilized. Of course, such a development would change the great cataract into a dry, perpendicular cliff something more than 160 feet high, and suck the water from the river bed all the way from a point above the highest rapids down to Lewiston: but the thing can be done.

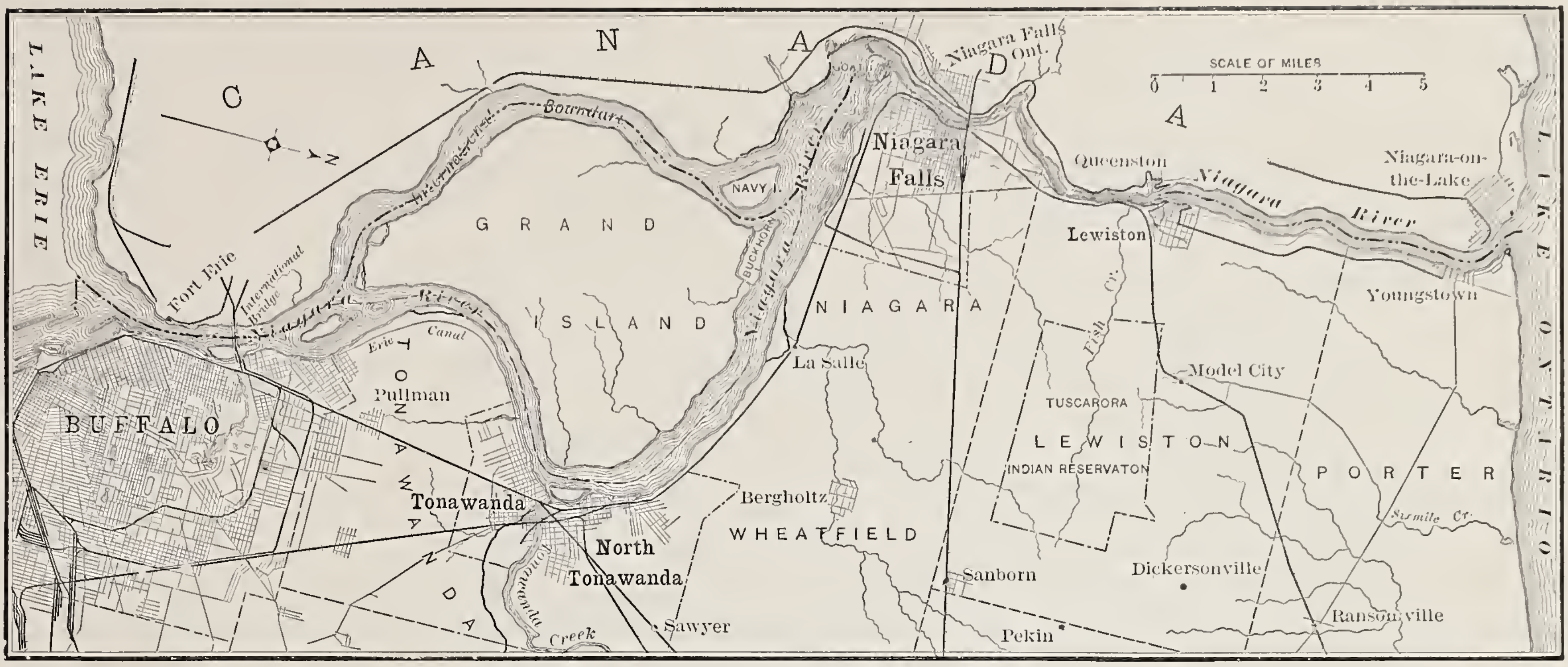
Between the first rapids, about three-fourths of a mile above the great cataract, and the foot of the falls, Niagara River drops about 210 feet. All the power plants now in operation or under construction along the river divert water between the limits just mentioned, and utilize more or less of the 210 feet of available head. This diversion, if carried far enough to suck up the entire 230,000 cubic feet per second discharged by the river, will lay bare the rugged bed of the cascades and also the brink of the main falls.

The total energy developed by the river over this part of its course, on the basis of the head and volume of water just stated, amounts to 2,994 600 foot-pounds per second, or to 5,081,000 horse-power. Allowing a combined efficiency of 50 per cent., as before, which is a little low in view of the short lengths of the canals, tunnels or pipe lines for the development, the entire discharge of the river under the head between the upper rapids and the foot of the great cataract would yield 2,540,000 horse-power for the use of consumers along the Niagara frontier. When, if ever, this development is completed, the great gorge below the falls, with its rapids and whirlpool, will be all that remain of the grandeur of Niagara.

One other alternative remains for the development of a vast, useful power, far beyond that of the present plants along Niagara River. This is the utilization of the entire discharge of the river under the head of more than 90 feet between the foot of the great falls and that of the lower rapids near Lewiston, a distance of about 6 miles. As much as 90 feet of this head results from the fall of the river in about 2 miles of its course from a point a little above the old suspension bridge down to the Devil's Hole, below the Whirlpool. Under this head the 230,000 cubic feet of water per second, discharged by the river, are doing 1,283,400,000 foot-pounds of work in each time unit of that length, equal to 2,515,000 continuous horse-power.

With the efficiency of 50 per cent., before estimated, between the total working rate of the falling water and the electric output that might be developed by it, the discharge of the river past the rapids and Whirlpool in the Niagara gorge would generate 1,257,000 horse-power for the use of consumers. This development would dry up the lower rapids and the Whirlpool, but would not affect the great downpour of water at the main cataract. Nothing has thus far been done in the development of power on the plan just considered, for the reason, no doubt, that it is somewhat cheaper per unit of power developed to divert water a little above and discharge it just below the great falls, and charters authorizing such construction have not been lacking.

Each of the plans just considered for the development of Niagara power has its advantages and disadvantages. Their differences relate to the available heads, to the kinds and lengths of conduits that must be employed to convey the water, and to the effects on the great falls. For the diversion of water from Niagara River in the vicinity of Grand Island and its discharge at the foot of the escarp-



THE COURSE OF NIAGARA RIVER FROM LAKE TO LAKE

ment, or into the gorge of the river near Lewiston, about 7 or 8 miles away, either canals or pipe lines are available, but the former would probably have the preference because of their lower ultimate cost over a long term of years. Tunnels in this case would be too expensive as compared with the other methods.

The distinct advantage of this plan is the great head of water available,—nearly the entire 327 feet between the lake levels. As the power developed increases directly as the effective head of the water, and as this head of 327 feet is nearly twice that afforded by the falls alone, the plan of utilizing the total descent of the river is probably the cheapest to develop per unit of power. Owing to the high value of real estate in the city of Niagara Falls, N. Y., the construction of an open canal around the falls there at this time is impracticable, and future developments at that point must resort to tunnels or pipe lines. On the Canadian bank of the river, the circuit about the falls may be made with one of the three types of water conduit, but either must be materially longer than those on the New York side for any developments, except those now under way there.

In the lower Niagara gorge, with its depth of fully 200 feet before the surface of the river is reached, tunnels through the soft rock seem the only practicable means by which the water can be diverted from its natural channel by way of the rapids and Whirlpool, and then returned to the river above Lewiston. The expense of this plan is only moderate, though somewhat greater than that of either of the others, because the available head is so much less.

The cost of construction for plants that utilize the head of about 210 feet between the upper rapids and the foot of the main falls, including the buildings and equipment necessary to transform the water power into electric energy, varies with the type of water conduit adopted, and with its length. For the plants now in operation, discharging their tail water through a tunnel which, in its main part, is 6890 feet long and about 200 feet below the ground surface in solid rock, the total investment appears to be somewhat less than $150 per electrical horse-power. For the plant that conveys its water through an open canal about three-fourths of a mile in length, the investment seems to be under $100 per electrical horse-power. This development with an open canal in the city of Niagara Falls, N. Y., could hardly be duplicated at the present time, because of the great cost of real estate, if for no other reason. A steel pipe line would no doubt show a lower first cost per horse-power capacity of the plant than does a tunnel through the rock, but this advantage would be offset, in part at least, by the higher rate of depreciation and repairs on the steel pipe.

Though at first sight the constancy of water power at Niagara Falls seems all that could be desired, plants that divert water above and discharge it just below the main cataract are in fact subject to some rather serious fluctuations. One of these is the variable discharge of Niagara River, which sometimes drops from 230,000 cubic feet per second at mean Lake Erie level to as low as 150,000 cubic feet per second.

This variation of discharge is due in part to changes in the water level over the entire surface of Lake Erie, but in a greater degree to the piling up of water at one end or the other of the lake. Changes in the level of Lake Erie, due to the volume of contained water, have a maximum value of about 4 feet over a series of years, though the average annual change is only about 1.5 feet. East or west winds, however, blowing along the lake from end to end, are known to change its level at the head of Niagara River as much as 7 feet either way from the normal.

Even 150,000 cubic feet of water per second are far beyond the requirements of present plants at Niagara Falls, so that there is no actual want of water; but the indirect results are not desirable. Owing to the changes in Lake Erie levels the elevation of Niagara River above the upper rapids varies as much as 7.5 feet, as is shown by records that date back twenty years. This change of river level, of course, affects the rate at which water will enter a given canal or tunnel opening, and such openings must be made large enough to take a sufficient supply at low water. More than this, the change of river level is nearly four times as great below the main falls as it is above the upper rapids, and the result is a marked variation of the available head of water. Thus in a single year the surface of the river at the "Maid of the Mist" landing has varied nearly 28 feet in elevation.

Inspection of the river itself, or of a map, reveals at once the cause for these widely different changes in surface elevations above and below the falls. At Port Day, about a mile above the cataract, the width of Niagara River is approximately 5000 feet, while at the new suspension bridge, where the tunnel of the 105,000-horse-power plants vents, 1000 feet down stream from the end of the American Falls, the width of the river is only about 900 feet, and this width is hardly exceeded, save at the Whirlpool, until Lewiston, about 6 miles down stream, is reached.

Close on each side of this narrow river in the gorge rise perpendicular cliffs, so that any increase in the volume of water must be provided for mainly by a change in surface elevation. Variations of the working head of water equal to the rise and fall of the lower river would materially affect both the speed and power of wheels in an undesirable way.

The 105,000-horse-power plants now in operation on the American side of the river have been so designed that this large fluctuation of head is avoided, but this result has involved a sacrifice of quite a large percentage of the total head between the upper and the lower river.

The water surface in the intake canal of these two plants, which stand on either side of the canal, is fully 216 feet higher than the river level at the vent of the discharge tunnel in the gorge, for mean Lake Erie level. In spite of this total head, the turbine wheels of one of the two plants just named are set with an actual head of only 136 feet, and of the other plant with a head about 10 per cent. greater than this. The entire descent of the main tunnel that conducts the tail water from these plants to the lower river is only about 43 feet, which leaves a margin of about 37 feet in one case and over 20 feet in the other, for changes in the water level below the falls, before the effective heads on the wheels are affected.

Records are not at hand that show the changes of surface elevation along the 6 to 7 miles of river between the falls and Lewiston, but as the width of 900 feet is hardly exceeded over this distance, save at the Whirlpool, and shrinks to not more than 300 feet along the Whirlpool Rapids, the fluctuations of level are probably as great in the lower part of the gorge as they are at the "Maid of the Mist" landing.

It follows that any power development which takes water from the river above the falls and discharges it into the gorge below must encounter the fluctuations of head noted above. If water diverted from the upper river is discharged at Lewiston or below, where the Niagara River widens to more than 2000 feet in its final course to Lake Ontario, the extreme fluctuations of head, incident to the discharge of water into the gorge, may be avoided, but this plan involves the construction of a canal or pipe line 6 to 7 miles long.

With this disadvantage of a long water conduit goes the benefit not only of a nearly constant head, but also of an increase in head amounting to about 90 feet, corresponding to the descent of the river from the foot of the falls to the nearly level stretch that begins at Lewiston. The plan to take water from the river by a tunnel with its head between the foot of the falls and the Whirlpool Rapids, and discharge this water at or below the Devil's Hole, must encounter the large fluctuation of water level in the goige.

Condensers for Steam Turbines

By GEORGE I. ROCKWOOD

A Paper Read at the Recent Annual Meeting of the American Society of Mechanical Engineers

VISITORS to steam turbine power stations generally notice, as a first impression, the relative inconspicuousness of the turbine itself in the midst of its numerous and larger condenser auxiliaries. This prominence of the condenser equipment is especially noticeable in the case of the smaller turbine plants, in which the floor space occupied by the condenser system far exceeds that required by the turbine.

There appear to be three accepted designs for these condenser systems:—First may be mentioned the combination consisting of a surface condenser, a centrifugal hot-well pump, an air cooler, a single-cylinder dry vacuum pump, a centrifugal circulating-water pump, together with their connecting and drip piping and valves. Second, the foregoing arrangement may be varied by omitting the hot-well pump and also the air cooler and dry vacuum pump, substituting the wet vacuum pump—preferably of the Edwards type. The cost per kilowatt is about the same—$7 to $10—for either of these systems. The third system is like the first, except that an elevated jet condenser with barometric tube and hot-well takes the place of the surface condenser and hot-well pump. The advantage of this third type over the surface condenser systems is that it may take up less floor space, while its cost is but $5 to $6 per kilowatt. The dry vacuum pump used with barometric condensers must have a two-cylinder air-pump, and the exhaust steam from the turbine cannot be used again in the boilers.

The whole cost of a condenser system, as intimated in the opening paragraph, is not, however, fully expressed in the contract with the condenser contractor. The turbine room is made a full third larger, and hence more expensive, by the provision of the necessary floor space—space, too, that is needed in the operations of the turbines. The smaller the turbine plant is, the greater this part of the cost becomes relative to that of the whole power plant.

There is, besides, a fourth type of condenser which may be used with steam turbines and to which it is the object of this paper to direct attention, namely, the injector or ejector condenser.

Within the past year, the Atlantic Mills, of Providence, R. I., have installed a 400-K. W. Westinghouse-Parsons turbine. A vacuum of 28 inches to 28½ inches is maintained on this turbine by means of the following condenser system:—The exhaust steam is led through 20 feet of vertical 16-inch cast-iron pipe and three short-turn elbows into a 16-inch Bulkley injector condenser. The level of the ground floor is 34 feet below the condenser bulb, while the turbine lies on a concrete-steel floor, the level of which is 12 feet 6 inches above the ground floor.

The injection water comes 500 feet from the river to the power house, under a slight head—perhaps 3 feet—depending upon the state of the river. A 6-inch belt-driven Lawrence centrifugal pump elevates the water into a vertical tank, 30 inches by 15 feet deep. The level of the water in this tank is maintained by the waste pipe 6 inches below the water inlet nozzle on the condenser. From near the bottom of this vertical tank a 7-inch injection pipe rises up to the condenser.

A good deal of air is pumped with the water into the top of the tank by the centrifugal pump, but apparently the depth of the tank acts efficiently as an air separator, and no air in the form of bubbles passes over into the condenser. At any rate, the vacuum shown by the mercury column is 28½ inches. The remarkable thing is that this is so, as nearly as the height of a mercury column can be measured, whether the column be attached to the bulb of the condenser or to the exhaust chest of the turbine.

To prove this absence of friction in the exhaust pipe a ¼-inch pipe was connected to the elbow above the condenser, then led down and attached to the turbine exhaust chamber. A branch horizontal pipe leads off to a mercury column. Two valves, one above and one below this horizontal pipe, enable either connection to be made at will. Starting with both valves open and the mercury quiescent, it was impossible to perceive any movement of the mercury, either up or down, after shutting either valve.

Not only is a 16-inch exhaust pipe thus proved more than ample in size for a 400-K. W. turbine, but the vacuum obtainable with this condenser is substantially the same, whether steam is passing through the turbine or not. The falling of the water through the "throat" is the air pump, and is the only air pump needed. The builders provided a 20-inch exhaust nozzle on the turbine, but Mr. Bulkley, the builder of the condenser, believes that, on the contrary, a 14-inch condenser would do as well as a 16-inch.

It may be of interest to relate here a rather unusual experience, encountered when this 16-inch condenser was first put into service.

It was convenient to have the injection pipe rise on that side of the 16-inch exhaust pipe farthest from the condenser. At the top a 45-degree bend connected to a long-radius elbow enabled the pipe to turn and pass the exhaust pipe, approaching the condenser horizontally instead of vertically as in the usual case. Upon starting up the turbine only 22 inches of vacuum could be obtained. The piping was, nevertheless, proved to be absolutely tight. After shutting the injection valve Saturday afternoon with the turbine blanked off at its nozzle, and with 22 inches vacuum on the exhaust pipe and condenser, we found 12 inches vacuum still left on the system Monday morning before removing the blank flange in preparation for starting. Still, only 22 inches were the maximum height of the mercury column while running.

Finally, at the suggestion of Mr. Bulkley to the effect that in his experience he had found it necessary to have the injection pipe to his condensers approach the condenser vertically rather than horizontally for the best results (although he had no explanation satisfactory to himself why this was so), a rearrangement of the injection piping was made permitting this vertical approach. At once, upon starting up the turbine, the result was $28\frac{1}{2}$ inches of vacuum, and this has been maintained without interruption since. With the present load—about 300 K. W. to 350 K. W.—the 7-inch injection valve is open only a few turns, the temperature of the hot-well is from 80 degrees to 90 degrees, and enough water can be passed through this condenser to maintain the vacuum in summer weather. The highest degree of vacuum thus far recorded, as measured in the turbine exhaust chamber, is $28\frac{3}{4}$ inches, the lowest $27\frac{1}{2}$ inches. The variation is caused partly by changes in the barometer, but more by variable leakages in drip-valve seats. Perhaps also the amount of air entrained by the injection water varies from time to time.

If water is not to be had in abundance, then the best way is to have two pumps, one of which returns to the condenser the water taken from the hot-well. In this way the highest theoretical temperature of the hot-well water may be reached. It takes 10 H. P. to supply water by means of the centrifugal pump in sufficient quantity to condense 400 K. W. of steam.

The method of sealing the spindle of the Parsons turbine against air leak where it passes out to its journals from the low-pressure chambers, namely, by pumping water with centrifugal pumps formed in small recesses in the shaft cover, so as to keep a water pressure in these recesses in excess of that of the atmosphere, is a perfect success, as the experience with this condenser shows, although when but 22 inches could be obtained, owing to the fault in the injection pipe design described, the efficacy of these air seals was very seriously doubted.

It is interesting to note our experience that no drip pipe or drip pump, for removing the water of condensation or the leakage into the exhaust chamber from these air seals, is found to be necessary or desirable. It is, indeed, necessary to exclude any accumulation of water in the exhaust pipe for fear that it will sway back and forth until it flushes up on to the large low-pressure blades of the turbine. Running as they do at a very high velocity, sudden contact with water from the exhaust pipe will strip the last row off clean if such contact is permitted. Any further damage, however, to the other rotating blades seems to be prevented by the presence of the fixed row, which, by dividing up the water into small streams, seems to protect the moving rows from contact with solid water and therefore from injury.

The rate of accumulation of water leaking by the small centrifugal air-seal pumps into the exhaust pipe may be any amount up to over 950 pounds per hour. If, however, there is the least external load on the turbine, the flow of the steam up the exhaust pipe has the power to sweep the exhaust chamber dry. The method of starting the turbine at the Atlantic Mills is to first turn on the injection water, and then admit steam to the turbine without admitting water to the air seals. After the load begins to come on, as shown by the ampere meter, the drip-pipe from the exhaust chamber to the atmosphere, which has been open all night and up to this point, is now closed, the water turned on to the air seals, and the vacuum immediately draws down to 28 inches. It is not found absolutely necessary to start in this way, as the turbine can be run hours before the water accumulates in quantity. The object is simply to drain the turbine up to the moment when the load begins to come on.

If the load is a "jumping" one, from nothing to full load, there is no danger of water accumulation. It is, of course, quite possible to provide a drain receiver and pump which will work under the vacuum if it is deemed desirable to do it. There is no exhaust steam "entrainer," or water trap or seal provided at the Atlantic Mills turbine.

The injector condenser costs, fully installed, with centrifugal circulating water pump, tank piping and valves, from $2 to $2.50 per K. W. This cost is much reduced if there is a natural head of water available. At the installation described the condenser, two elbows, one tee, 18 feet of cast-iron exhaust pipe and a 14-inch automatic relief valve cost, erected, $591.50. The room it occupies is practically nothing.

Theoretically considered, in its relation to turbines, the injector condenser would seem to bar out all other condenser systems in those situations where the water used in the boilers is pure in its natural state. Where it is absolutely essential to save the water of condensation for re-use as boiler feed-water, then it pays to use one of the surface condenser systems, owing to the presence of salt, sulphate of lime, wool grease, acid from steel works, or other hurtful pollution. If the city water is pure and costs about 7 cents per 1000 gallons, water enough for a 400-K. W. machine at 100 per cent. load factor would cost per factory year of 310 days, 10 hours a day, at 1000 gallons per hour, about $217. With interest at 5 per cent. and fixed charges at 8 per cent., this sum warrants a capital expenditure not exceeding $1670. It is thus clear that it does not pay to buy the surface condenser system simply to save the cost of paying city rates for boiler feed-water.

Much talk has been made about the freedom of the condensed exhaust steam in turbines from cylinder oil, and the advantage which this purity gives to it as compared with the oily exhaust from reciprocating engines, where the condensed steam is returned to the boilers. It should not be forgotten that great purity of feed-water is not in itself a desirable thing, being only better than very impure water; for it pits the tubes and water-legs of steel boilers unless some lime is added.

Where the waste injection water from a jet condenser is used for washing in a dye-house, this freedom from oil is of great advantage. Such is the aversion of dyers to using exhaust steam to heat water on account of the supposed presence of cylinder oil, no matter how careful one may be to provide and operate oil eliminators successfully, that this freedom of the turbine from the use of cylinder oil is sufficient cause to determine the purchase of turbines in place of engines for power in such places.

The Atlantic Mills turbine is, so far as the writer knows, the only instance on record of the use of injector condensers for large turbines either of the Parsons or Curtis type.

An Instrument for Measuring Telephone Currents

By FREDERICK G. FASSETT

As the result of long study and experiment, an instrument was recently perfected to measure electric telephone currents. The mere statement of the fact does not greatly impress the layman, but, when he learns that this new device must be nearly as delicate as that which records the degree of heat thrown upon the earth by a star millions of miles distant, there comes to him a new appreciation of the wonders of the telephone which stands upon his office desk and which he uses a score of times in the course of the day.

When a man in New York, for example, talks over the wires to a friend in Chicago, 1000 miles away, the current at the farther end of the line is so minute that, until within the past few months, it has been impossible to measure it. Suppose the New York man is telephoning in the evening, perhaps reading a memorandum by the light of an incandescent lamp. It might very naturally be supposed that the electrical energy which reproduced his words was greater than that which caused his lamp to glow, but, as a matter of fact, the energy in a 16-candle-power incandescent lamp is five million times that in a telephone receiver at the end of a line 1000 miles in length.

The heat in the star ray has come millions of miles and spent many years upon its journey. To detect it requires apparatus as delicate as any known to the scientist, an instrument so sensitive that it responds to a change in temperature equivalent to one hundred-thousandth part of a degree Fahrenheit. When means were sought to measure the telephone current on a long-distance line it was necessary to make a device on the model of this wonderful astronomical appliance.

Samuel Pierpont Langley, secretary of the Smithsonian Institution at Washington, D. C., invented the bolometer,—the device which measures the heat in the rays of a star. In this instrument, under the action of light rays, a strip of platinum varies its resistance to an electrical current flowing through it, this variation being recorded by a delicate registering device.

The minute current in a telephone circuit is made to reveal its presence by the barretter, an instrument similar in its delicacy to the bolometer. In the barretter the current flows through a wire one ten-thousandth of an inch in diameter. Few people have seen a wire of that size. It is so fine that it can be detected by the eye only with great effort and when it is held where a strong light falls upon it. Such a wire is many times less in diameter than the finest hair. Compared to it, the filmy meshes of a spider's web are as a ship's cables to the wires which connect wheelhouse and engine room.

The production of such a thread of platinum, the material employed, is an interesting process. First there is taken a silver wire which is bored through from end to end, thus being transformed into a tube. A bit of platinum is inserted as a core, of a diameter small enough to excite the wonder of the man not familiar with the possibilities of wire drawing. Then the silver strand is drawn out until its length has been increased many times. Inside this wire of silver is the thread of platinum which, because it was finer to begin with, has undergone a decrease in size relatively much greater than that caused by the elongation of the silver.

Now comes one of the most interesting parts of the process. The platinum must be released from the grasp of its coating of silver. This is done by placing the wire in a little contrivance, the operation of which causes a portion of the silver coating to come in contact with an acid, which eats or etches away the silver, leaving the platinum exposed. Held in a strong light it may be made out as a faint line between two bits of silver. It is then enclosed in a small glass bulb, from which the ends of the silver wire project in order that they may be brought in contact with the wires in the telephone circuit. The wire in the barretter, because of its great attenuation, will become appreciably heated by the telephone circuit. In an ordinary wire no increase of heat can be detected when such a minute current flows over it, but the barretter responds to even the slightest impulses known to the electrician.

A milliammeter is used in connection with the instrument and, in practice, a small generator supplies the current on the lines to be tested, the generator taking the place of the transmitter and the barretter acting as the receiver. The milliammeter, placed in circuit with the barretter and a battery, is so regulated that the needle on the dial assumes a definitely determined position until subjected to the action of the alternating telephone current. As this passes through the barretter it varies the battery current, deflecting the needle on the dial. The extent of this deflection indicates the strength of the telephone current. So then, to determine whether a line is in good working order, it is only necessary to note the movement of the hand on the dial.

The investigations which have resulted in the construction of the barretter and its application to the needs of the telephone companies were conducted by Prof. Arthur E. Kennelly, of Harvard University, in conjunction with the engineers of the American Telephone & Telegraph Company. Students in the scientific department of the university assisted in the solution of many of the intricate problems involved and the elaborate mathematical calculations which these necessitated.

Telephone men have long felt the need of such an instrument as this. When trouble exists on a telegraph line, additional current may be supplied and the difficulty is often overcome in this way. But with the art in its present stage of development, such a course is not possible in telephoning. That there may be no serious loss, the lines must be kept free from obstructions. A small boy's kite string, when it breaks and falls in tangled loops over telegraph wires causes no trouble. When it falls upon a telephone line it at once makes its presence felt. In a telephone line 1000 miles in length there are about 40,000 poles. A broken insulator on any one of these may be sufficient to throw a circuit out of working order.

Before the invention of the barretter, the testing of a telephone line required the services of trained electricians. In ordinary practice, it has been necessary to rely largely upon the judgment of the operators who talk over the lines while making connections. The operation of the barretter and its connected appliances is so simple that technical knowledge on the part of those who manipulate it is not necessary. If the needle on the dial assumes certain positions, it shows that the circuit which is being tested is in good condition. If the needle takes other positions, it indicates that the circuit is not in proper working order and another must be selected. For ordinary use, the barretter will be made in such shape that it may readily serve to test a line in but a few moments.

If trouble exists on a line the barretter will make the fact known, but it will not locate the difficulty. That must be done by trying the sections of the line between the many testing stations. Wherever the long-distance lines extend, these stations are placed at intervals of 40 or 50 miles, and when a line is not working well, the trouble is located between two of the stations, and an examination of that portion of the line is then made by the repair men, who rejoice in the picturesque title of "trouble shooters."

The necessity which led to the invention of the barretter is an indication of the many difficulties which telephone engineers encounter in their efforts to improve the service. Dealing with currents so weak that they escape detection by the ordinary measuring devices, the men who have developed telephone apparatus have, nevertheless, been able to so perfect it that distinct transmission of speech is obtained over distances which 25 years ago would have seemed incredible.

The deepest oil or gas well in the United States is said to be 5575 feet deep. To a depth of 40 feet a 10-inch casing was used; thence to 360 feet it was $8\frac{1}{4}$-inch; to 1320 feet, $6\frac{1}{4}$-inch, and thence to the bottom is a $6\frac{1}{4}$-inch hole. At a depth of 525 feet the temperature is 57 degrees F.; at 2250 feet it is 64 degrees; at 2400 feet, 78 degrees; at 5000 feet, 120 degrees, and at 5380 feet, 127 degrees; the increase being at the average rate of about 1 degree F. for every 70 feet.

The South African Electrical Industry

THERE can be no doubt, says "The Electrical Review," of London, that South Africa is well to the fore from an electrical point of view and, being largely composed of young colonies, there are wide fields for development. Towns with populations of 1000 and upwards, scarcely heard of before the late Boer war, are now opening works or have granted concessions for electricity undertakings. With the mushroom-like growth of many of the towns, the list of works will doubtless grow rapidly, especially when there is such a free field, for gas works are confined to four towns, viz., Cape Town, Port Elizabeth, Grahamstown and Johannesburg; and there are no such restrictive regulations in force as there are in England.

In the matter of low-pressure distribution, very free use is made of overhead mains, a condition of things which enables the smallest towns to adopt an electricity supply, and the larger towns to supply their suburbs at a minimum of expenditure, while the towns proper in the latter cases are generally supplied by underground cables.

The industries of South Africa, apart from mining, are of a very limited nature, and until the labor question has been settled and more confidence is shown, new industries are not likely to go ahead, and consequently electrical projects are withheld.

In regard to electrical work other than town lighting, the harbor authorities at the various ports are in keen competition with each other to secure the handling of goods for the up-country districts, and large developments are either in hand or contemplated. Delagoa Bay is a keen competitor with Durban, and has taken the lead in the matter of electric cranes and transporters. At Natal the installation of electric cranes is being considered by the Harbor Board, and a new electric power station is to replace the old one, and at East London also electric cranes are to be installed.

The railways of South Africa are also not behind-hand in the matter of electricity, most of the main line trains being so lighted, and the majority of the works along the line have generating stations in connection therewith. The electrification of the railway is as yet a suggestion; the first section to be so equipped is most likely the new line recently laid down, running the length of the Witwatersrand Reef. Further north to the Zambesi there are immense possibilities for electricity works, and engineers are now examining the territory. This district is, perhaps, the only one where water-power may be utilized on a large scale, because of the South African rivers suffering generally from long seasons of drought.

With the development of the mining industry of the Rand and Rhodesia, large demands for machinery are expected, the present tendency being to centralize the electric generating stations in the place of many small and scattered plants.

Electric haulage has not as yet been put into use on anything like a large scale, but on the deep level mines one is certain to find a field for development. The applications to pumping and coal-cutting are becoming very popular, and manufacturers will do well to follow up these matters. The air drill still holds sway, in spite of the great inefficiency of transmission from the compressors.

The telegraph and telephone industry is very active just now, many new lines being in hand throughout the territories recently annexed, and the telephone systems of the older towns are being remodelled on the latest ideas. Trunk lines are being run which will put Johannesburg in connection with the coast towns and others en route.

Governmental Control of Wireless Telegraphy

THE board appointed by President Roosevelt, consisting of representatives from the several departments, which has considered the question of wireless telegraphy being placed under governmental control, has recommended that the Department of Commerce and Labor issue licenses for space-telegraph marine stations in special cases, under such regulations as will prevent interference with stations necessary to the national defense. It has also recommended that all private stations in the interior of the country be under the supervision of the Department of Commerce and Labor. To prevent the control of wireless telegraphy by monopolies or trusts, the board deems it essential that any legislation on this subject should place the supervision of it in the Department of Commerce and Labor.

The city of Dresden, Germany, has now four systems of electric traction—overhead trolley, conduit, accumulator and surface contact.

Three-Phase 40,000-Volt Power Transmission

From Gromo to Nembro, Italy

By L. RAMAKERS

THE Serio, a swift-flowing mountain stream having its origin in the Alps, north of the industrial town of Bergamo, in Lombardia, Italy, was found to be capable of developing 4000 H. P. Of this amount, 2000 H. P. were available at Gromo, and the remaining 2000 H. P. at a point higher up the stream. At present this river has been utilized only at Gromo.

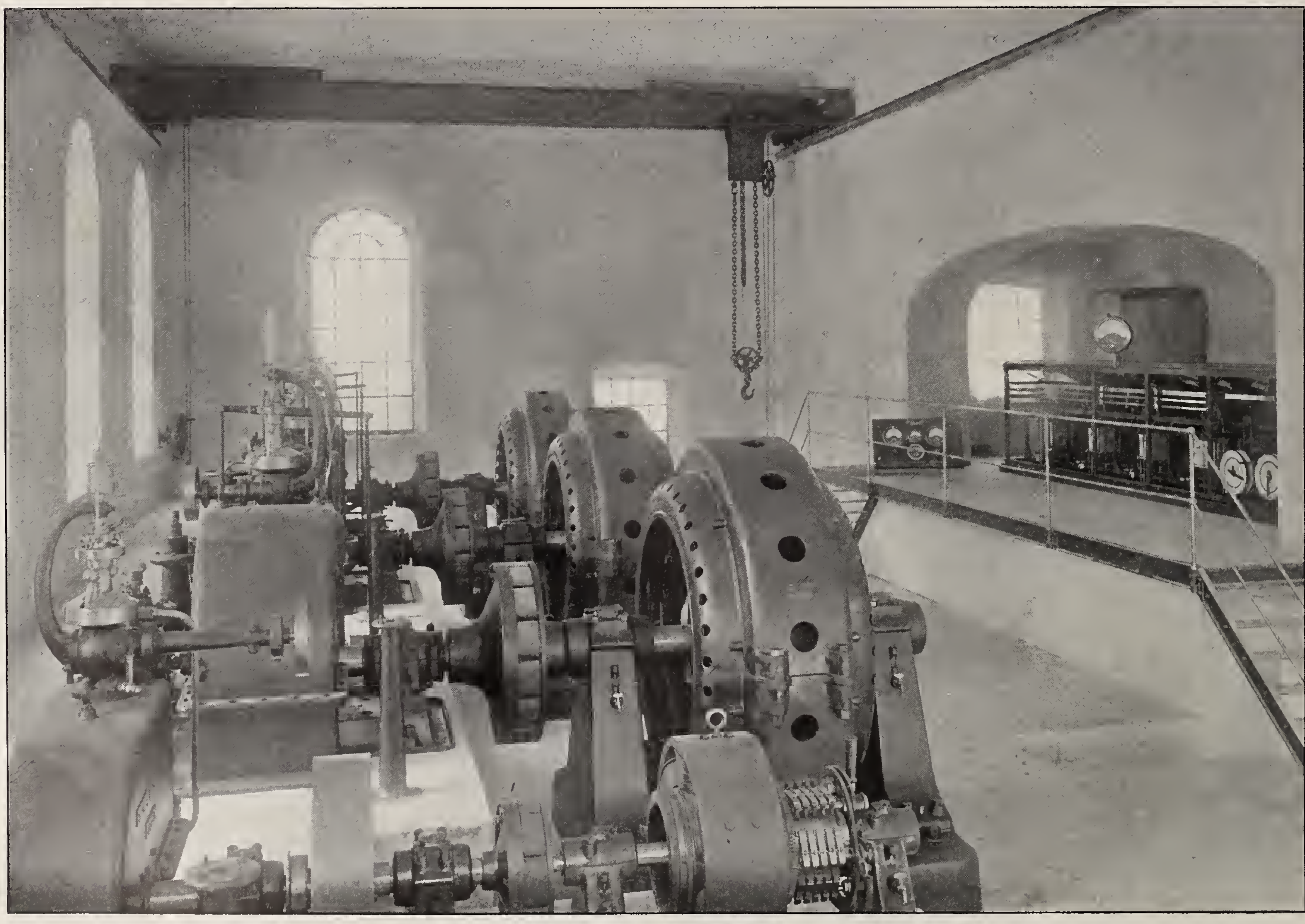
The problem which had to be solved by the engineers was as follows:—Given 2000 H. P. at Gromo, to convert this into electrical energy and transmit it by means of one or two three-phase overhead lines to Nembro, a small town about 21 miles distant, for the purpose of operating spinning mills. For a time but one three-phase line shall be needed, although a possibility exists that a second line will afterward be installed for carrying the energy to a greater distance. Provision must therefore be made for ultimately supporting this second line on the same poles used for the first line. It is important that the loss in the line be a minimum, although it is equally essential that the prime cost of the installation be kept low. Furthermore, the design of the entire plant must be such as to afford simplicity of operation and insure a safe working of the system.

These were the conditions which had to be fulfilled, and the carrying out of the scheme was entrusted to the well-known firm of Messrs. Brown, Boveri & Co., of Baden, Switzerland.

The central station has been built in the valley, a few minutes' walk from the village and at the foot of the mountain on whose face the top part of the penstock was laid. The lower portion of the pipe line, extending up to the power house, has been placed underground.

In the power house three generators of 1000 H. P. each, direct-coupled to Escher-Wyss turbines, were placed in a row. Behind the generating sets two exciters, also directly driven by water wheels, and each having a capacity of 25 K. W., have been put down. The third generating set has been provided as a reserve in case of a breakdown.

Each generator is connected directly to the primary of a step-up transformer; that is, without any instruments intervening. The current leaves the secondary terminals of the trans-



THE GENERATING PLANT AND SWITCHBOARD GALLERY

A PORTION OF THE TRANSMISSION LINE

THE SUB-STATION AT NEMBRO

former at a pressure of 40,000 volts, and is then led to the high-pressure bus-bars, in order to permit of parallel operation with the other units. The switches necessary for effecting parallel operation are thus situated in the 40-000-volt transformer circuit. The turbine, generator and transformer really form one unit.

By eliminating the bus-bars between generators and transformers, the number of controlling and measuring devices is practically halved. The current and pressure transformers for the ammeters, voltmeters and the overload relays of the automatic switches are energized from the low-pressure circuit; that is, from the 4000-volt side. Since the ratio in each of the transformers is 1 to 10, it follows that the ammeters and voltmeters indicate simultaneously the current, pressure and phase difference of both the 4000-volt and the 40,000-volt circuits.

The generators are of the standard horizontal shaft type, with stationary star-connected armatures and revolving-field magnets. Each machine has a rated capacity of 1000 H. P. at a pressure of 4000 volts, and a power factor of 0.08. Each of the machines has 12 poles and runs at a speed of 500 revolutions per minute, which corresponds to a frequency of 50 cycles per second. The guaranteed efficiency, including excitation losses, is 93 per cent. at full load and 89.5 per cent. at half load. The drop of voltage from no load to full load was found to be 7 per cent. on a power factor of unity, and 20 per cent. on a power factor of 0.80. The magnet-wheel, poles and pole shoes form one steel casting.

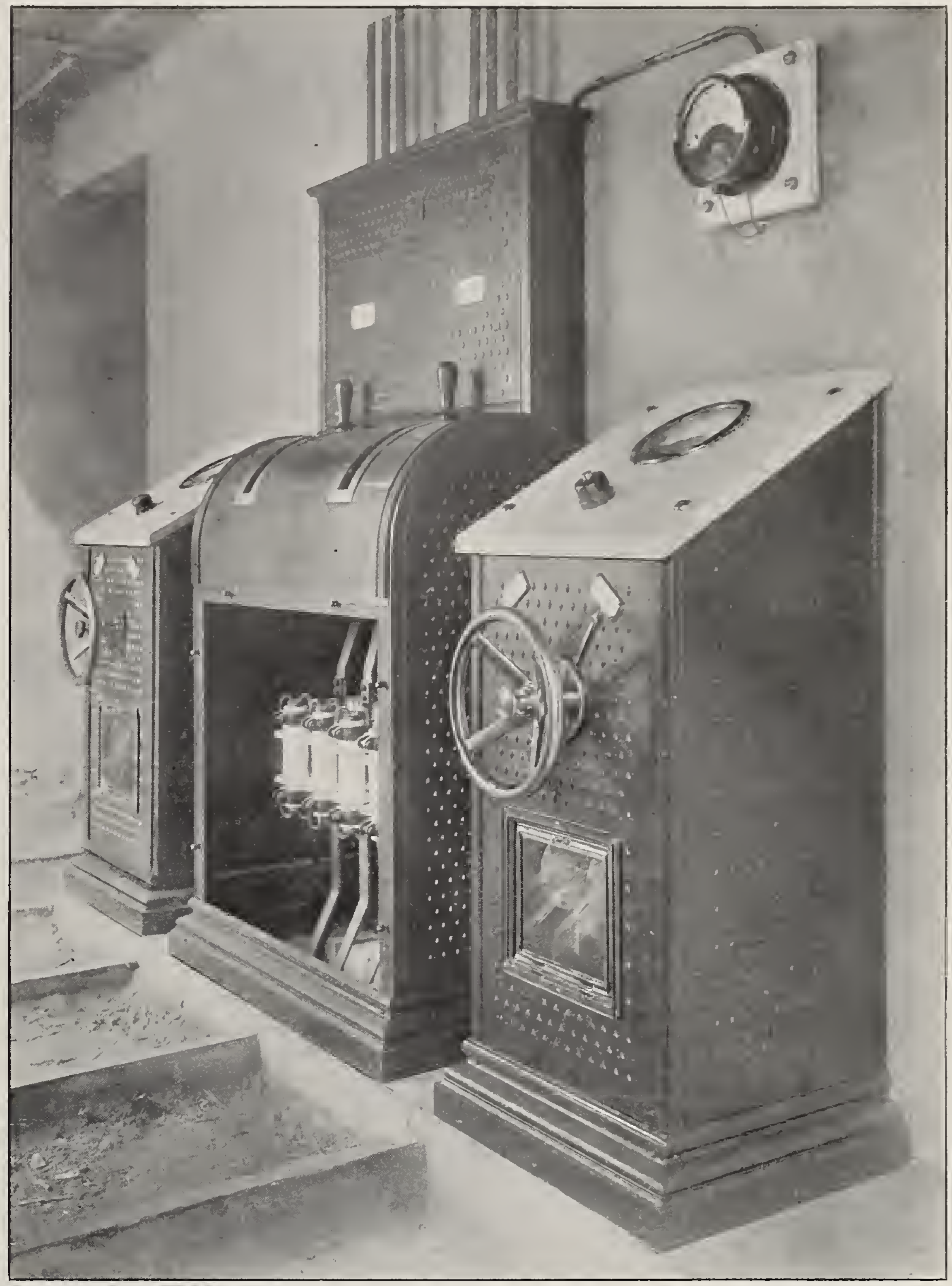
Each exciter is capable of developing 25 K. W., 217 amperes at 115 volts, when running at a speed of 800 revolutions per minute. Each of these dynamos has 6 poles, which are built up of soft-iron laminations. The dynamo frames are constructed of the best cast-steel. The armatures are each of the slotted drum type. The guaranteed efficiency for each of these sets was 89 per cent. at full load and 87.5 per cent. at half load.

Each transformer is designed to give an output of 850 kilovolt-amperes when working on a 50-cycle circuit. The ratio of transformation, as already mentioned, is 4000 to 40,000, or 1 to 10. The efficiency obtained on a non-inductive load was 97.8 per cent., 97 per cent. being the guaranteed figure. The inherent regulation, that is, the drop of voltage from no load to full load, on a non-inductive load was 0.76 per cent., and with a power factor of 0.7 it was 2.6 per cent. These transformers withstood a flash test of 67,000 volts applied between primary and secondary windings. The over-all dimensions of each of the transformers are as follows:—length, 63 inches; breadth, 53½ inches; height, 85 13-16 inches.

The transformers are of the oil-insulated and water-cooled type. Each transformer consists of three vertical limbs placed in the same plane, and held firmly together at both extremities by means of soft-iron yokes. The primary and secondary windings are wound in the shape of concentric cylinders, and are separated from each other by means of a strong insulating partition. To remove as far as possible the danger of a breakdown, the high-pressure coil is wound in sections. Each subdivision has a potential difference of only 300 volts between its terminals.

The switch gear, which is of the utmost importance in installations such as the one here considered, is erected, together with the transformers, in a special building adjoining the generator room. This building consists of a basement and three stories, each of the latter having a floor space of 754 square feet. The basement is divided into two compartments, one of which is situated 3 feet 9 inches below the generator room floor level, and contains the regulating resistances and framework for the 4000-volt apparatus, while the other compartment is situated 8 feet 10 inches above the generator room floor and holds the transformers. The leads from the generator room reach the first compartment through a wide trench under the generator room floor.

The first floor is also divided into two rooms, one of which gives access to the generator room, forming a kind of gallery from which the whole installation may be overlooked. This



THE SWITCH GEAR IN THE SUB-STATION

compartment contains the main operating board, on which are mounted the switch hand wheels and measuring instruments. In the second room are located the high-pressure automatic switches and the three current transformers for the outgoing feeder.

The 4000-volt conductors, the exciting leads for the generators and the exciter leads themselves are all placed in one common trench under the generator room floor, leading into the basement. The second floor is entirely taken up by the bus-bars, and by the pressure transformers connected with them. The third floor has been reserved for the lightning arresters and the leading-out arrangements of the line.

Each generator is provided with a framework, on which are mounted three high-pressure single-pole removable tube type fuses with blow-out horn, one pressure transformer with fuses, and two current transformers. The framework is a riveted structure made completely of iron, the sides being covered with embossed sheeting. At the front, removable shields have been provided in order to permit renewal of the fuses, or their inspection when necessary. The leads enter the transformer room through thick glass

ANOTHER VIEW ALONG THE TRANSMISSION LINE tubes cemented into the dividing wall.

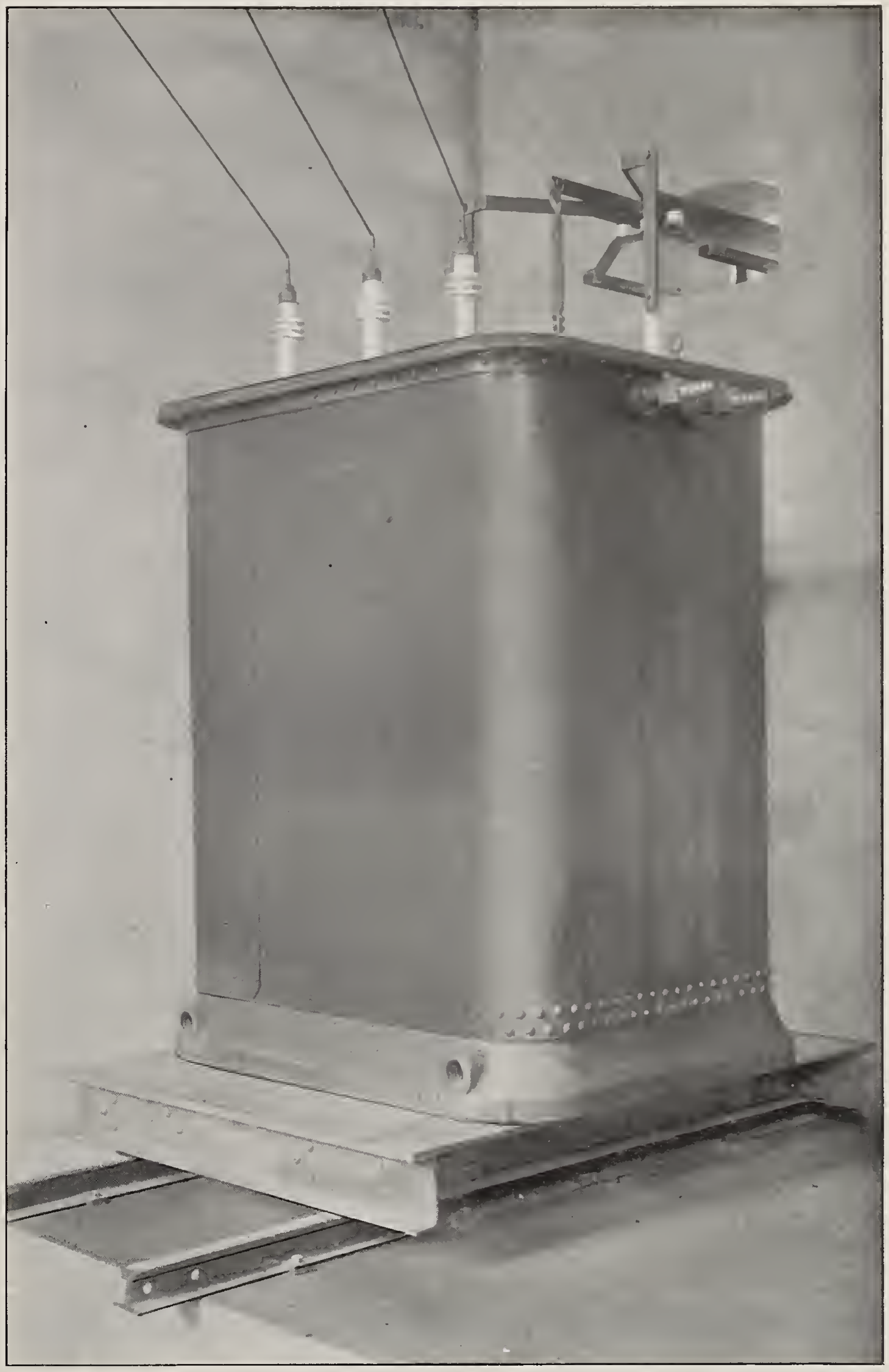
In laying out the 40,000-volt apparatus, the extra high-pressure bus-bars were taken as the starting point. In order to exclude all possibility of arcs being formed between bars of different polarities, each phase was enclosed in a separate cell made of incombustible material. Each insulator consists of three parts, glazed separately and baked together; on the main body of the insulator are four deep grooves.

Immediately below the high-pressure bus-bars on the first floor, the high-pressure oil switches are located. To avoid the use of heavy apparatus, each phase has been equipped with a separate switch. The three switches are, however, operated simultaneously. A similar structure was adopted for carrying the switches as for the bus-bars, and each switch is separated from its neighbor by a wall 4¾ inches in thickness. The brackets and supports for the switches are cemented into the wall. In this way each switch is in a fireproof cell 23¾ inches wide. Through an aperture at the top the connections pass from the switches to the bus-bars. Removable disconnectors have also been provided; these permit one to isolate any of the cells when they have to be switched out of circuit to be cleaned or inspected. The disconnectors are composed of copper strips with stop split-pins. These strips fit into two contacts mounted on porcelain insulators, and are handled by means of a wooden rod provided with an insulator at its extremity. To further safeguard the attendant, the bush by means of which the insulator is fastened on the stick, is earthed through a little metal chain; this enables the attendant to operate the disconnectors, when the switches are open, without running any personal risk.

The switch is operated from a distance by means of the hand-wheel on the main board, and is actuated by a rotary motion, which is probably the most suitable mechanical movement for appliances of this kind, a great advantage being that one is not tied down to a particular spot in operating the switch, for, by means of a counter-shaft, the apparatus can be controlled at almost any distance.

The switches are of the multiple-break type. Both the moving and stationary contacts, as well as the mechanism, are immersed in an oil bath. All current-carrying parts have been solidly constructed and are of ample cross section. To avoid fusing of the main contacts, small auxiliary contacts have been provided, which latter carry the current at the moment of breaking the circuit. To make sure that the arc produced when breaking the circuit is quickly destroyed, the contacts have been formed in such a way that, at the moment of rupture, a volume of oil is forcibly thrown against them. In order to weaken the destructive effect of the arc, the circuit is simultaneously broken in six places.

If the switch is operated by hand, and by mistake the crank is turned past the dead point, the switch will, nevertheless, remain closed. When the switch is worked automatically, however, the crank never quite reaches the dead point, but is kept in position by means of a pawl and a



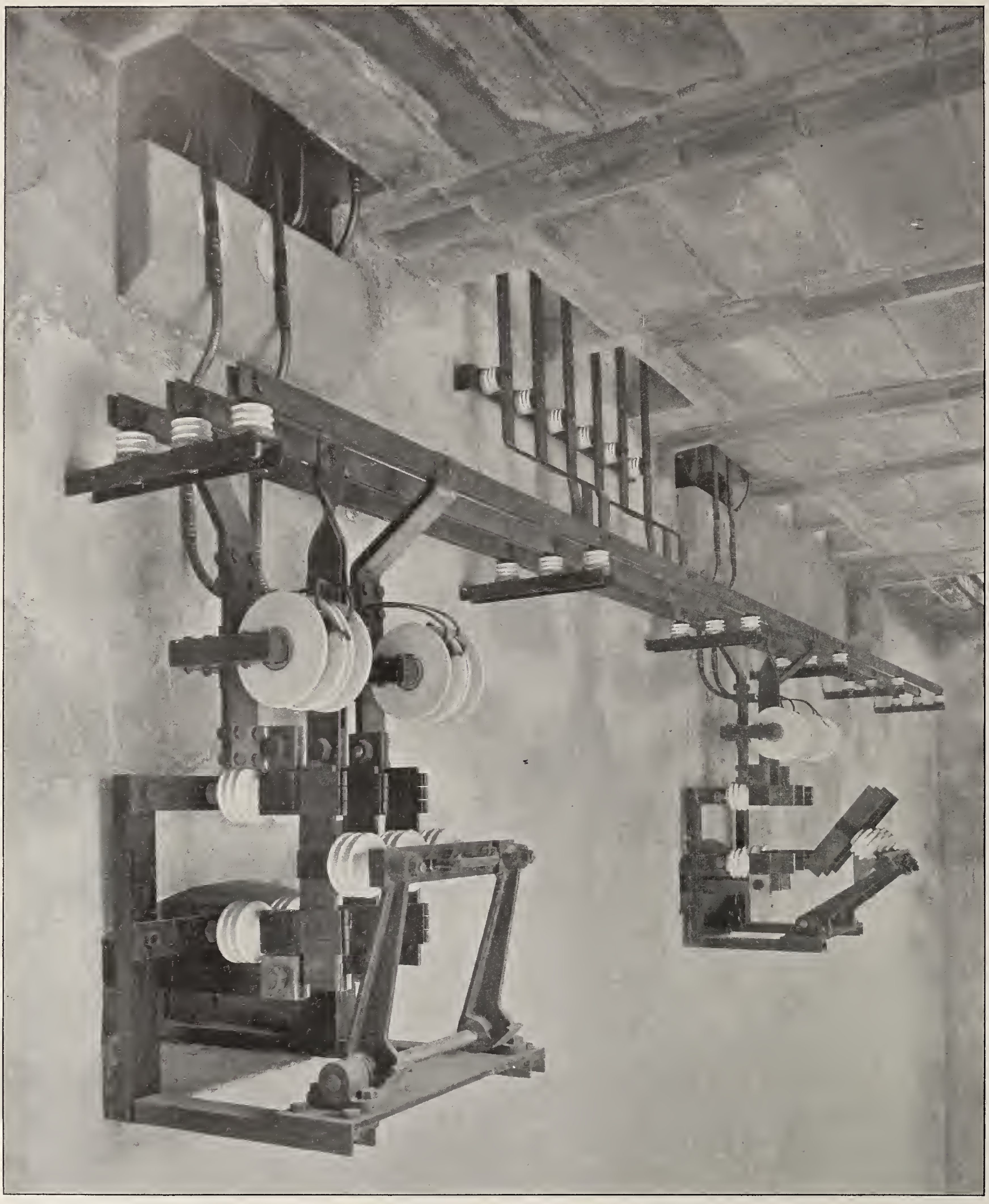
ONE OF THE 500-K. W. TRANSFORMERS

By this method the moving contacts need travel but a short distance.

On turning the switch hand-wheel, the rotary movement is transmitted to the switch spindle, and this, in turn, actuates a crank. The latter moves the contacts and thus closes the circuit, at the same time applying tension to the springs fixed around the guides.

cam-wheel. As soon as the pawl is lifted the springs of the switch pull the contacts apart.

In order to refreshen the memory of the attendant, an inscription "wheel to be turned back" appears as soon as the switch is closed. Should the operator, in spite of this reminder, still forget to return the hand-wheel to its



THE LOW-PRESSURE BUS BARS AND DISCONNECTING GEAR

THE MAIN OPERATING BOARD

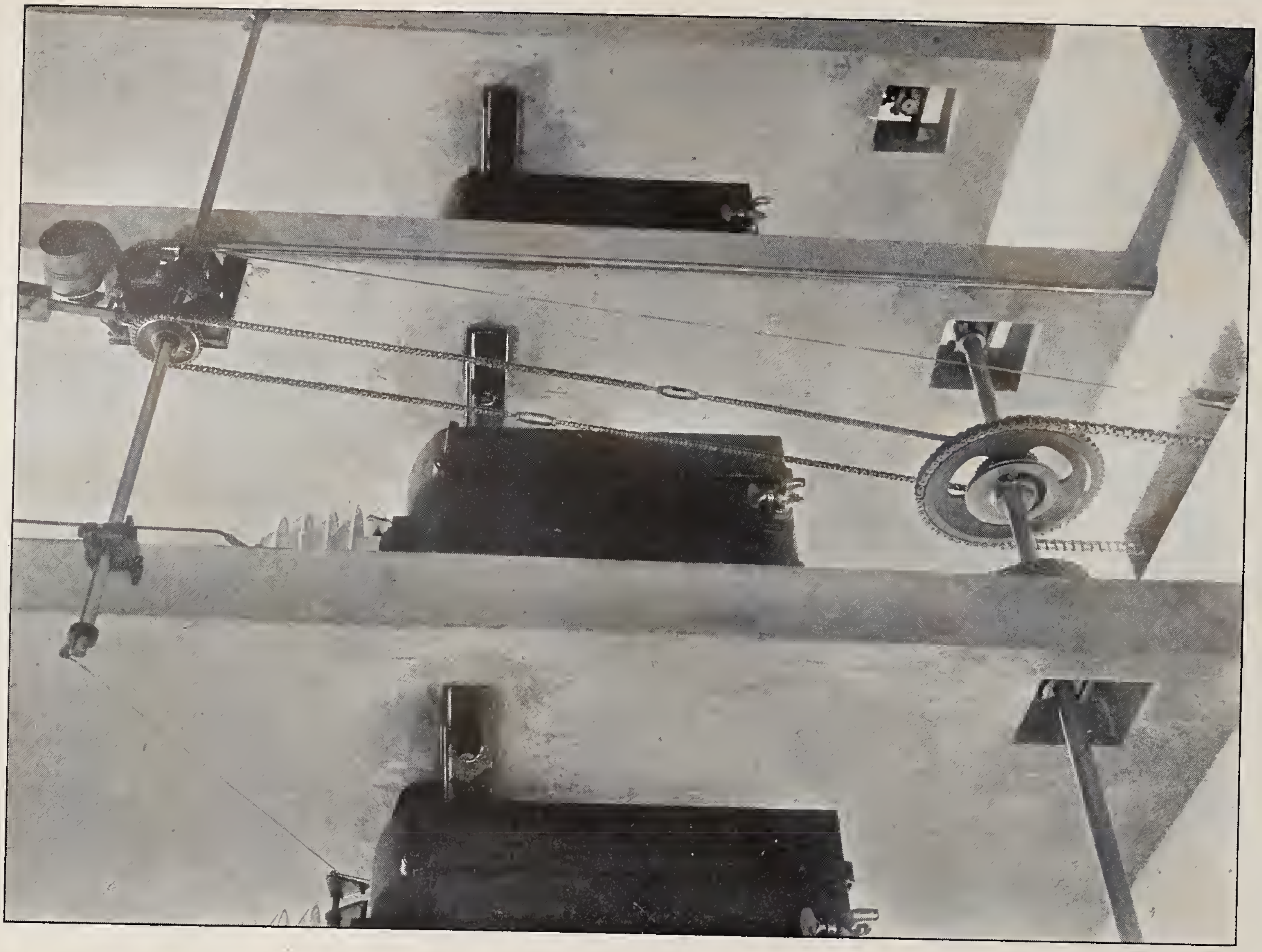
off position, even then no harm will result, as it has been proved by tests that the springs of the switch are sufficiently strong to drag the whole driving gear back to its first position. Provision has also been made to open the switch by hand, should the relay fail to act. A knob passing through the center of the switch hand-wheel, when pulled, lifts the pawl on the releasing shaft, and the switch opens in the usual way.

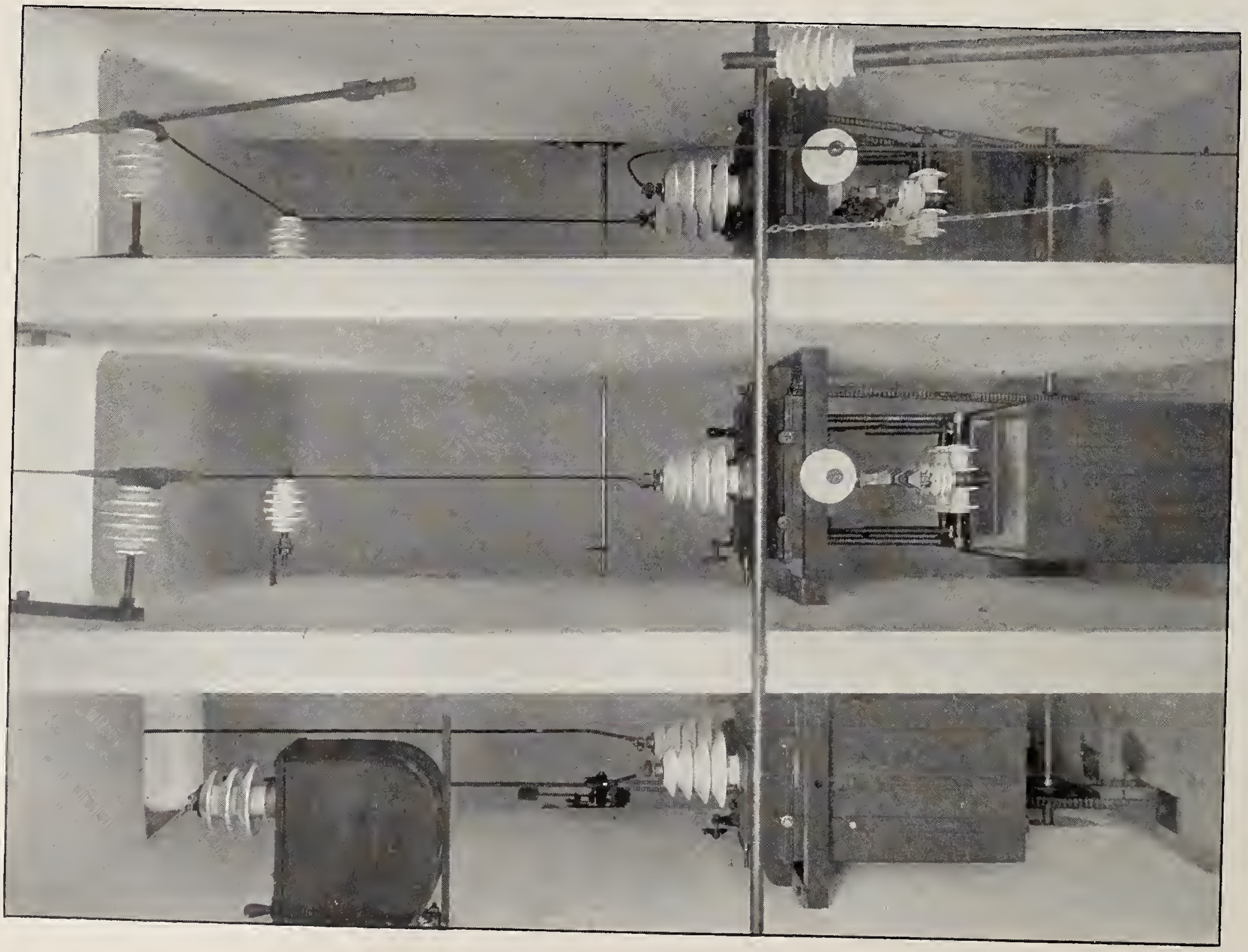
The switchboard is built in the form of a desk, the top part inclining toward the operator; it is placed in the gallery so that the attendant can see the whole of the machinery and at the same time have his hands close to the controlling apparatus. The operating board is equipped only with low-pressure apparatus, and consists of three generator panels, one feeder panel and one exciter panel. It will be of interest to American switchboard manufacturers to learn that no marble or slate was used in the construction. The vertical sides of the boards are covered with ornamental embossed iron sheeting.

A bus-bar voltmeter is mounted on a bracket placed in a prominent position over the middle of the board. The regulating rheostats, placed directly beneath the operating board, can be inspected without running any personal risk while the station is in operation.

The third floor has been reserved for the lightning arresters, as previously noted, and each phase is separated from the others by a partition. On a level with the lightning arresters are the leading-out arrangements for the high-pressure line. Each line wire leaves the power house through one of the glass panes of the window. On both sides of this glass pane a stout glass tube projects, through which the conductor passes. This tube is kept in place by two copper hoods soldered to the conductor. The tube is of such a length that the shortest path for leakage to a non-insulating body is about 10 inches.

The total length of the overhead line is approximately 21 miles. It follows the Serio River till Nembro is reached, where it drives the machinery of large cotton mills. The line has been designed to transmit a total of 4000 H. P. with a maximum drop along the line of 5 per cent. The line consists of three bare copper wires, each





FRONT AND REAR VIEWS OF THE 40,000-VOLT OIL SWITCHES USED IN THE GROMO-NEMBRO, ITALY, ELECTRIC TRANSMISSION PLANT. SEE PAGE 43

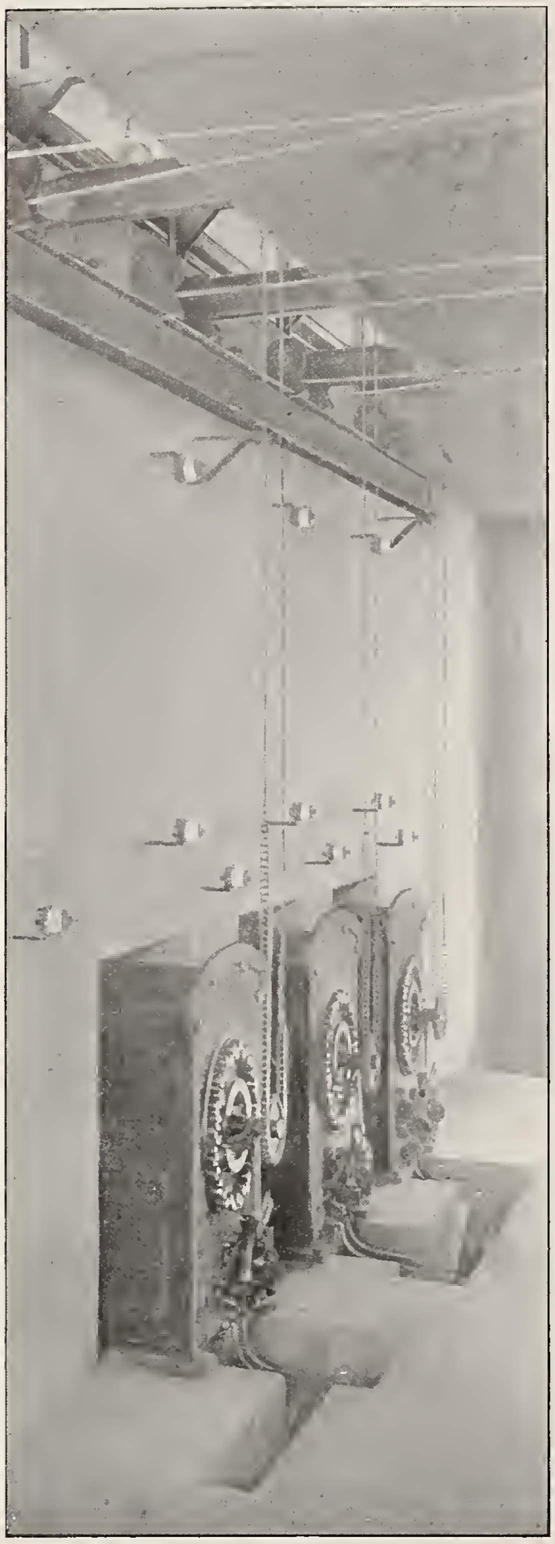
THE LIGHTNING ARRESTERS

255.905 mils in diameter, and mounted on delta insulators supplied by the Hermsdorf Earthenware Factory.

The insulators are of a new design, specially constructed for this installation. They are supported on wooden poles and cross-arms. As a rule, the lines are mounted on a single pole in the form of a triangle, each side measuring 33 7-16 inches. The standard height per pole is 26 feet above the ground, and at crossings, 29½ feet. The lower insulators are placed 24½ feet above the ground; at crossings, 27¾ feet.

The transformer station is situated at Nembro, in close proximity to the cotton mills. The line enters the building at a pressure of 38,000 volts, this being the voltage to which the generating plant at Gromo has to be regulated. The Nembro station thus far contains only two 500-K. W. transformers of the same type and design as those at Gromo. Space has been reserved, however, for a third transformer. These transformers have been designed for a normal continuous output of 500 K. W. The ratio of transformation is 38,000 to 500.

The connections of this sub-station, so far as the high-pressure circuits are concerned, are similar to those at the Gromo station. A three-pole emergency switch, mounted on poles outside the station, enables a complete isolation of the sub-station to be effected if necessary. As this apparatus is placed in the open, the possibility exists that, when the sub-station is switched out, discharge of current might result between the live line and the line entering the transformer station. This could happen through the presence between the horns of a foreign body, such as a



THE REGULATING RHEOSTATS

bird, or it might occur in very rainy weather on account of moisture. To avoid such an occurrence, three contacts have been attached to the switch, and these, when the switch is opened, short circuit the lines entering the station and connect them to earth.

The line enters the sub-station in identically the same way as it leaves the primary station at Gromo, and the current passes through the lightning arresters to the high-pressure bus-bars. The leads from the bus-bars pass through three single-pole disconnectors, and three single-pole automatic high-pressure oil switches, to the primary side of the transformers. The secondary side of the transformers is also provided with three-pole disconnectors and two current transformers; of the latter, one is for feeding the overload relay and the ammeter, while the other is for the relay alone.

The sub-station is a plain two-story building. Each floor is divided into two compartments. On the ground floor at the rear the transformers are situated; in the front room, mounted on the separating wall, are the secondary bus-bars with the disconnecting gear and current transformers. Immediately above the transformers on the second floor are the high-pressure automatic switches. On the second floor have also been placed the 38,000-volt bus-bars. These are duplicates of those erected at Gromo. The lightning arresters are placed in the next compartment, together with the leading-in arrangements.

This power transmission plant was officially started in July, 1904, and the results obtained were satisfactory beyond expectation; the plant has also withstood the severe thunderstorms which are of frequent occurrence during the hot summer months in the north of Italy.

The Action of Lightning Strokes on Buildings

By KILLINGWORTH HEDGES, M. I. C. E.

Abstract of a Paper Read Before the British Association for the Advancement of Science

IN a paper entitled "The Protection of Buildings from Lightning," which was read at the Glasgow meeting of the Association in 1901, the author mentioned the establishment of the Lightning Research Committee, organized jointly by the Royal Institute of British Architects and the Surveyors' Institution, who have since investigated a very large number of occurrences from the reports furnished by their observers. It was decided after the first year to confine the committee's investigations to buildings which were fitted with conductors, and following this course the reports on about 40 protected buildings, affected by lightning have been summarized by a sub-committee, and are having the attention of the General Committee, who will in due course issue a report.

The principal causes of the failure of the usual style of lightning rod as fitted on the buildings investigated, appear to be due to the following:—Insufficient number of conductors and earth connections; the absence of any system of connecting the metallic portions of the buildings to the lightning conductor, and especially the interconnection of the finials, rain-water pipes, and gutters. In the author's opinion the frequent damage by side-flash from the conductors might be lessened by running a horizontal conductor along the ridge, or along the parapets of all the roofs, somewhat after the method which is almost universally adopted in Central Europe.

Lightning strokes may be divided into three classes:—Those where the conductor conveyed a portion of the flash to earth, but the side-flash to other unearthed metallic conductors damaged the building; the practice of running the conductor around the projecting masonry, often taking sharp bends, doubtless facilitated the deviation of the current from its direct path to the earth. (2) In several observations a metallic roof of large area received the flash, consequently became highly charged and the single conductor failed to convey the whole of the stroke, a portion of which took a circuitous path—for instance, through a speaking-tube and an electric bell wire. (3) A flash struck the building at two points simultaneously, a lightning conductor taking one part of the stroke; but damage was caused by the other portion selecting an unprotected part of the roof.

Earth Connections — With a few exceptions, these had the defect common to nearly all earth-plates which are simply buried in the ground close to the foundations of a building, and owing to drainage soon became dry, and consequently are of very high resistance. Architects, as a rule, object to sufficiently deep holes being made near a structure; consequently the permanently moist ground is not reached. The tubular earth designed by the author does away with this objection, and can be kept moist by leading a small tube to the nearest rain-water pipe.

Interconnection with the Metal Work of a Building—Although the utility of the external metal was specially put forward in the report of the Lightning Rod Conference in 1882, their recommendation has been apparently disregarded in all the cases under review. The Cavendish Laboratory stroke, which was fortunately unattended with danger owing to the gas in the gas-pipe which formed the path of the current being turned off, would not have taken this circuitous path had the leaden roof been connected to the conductors which ran down the tower only, and also to the rain-water gutters and pipes, which ought to have been interconnected at the bottom and properly earthed.

Again, at Bedford last year, St. Paul's Church was seriously damaged by the flash leaving the single conductor on the tower by the water on the roof and passing thence to earth by means of the rain-water pipes. In this case it is interesting to note that the lead pipes were not fused, but their round section was changed into an oval one. The iron water-pipes were broken. This incident and that of St. Pancras Church, Euston, show clearly that the damage was due not to direct stroke, but to a portion of the flash leaving the main conductor and taking a circuitous path around the unconnected metal work outside and inside the buildings.

The copper sheathing of the spire on Kla Church; Truro, owing to its great capacity, could not discharge through the one excellent conductor to earth, consequently the flash divided, part going by the conductor and part by the alternative path formed by the copper covering of the spire to a rain-water pipe, thence sparking through a parapet wall to lead flashing down another pipe, and then along a very small copper wire, used for training plants, to the main conductor.

Similar effects were noted in Stoers Lighthouse and Devaar Lighthouse, the divided flash in the former leaving the conductor for a telephone wire and in the latter for a speaking tube. In these observations the conductors may be said to have acted to a certain extent, and if the structures had been entirely unprotected the damage would have been greater; but by proper attention to the necessities of each case, and increasing the number of the conductors, the risk would probably be nil, as there would be a definite path for the lightning to take.

Quite the most interesting case is that at Possingworth House, struck in June and again in August, 1902, although the roof fairly bristled with air terminals, every chimney being protected, mostly with its own conductor and earth connection. It is probable that on the second occasion the flash divided, one part selecting a chimney stack, which it damaged, bending the air terminal to an angle of 45 degrees, while the other, neglecting the many joints, fell on an unprotected statue much lower than the chimney and went to earth by the iron frame of a conservatory, showing the unreliability of a number of independent conductors which ought to have been interconnected by means of a horizontal wire led along the ridge. This would in all probability have prevented any serious damage.

Sir Oliver Lodge has shown by an interesting experiment that a column of hot air is often selected by a flash, although a lightning rod may be affixed to the side of the chimney. Most of our large stacks have a band of metal to which the air terminals are fitted, and from these two conductors ought to be led to earth. The method adopted in Germany appears to be simpler, and consists of a heavy iron frame rising to a sufficient height above the stack, and continued at the apex so as to form an aigrette. That lightning may prefer the smoke issuing from a chimney was shown by the stroke at the East London Waterworks, Sunbury, last year, the flash doing some damage to the capping, before it arrived at the standpipe inside, which was a perfect earth in that it was in direct connection with the company's mains.

The general conclusions arrived at by the author are that there is very little advantage in placing isolated rods on an ordinary building unless it has a high tower. A church, for instance, with a spire ought to have at least two conductors from top to earth. Even then, if any other part of the structure happens to be in the path of a discharge from a cloud to the ground, the stroke may disregard the protected towers or spire and fall on the building, choosing some lower point.

If the suggestions put forward by Sir Oliver Lodge at the Bath meeting in 1888 were more closely followed, and the conductors so arranged that they form a protective network over all the roofs, a flash would in all probability be received by some portion of the system and pass without harm to the ground by one of the numerous earths to which the network would be connected.

The insurance offices appear to disregard the question of adequate protection, and are quite content if the single conductor which has not prevented serious damage, to the church, for instance, is replaced, and, moreover, take no steps to have the earth connection tested periodically; also the few unconnected lightning rods erected on our national museums, picture galleries, and other public buildings contrast most unfavorably with the more scientific methods adopted on the Continent, more especially in Germany, where in some districts the local authorities have issued rules as to the erection and testing of lightning conductors, to which the various public bodies have to conform, and in some cities householders are subject to penalties if the system is allowed to get out of order.

A Unique Railroad

THE little railroad called the Inter-Works Railroad, which runs between the various plants of the Westinghouse Companies from East Pittsburg to Trafford City, near Pittsburg, holds a unique position among transportation lines. Its method of operation now consists of five distinct systems of motive power.

The first is the old-fashioned trolley line, with overhead wires for supplying power. The second is the third-rail system which supplies power to a motor car from a rail. A third system is the button system, by which a motor car is, while in motion, always in touch with a button, thousands of which are scattered along the road and each giving power to the motors. A fourth represents the latest invention in electrical railroading,—the single-phase alternating current, by which wires supply power to the older form of trolleys, but at high voltage. The final system is the ordinary steam locomotive, which operates over the same line, supplying motive power for handling freight cars. The purpose of having so many systems attached to it is to permit the company to experiment with the constantly arising improvements.

The Baltimore & Ohio Railroad Company is compiling a set of rules for the use of the telephone as an auxiliary of the telegraph in directing train movements.

The government of Cuba has granted a concession to the Berlin Wireless Telegraph Company for the establishment of two stations on the Telefunken system. One is to be erected at Havana, and the other on the Island of Pinas. The Cuban Government desires to make experiments with these stations in order to decide whether wireless telegraphy shall be introduced as a means of communication in that country.

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Leading Articles

Power Concentration in Isolated Plants

THE determination of the number and size of units to be installed in an isolated plant of new design is a problem often decided offhand, although a wise solution demands careful consideration of all the factors bearing upon the matter. The type of machinery employed, its operating efficiency, cost of maintenance in other installations, first cost, space occupied, and expense of attendance must all be considered before a proper decision can be reached. There is much question in these days as to the advisability of installing machines of different size in the same plant, particularly in cases where current is required for lighting work on a small scale with limited elevator service after regular business hours. The superior economy of a smaller unit carrying extra-hour loads which would underload the larger machinery is, of course, the main reason for splitting up the equipment into two or more sizes. It is open to debate, however, whether more than one machine of smaller size than the main units is desirable.

Unless the load varies broadly in a regular cycle of lasting changes each day, there would seem to be little advantage in using more than two sizes of generating units. Where a storage battery is installed to carry peak loads and fluctuations above the average, there appears to be still less need of subdividing the power equipment unevenly. Here is where the value of studying load curves and the operation of similar plants comes in. A strong point in favor of installing duplicate units is the interchangeability of spare parts. Space economy is a valuable feature of many isolated plants, and when breakdowns occur, the duplicate equipment shortens the period of shut-down every time. During the months of the year when the exhaust steam from the automatic non-condensing engines used in most isolated plants is thrown away, instead of being used for heating, the question of efficiency becomes all the more important, so that the loading conditions of the machinery deserve the closest study.

Good practice is well settled, however, in providing two machines, or at least one generator and an outside alternate supply, in every plant where continuity of service counts for anything. The mistake of putting sole dependence upon a single machine is not often made, and yet a plant was started a few months ago in a large manufacturing establishment without the slightest provision for reserve power in case of breakdown. In other respects the plant is an admirable example of engineering practice, but in regard to power the station was built for but one unit—an 800-kw. generator, direct-connected to a horizontal cross-compound engine.

The local electric light and power company does not supply current of the character needed to operate the factory machinery, so that a complete shut-down of all power-driven processes would be the certain result of a breakdown of the generator or engine. The cost of such a shut-down may easily amount to several hundred dollars an hour. There appears to be room in the plant for the installation of two vertical engine-driven units, and it is hard to see why a station of this size was not laid out in the safer way. With a fairly steady load upon the plant, the use of steam turbines might have been made with the prospect of high operating economy. Although the plant has been operated for several months without mishap, and no one can predict the day when an expensive shut-down will come, there is little reason to doubt that this unusual instance of "putting all one's eggs into a single basket" will, in time, cause the owners to regret the absence of duplicate machinery. The higher efficiency and lower maintenance expenses of a single large unit are likely to count for little when a shut-down of a few hours will occur at some future time when the factory may be working hard to fill its orders. The added cost of attendance would seem to be a small item in a plant of this size.

A Forward Step in Exciter Practice

AN interesting illustration of the ability of the electric motor to displace the inefficient single-cylinder type of non-condensing steam engine occurs in recent isolated plant practice where the generators supply alternating current to the installation. It is growing more and more common in such cases to install motor-driven exciter sets for continuous operation, leaving a single steam-driven set to be used in starting up the plant, the latter outfit being shut down as soon as the alternators are running at full speed.

The arrangement enables the alternators to be excited with an economy which could not possibly be obtained with a steam engine. An efficiency of 75 to 80 per cent. is readily secured with motor-generator excitation, even allowing for the trifling extra loss in wiring. The load is seldom of a violently fluctuating character as far as the exciter set is concerned, and the cleanliness, comfort and flexibility of the method are far superior in the case of the motor-driven as compared with the steam-driven unit. In very large plants, where an interruption of exciter service is liable to cause great financial loss if the plant shuts down for a single moment, it is often desirable to add a storage battery to the exciting equipment. The battery "floats" upon the exciter bus-bars, and, as an additional safeguard, stands ready to supply current automatically the instant that the regular supply fails. It is to be noted that engineers have thought it worth while to use motor-driven exciters for continuous operation, even when the steam-driven set stands idle most of the time, running up a bill of fixed charges. This fact in itself is a significant comment upon the superior efficiency of the newer method.

The Electrical Engineer in Municipal Service

THE planning and execution of public works in cities and towns has required the services of engineers from the earliest days of municipal enterprise. The problems of road and street making, water supply, sewerage, bridge building, and the supervision of railroad construction, which are always more or less intimately associated with urban life, require the hand of the civil engineering specialist for their successful solution; and so long has this fact been appreciated in city governments, that few laymen would presume in these days to decide even the broad questions of policy in regard to public works without expert advice. And it is well that this is so, for, as has recently been pointed out, the general questions of policy and method to be employed in municipal enterprises require the highest degree of engineering skill and knowledge. In many cities the civil engineer of the municipality therefore is an honored official, with a salary that is, to some extent at least, a measure of his responsibility, although there is certainly room for improvement in many cases that might be cited.

Of late years the increasing applications of electricity in street railway, lighting, telephone, and power work have laid upon municipalities a burden of inspection which the city officials have often found difficult or impossible to carry. Probably the most vital feature of electrical development as concerns the modern city is the possible fire risk. Danger to life through accidental contact with circuits would be equally important were it not for the fact that practically all companies distributing high-voltage current are obliged to protect their own employees by good construction, which naturally results in a still higher degree of protection for the general public. From the widespread applications of electricity, however, the gravest danger of fire arises, although a properly installed electric light or power circuit is one of the safest things in the world. Consequently, the electrical work of cities has come to be placed in charge of the official who supervises the fire alarm system, although in some cases inspection of new installations is carried on by separate bureau or wire department.

The importance of skilled electrical inspection is unfortunately not always realized by city councils and other non-technical bodies. That there is a field for electrical engineers of ability in municipal work no one can doubt who has been brought into contact with the splendid results which are being obtained in the way of fire protection and prevention on narrow appropriations in more than one medium-sized American city at the present time. There is, of course, not the same demand for electrical as for civil engineers in municipal work, because great electrical undertakings are usually carried on by private rather than public enterprise. Trained knowledge is, however, required in the work of inspection, and there are frequent occasions in the regular construction work of a city's organized engineering department when a knowledge of electrical apparatus and methods is of great value. Electric hoists are coming into use more and more; motor-operated scows have been employed with success in sewer work at Worcester, Mass.; lighting and telephone problems are constantly arising in the work of contractors, and in the matter of the electrolysis of water and gas pipes by the return current of street railways, there is a field for the best analysis and investigation which experienced electrical judgment is capable of making.

While the evils of electrolysis have been greatly reduced in the past decade, the pipe systems of every city should be periodically subjected to potential tests, and the results plotted for convenient reference. Even in cases where the water supply is furnished by a private company, the city should keep an eye upon the electrolysis situation and lend its aid to the railway and water companies in the matter of keeping the problem well in hand. It is not enough to solve the electrolysis problem once; conditions change in regard to load and traffic distribution, and new pipes may easily be laid in sections which may prove to be unprotected.

It is a mistake for a city of over a hundred thousand inhabitants to appropriate only a few hundred dollars each year for the important electrical inspection which means so much in holding down the fire losses. Such a course is the poorest kind of economy. This sort of parsimony sometimes runs to inordinate extremes, as in the case of a city in the East which refused to appropriate $25 for the installation of a fire alarm gong in its new city hall, for the convenience of the wire department and other officials, the wires being already in place on the completion of the building.

The difficult feature of this inspection work is the fact that the results are more or less intangible. No one can say how large an amount of money is annually saved by the prevention of fires, and the conditions are likely to vary so much from one year to the next that a comparison is manifestly difficult. In the last analysis, it lies with the electrical engineers engaged in actual municipal work to show, by well prepared annual reports the conditions confronting the valuable, but little appreciated, work of his department, and most of all to so carry on that work that the department will stand for a potent force in the community.

Electric Motors for Driving Big Machine Tools

THE question of driving big machine tools is simplified by the electric motor. Long ago the growth of large machines used by boilermakers for steel work occasioned the introduction of the independent drive, effected by means of a steam engine attached directly to each machine. But that does not meet the case of the big tools of the machine shop, in which two or more movements are involved, each absorbing different degrees of power, and to each of which a separate motor can be fitted, with the subsidiary advantage that there is no trouble about the direction of drive of belting.

Machines driven electrically can be

set in the positions which are most convenient for the shop arrangements and the handling of work, instead of being controlled by the position of the line shaft. In some of the heavy boilermakers' rolls two sets of steam engines are fitted, the main ones for driving, the smaller ones for elevating the girder to give the plate thickness to be rolled. In this way the idea of fitting several motors to a machine has, therefore, been anticipated.

The difficulties of belt-driving increase with the power absorbed by machines. Long drives are difficult to obtain in shops, and short ones do not admit of the sag which is desirable in an ideal drive. A short, wide, thick belt is difficult to keep in working order, and the bearings adjacent are greatly strained. Link belts are, therefore, often substituted with advantage in such cases. Rope drives are not common on machine tools, though used freely in one notable works in Ireland. The electric drive has come opportunely here, though the high motor speed involves more reduction gear than it does on the smaller, quick-running machines. But a good worm gear again solves this difficulty.

The increase in dimensions of machines has thus been conducive to an extension of electric driving, and in a similar way to that of overhead travelers. The necessity for power movements of the parts of mechanism, each part requiring different amounts of power, affords just the opportunity for individual motors selected for the special duty required. The three movements of overhead travelers, each taking a motor of a different power, have their analogies in planing machines, in the table travel (or the travel of housings), and in the elevation of the cross-slide. In the plate rolls it is found in the driving of the rolls and the adjustment of the top rolls; in planer-millers, in the table travel and the cutter spindle driving, with also the cross-slide elevation sometimes. When an independent standard and tool box are fitted, the case is analogous to that of the auxiliary hoist in a crane, and a separate motor is frequently attached.

Electricity in Safeguarding Service

THE perverseness of some people in interfering with the peaceful plans and occupations of other people is almost proverbial, and it is undoubtedly regretted in some quarters that electricity is sometimes employed as an agent in abetting the aforesaid people in carrying out their ends. A few instances of this may be here cited.

In far-off Mysore, India, for example, some of the native guileless jewelers who use copper in the making of certain alloys of which gold is the base, had been in the habit of helping themselves to comparatively small portions of the copper telephone wires that are strung on the same poles as the heavy copper wires used in the Cauvery Falls electric power transmission line in that country. Now the Mysore jewelers was to interpret telephonic communication until the wire could be replaced, and as the interruptions invariably occurred at night time, the intended consideration of the thrifty jewelers for the interests of the Electric Power Company was obvious. Yet it will scarcely be credited that before their interruptions had continued for a month, the Electric Power Company, with that perverseness to which we have referred, began the practice at night time of connecting the telephone wires with a 1200-volt generator with the result, as we have been told, that the simple-minded jewelers could not afterwards, with any degree of comfort, further avail themselves of this source of copper supply which had previously been open to them; on learning which, it is said, their feelings were naturally shocked that mean tactics should be employed against them.

Here is another instance somewhat analogous to that just given. It is known that there are certain gentlemen in all large cities who are averse to entering certain business premises, or private premises for that matter, by the front doors, especially at night, and who, therefore, in order to carry out their intention of entering these premises, are even willing to take the trouble of entering by a skylight. These gentlemen usually find, however, that the skylights are bolted against them, but foreseeing this contingency they generally carry along with them an auger and a saw with which they may, after considerable labor, make for themselves an opening into the building.

Even this plan, however, is not peacefully permitted to them, for the owners of the building, in their perversity, have had the wires of an electric circuit concealed within the skylight frame in such a manner that the saw itself innocently connects the wires together, and this intimates to certain people in what is termed a protective office, not too far away, that some one is effecting an entrance into the very building where the gentlemen aforesaid are industriously at work. No sooner does this fact become apparent to the minions in the central office than they deliberately direct policemen to the spot where the sawyers are at work, and this of course causes the latter to desist from their labors.

Another instance may be cited in which electricity is used for a somewhat similar purpose, this time to thwart the innocent attempt of a police officer to conceal his exact whereabouts from headquarters, for which perhaps he may have good reasons. It is known that in many cities there are police signal boxes, stationed at different parts of the policeman's beat, and it was the officer's duty when he reaches one of these boxes to pull a handle which has the effect of opening the circuit a certain number of times corresponding to the number of the box.

Now it sometimes happens, as already intimated, that the policeman is at one box when he should be at another, and he has learned that by a certain manipulation of the box he can, after he has pulled the handle, open and close the circuit as he plans; so, in that case, what is easier than to tap off the number of the box at which he should be, and then headquarters will be none the wiser. But no; this pleasantry on the part of the officer has been foreseen, and the mechanism of the box is so contrived that after the officer has taken the trouble to transmit manually the number of the box at which he should have arrived, the box which he has opened will proceed automatically to transmit its own number despite anything he can do.

Other instances of a similar nature could be enumerated, but these will suffice to confirm the opening statements of these paragraphs.

Piles made of armored concrete, having been used for extensive and difficult foundations in Stockholm, Sweden, seem to have won high appreciation from builders. Tests have shown them to be extraordinarily strong. It has, therefore, been recommended that posts for electric conductors should similarly be constructed of concrete on an iron skeleton. Besides possessing strength and durability, they are claimed to be easy and cheap to make, and would be particularly suitable for carrying high-tension electric mains across public roads.

When the season of 1905 opens on the Great Lakes, it is expected that ten wireless telegraph stations will be in operation. Four stations have already been placed in commission, and six others are being erected or arranged for. This number is sufficient to keep a steamer equipped with wireless apparatus in touch with the shore from St. Louis to Duluth or Chicago.

Polyphase Alternating-Current Crane Equipments

By C. L. DE MURALT

POLYPHASE alternating electric currents have long been considered as something rather mysterious, something that had better be left alone as long as direct currents could be made to do the work passably well. Alternating currents are connected in most people's minds with power factors of strange values, anywhere between 60 and 100 per cent., with wattless currents of peculiar characteristics, with inductances and other curious things. And thus it is not difficult to see why the average man, wanting a motor to drive some of his machinery, did not, as a rule, care to investigate the charms of the alternating-current motor if a satisfactory direct-current motor was available.

But by and by the many and important advantages of the alternating-current motor over its direct-current rival were realized and appreciated. During the past few years many factory plants have deliberately put in alternating-current machinery in preference to anything else, wherever the conditions of driving were such that a fairly uniform speed was required as, for instance, in spinning mills, weaving mills, paper factories, water works, and the great variety of industrial establishments in which a certain number of machine tools is to be driven either independently or from a common counter shaft. In all these cases the alternating-current induction motor does splendid work, and the absence of the commutator alone and the consequent reduction in cost of maintenance and repair is worth a great deal.

The alternating-current motor is at its best when running at constant speed, and was long considered unsuitable for variable-speed work, such as occurs in all hoisting and traction problems. But experience has shown that the apparent difficulties in the way of such application can be easily overcome and, as a matter of fact, European designers have, as far back as 1890, made use of alternating-current motors on railway cars as well as on cranes and elevators of all kinds. In this country such installations are of more recent date.

About a year ago the first single-phase alternating-current railway motor was brought out here, and the first alternating-current railroads have just been put into operation. There are now several different kinds of single-phase railway motors on the market. But when viewed closely they all turn out to be very closely related to our old friend, the standard direct-current railway motor, which, by careful design, has been made to stand the strain of pulsating alternating currents without apparent trouble.

During the past two years a number of cranes in various places have been equipped with polyphase alternating-current motors. Views of several of these are here reproduced. Fig. 1 represents a gantry crane of 5 tons

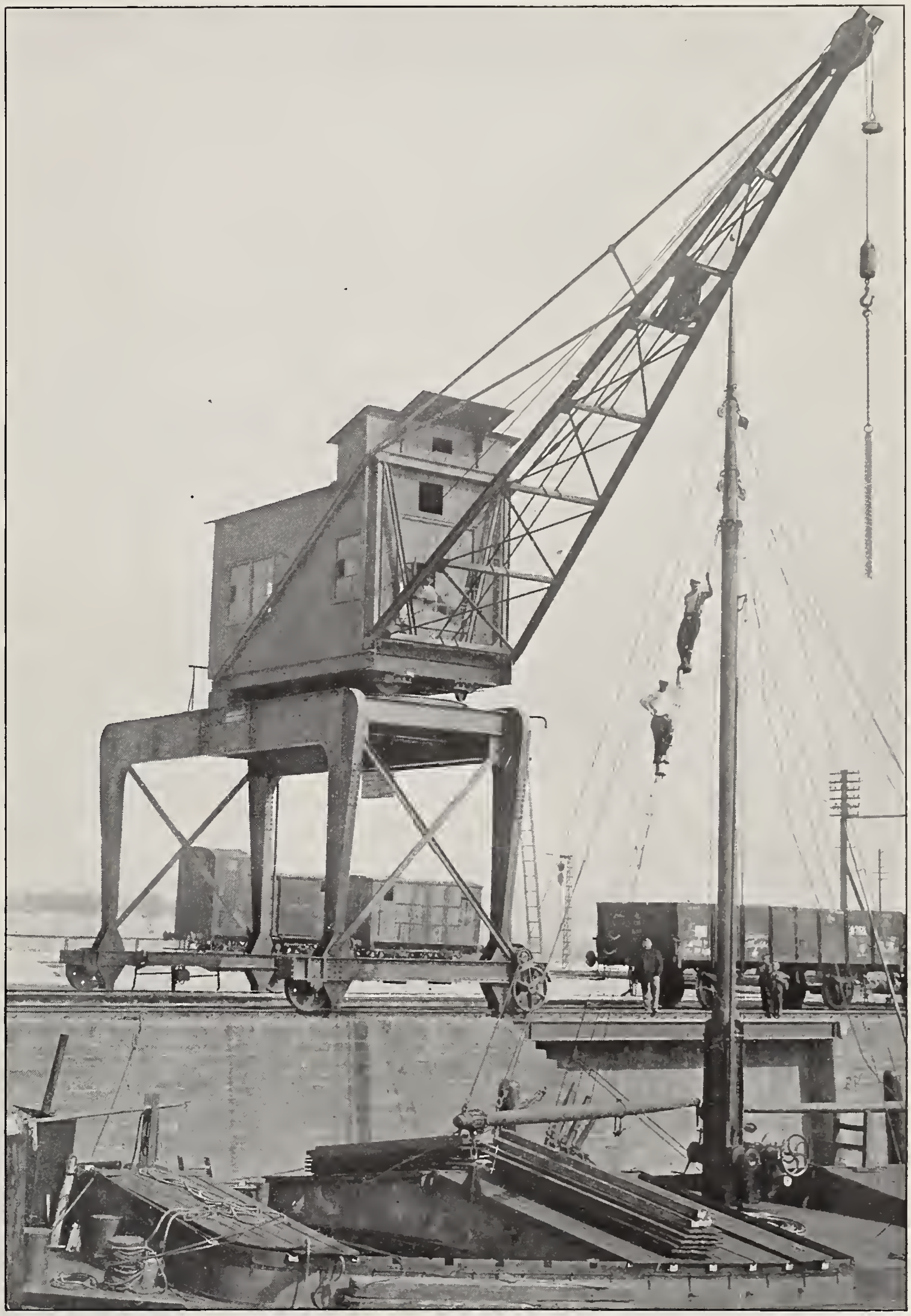


FIG. 1.—A 5-TON GANTRY CRANE AT LUDWIGSHAFEN, GERMANY, EQUIPPED WITH POLYPHASE MOTORS BY MESSRS. BROWN, BOVERI & CO., BADEN, SWITZERLAND

FIG. 3.—THE DRIVING MECHANISM OF THE CRANE SHOWN IN FIG. 2

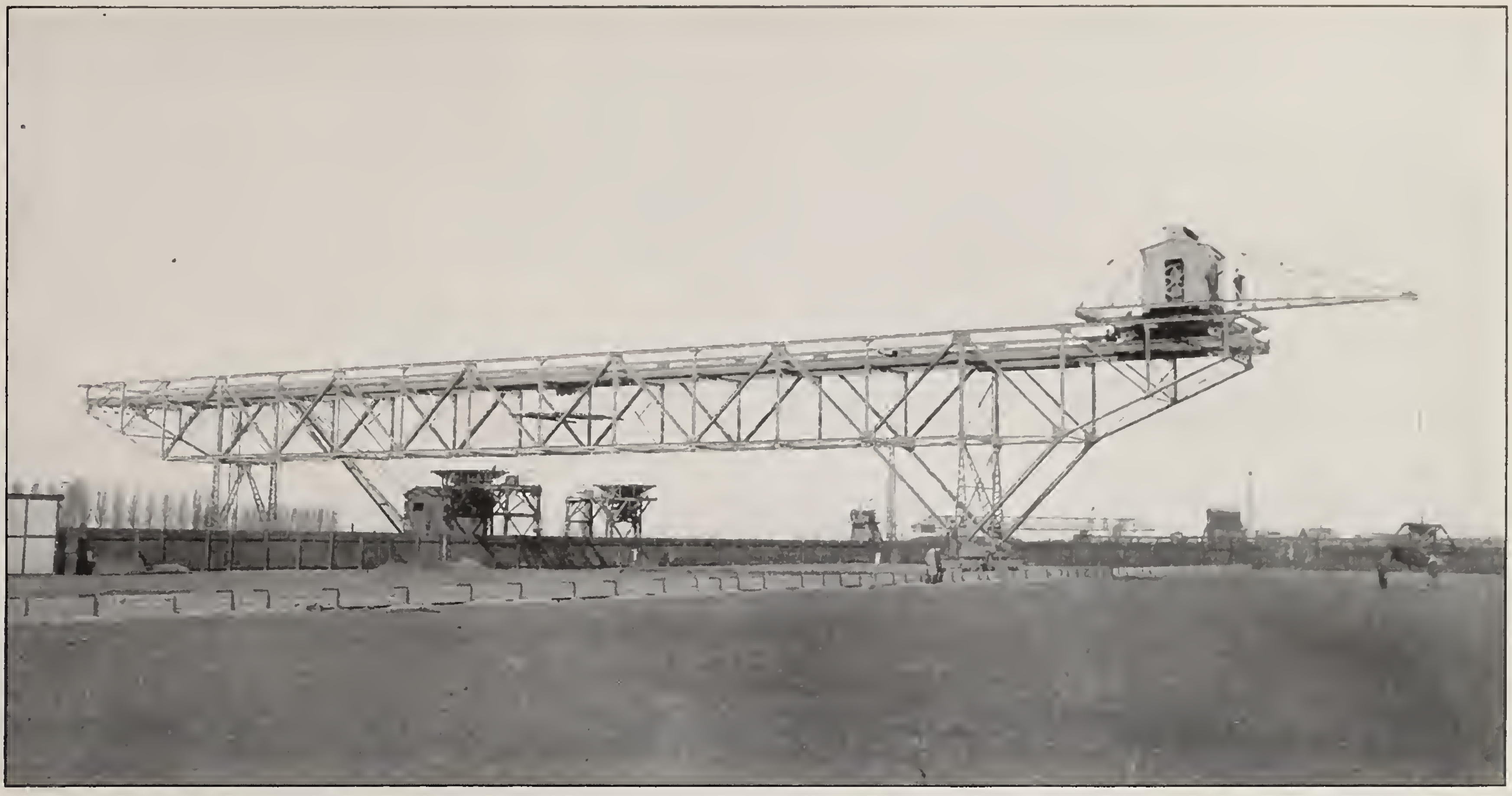


FIG. 2.—A COAL-HANDLING CRANE AT RHEINAU, NEAR MANNHEIM, GERMANY, EQUIPPED WITH THREE MOTORS FOR CROSS AND LENGTHWISE TRAVEL AND HOISTING

capacity, equipped with one 30-H. P. induction motor for the hoisting movement, and one 10-H. P. motor each for turning and lengthwise travel. All these motors are wound for 220 volts. The current is taken by a special type of trolley from contact wires strung in an open-slot conduit alongside the track. A special device is provided for automatically stopping the crane in case some foreign object should become fastened in this slot.

Fig. 2 shows a coal discharger, capable of 50,000,000 foot-pounds per hour. The bridge of this crane is 240 feet long and 37 feet high. There are three motors in all. One 20-H. P. motor is placed in the center of the bridge, and by means of a reduction gear drives a shaft which runs the whole length of the crane and is connected, in its turn, with two sets of driving wheels, one on each side of the structure. Another 20-H. P. motor serves for the crosswise travel of the truck on the bridge, and one 40-H. P. motor does the hoisting and turning work. These motors are all wound for 220 volts, and they are all controlled from the operator's cabin placed on the truck. The contact line is carried above ground on porcelain insulators and is protected against injury and accidental contact by a specially designed hood which gives the trolley access from one side. Fig. 3 shows the driving mechanism of this crane.

In all alternating-current cranes the motors are controlled by means of controllers very similar to the customary direct-current controllers. Variations in speed are obtained by inserting resistance in the rotor circuit of the motors. By this means a regulation in speed down to 50 per cent. of full speed or even less can be obtained without difficulty, and contrary to the often expressed view, this method of control has an efficiency in every way comparable to that of the best rheostat control of direct-current motors. Motors for crosswise and lengthwise travel are sometimes given short-circuited rotors, as variations in speed of these motors are often superfluous. It is frequently possible to combine the controllers for some of these motors, so that two controllers will suffice for the three motors, thus making a very compact equipment.

Modern equipments comprise electric braking apparatus which is usually so arranged that the brakes are set when no current passes. When current is switched on to the motor, the brake magnets are energized and the brakes are released. While the hoisting of the load is, of course, always done by a motor, the lowering of the load may, in some cases, be accomplished mechanically by a special lever lifting the brakes sufficiently to allow the load to glide down at varying speeds.

Judging from the number of alternating-current cranes already installed and in operation, it would seem that the induction motor for hoisting work has come to stay. It is admirably suited wherever energy is bought from a long-distance transmission company. Instead of using a rotary converter or motor generator for the purpose of transforming such energy, which is usually in the form of two or three-phase current, into direct current, it is now only necessary to install a stationary transformer to reduce the high tension of the transmission line to such value as is suitable for the crane motors. Alternating-current cranes will often be installed also on their own merits, as it has been proved beyond doubt that the induction motor is thoroughly reliable in the hands of comparatively unskilled attendants, and alternating-current equipment will stand practically any amount of rough treatment which might put direct-current machinery out of service.

The rubber industry of Guatemala should be of far greater importance than is at present the case. There are in the republic large tracts of land suitable for the growing of rubber, but, owing to the impossibility of sufficiently policing the country, the rubber is frequently stolen from the trees, and the unfortunate proprietors actually have to buy back what really belongs to them from the thieves or their intermediaries. The exports do not vary much; they amounted last year to 4423 quintals, about the average for the last five years.

Maximum Distance of Economical Electric Power Transmission

DISCUSSED AT THE LAST MONTHLY MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

THE last regular monthly meeting of the American Institute of Electrical Engineers was held at Carnegie Hall on December 23, 1904, President J. W. Lieb, Jr., presiding.

An interesting paper on "The Maximum Distance to which Power can be Economically Transmitted," was presented by Mr. Ralph D. Mershon, of New York City. In his opening remarks Mr. Mershon pointed out that in attempting to forecast the maximum distance to which electric power may be transmitted economically, the assumptions necessary to obtain definite representative figures add to the chances of the forecast proving erroneous. Thus it was primarily assumed that the future methods of electric power transmission will remain as at present, and he hinted that possibly, although not probably, transmission lines may be dispensed with at some time in the future. Or it may be that improvements on the present state of the art may modify very materially the conclusions arrived at now.

But at least the method of the treatment of the subject adopted in the paper will, with suitable changes in the value of the constants, apply as long as present methods of power-transmission are employed and permits a comprehensive view of the possibility of long-distance transmission.

There are two elements, according to Mr. Mershon, which, in the broadest sense, limit the distance to which power can be economically transmitted, namely, the cost of power at the generating station, and the price which can be obtained for the delivered power, the difference between which elements must cover the cost of transmission, the interest on the investment, and the profit. The less the sum of the interest on the investment and a dividend that will be satisfactory to the investors, the further power can be transmitted. All the elements in the annual cost per kilowatt for transmitting electric power, except those dependent upon the line conductors, may be continually reduced by increasing the amount of power to be transmitted. Hence the limiting distance to which power can be economically transmitted will depend finally upon the cost of the line conductors.

Among the conditions assumed by Mr. Mershon in the preparation of his estimate, are that power is to be purchased at low-tension bus-bars to step-up transformers and sold at outgoing bus-bars of the step-down station; the frequency employed to be not less than twenty-five cycles, nor more than thirty; idle synchronous motors at the step-down station to correct for power factor, the average power factor of the line being held as near unity as possible; that regardless of the capacity of the plant there shall be three transmission lines, each capable of carrying one-third of the load; that the power factor of the load supplied shall be 0.8.

It is also assumed throughout that ideal conditions consistent with delivering reliable and cheap power shall prevail. A net profit on the investment of 12 per cent., and power purchased at $10.90 per kilowatt per annum, and sold at $34 per kilowatt per annum, were assumed.

The conclusions reached were that the maximum distance of transmission would vary from 512 miles for 200,000 K. W., to 623 miles for 300,000 K. W., with voltages of from 150,000 volts to 170,000 volts, which pressures, Mr. Mershon thought, could be met by the manufacturers when required. The conclusion also was reached that voltage limits will not be fixed by conditions depending upon atmosphere losses, but by economic conditions.

DISCUSSION

The discussion was opened by President Lieb, who commented briefly on the great importance which the question of electric water power was assuming in various parts of the world.

H. G. Stott, of New York, thought that the question of reliability of the power was of prime importance.

That power would not, in his view, be reliable if the total interruptions per annum exceeded one hour. Even that amount would not be allowable in a city like New York. He thought that the assumption of a flat rate of $34 per annum was unfair to the consumer, since there were very few plants that had a load factor of over 50 per cent. per annum. He did not favor the use of synchronous motors on transmission lines, and regarded the voltages contemplated as rather beyond the bounds of successful practice.

Philip Torchio, of New York, discussed the paper from the point of view of transmitting power from Niagara Falls to New York, or to a similar large center, where there is a large market for power, and not from the standpoint of a territory where the cost of coal may be a great factor in the development of long-distance power transmission. The dominating factor in a study of this character is the determination of the cross-section of conductors for the fixed condition of each problem. The Kelvin law gives, with accuracy, the most economical cross-section of the conductors of a circuit in which we want a certain current to flow. Other requirements, such as the safe carrying capacity of wires, the regulation, the brush discharges of high-tension transmission lines, and other causes may substantially modify the conclusions arrived at from the consideration of the theoretical conditions of efficiancy alone, and these modifying influences must be given due weight.

Mr. Torchio submitted figures showing the total annual output of all the electric light and power and electric railway stations in this country to be 4,714,987 K. W.-hours, which, if generated by steam, with a consumption of 5 lbs. of coal per K. W.-hour, would require less than 1,200,000 tons of coal, which is insignificant compared with the 1,000,000 tons consumed daily for all purposes.

He thought that if electric water-power will ever be transmitted to large centers like Chicago and New York, it will be necessary to keep at these centers an equivalent reserve steam generating capacity, first, for tiding over shut-downs of the transmission power plant, and second, for taking care of a great proportion of the power required during the periods of heavy loads, thereby using the water-power for 24 hours of each day with a load factor of, say, 60 per cent. so as to save fuel.

J. E. Wallace, of New York, held that any discussion regarding transmitted potentials would balance the advantages to be gained by increased voltage, against a factor for more reliable operation at a lower voltage, which factor would increase with an increased load on a given line. On account of the factor of safety in operation, it would appear, no engineer would care to entrust more than a given amount of power to a given pole line. The inference is that good engineering will soon create a condition whereby the line cost would increase directly with the output.

M. H. Gerry, Jr., of Helena, Montana, considered that a mathematical analysis, or an attempt at mathematical analysis of a question of this kind, is always of doubtful utility, not because the analysis of itself may or may not be correct, but because of the fact that there are so many things entering into it that require assumptions based on engineering judgment, and there are no means of making a proper and correct assumption on these subjects. It would be easy to take Mr. Mershon's development, and, by modifying his assumptions, to show that the economic distance of transmission may be limited either to 200 miles or 2000 miles.

C. F. Scott, of Pittsburg, considered the paper more than mathematical gymnastics. In his opinion it was really the outcome of several years of study of this problem in different ways. The problem used to be to secure the smallest size of wire which would be mechanically strong enough to be put up in places and maintain its position, and so with the larger units the size of wire has become so very large that we have reached a new order of things. Mr. Mershon's wires would about reach the present limit of mechanical construction in size, and he has sought to bring out the very remarkable thing that the size of this wire is so great that apparently the atmosphere loses, which a while ago were thought to be the determining element, no longer determine the maximum voltage of transmission.

Messrs. C. L. de Muralt, P. G. Gossler and C. H. Parmly, of New York, and A. E. Kennelly, of Boston, also took part in the discussion, which was closed by Mr. Mershon, who replied briefly to the criticisms of his paper.

An Experiment in Municipal Lighting

HOLYOKE is one of the few cities in the United States owning and operating its own electric and gas lighting plants. There are a number of cities that own and operate municipal electric lighting plants, but the municipal operation of both electric and gas plants is not often met with. Last month it was two years since Holyoke as a city started to make and sell its own electricity and gas, and by this time some results of its municipal policy may be noted. These were given as follows in a recent issue of "The Evening Post," of New York:—

Both the gas and electric plants were formerly owned by the Holyoke Water Power Company. Holyoke bought the original water plant of the company and has since conducted it as a municipal function. The company, however, retained its gas and electric plants until 1902. The company was selling gas at $1.40 net per 1000 cubic feet, and its rates and discounts were so arranged that the small consumer felt that he was being unjustly discriminated against in favor of the large consumer.

In 1894 and 1895 the city government twice declared in favor of municipal ownership and operation of gas and electric plants, and this stand was ratified by a majority of the voters in December, 1896. Then ensued a protracted litigation. The company was not compelled under the law to sell out, but it saw that this was a wiser policy than facing municipal competition. A commission was appointed by the courts to determine the value of the plants. The company asked $1,000,000 for the two plants. The litigation and negotiations dragged until 1902, when the company was finally offered and accepted $706,000 for its plants. On December 15, 1902, the city assumed control and operation.

The first year, ending December 15, 1903, of municipal operation did not show on its face a decided advantage over the system of private management. In reality, however, there was a gain for both the city as a consumer and for individual consumers. William H. Snow, who for 26 years had been connected with the gas works, was made manager of the gas and electric department, and the department has been run strictly on business principles. Holyoke is normally a Democratic city, but six times it has elected its present Mayor, a Republican, and he, in turn, has continued in or appointed to office some Democrats of appropriate qualifications. With this spirit it has been comparatively easy to keep the gas and electric works free from political entanglements.

For the first sixteen and a half months of city ownership gas was sold at $1.35 net per 1000 cubic feet. The first year showed a total profit from both plants of $7000. There were, however, a variety of reasons why a larger profit could not be made. During the long period of litigation, the Holyoke Water Power Company had refrained from making improvements or extensions. When the city took ownership it had to make up for lost time, and the expense to which it was put in making improvements and extensions was considerable.

The current year, ending December 15, 1904, is expected to show a profit on both plants of $31,000 at least, and this, with reduced price for gas and electricity. On May 1, 1904, the city reduced the price of gas from $1.35 to $1.20 net per 1000 cubic feet.

ALL CONSUMERS ON THE SAME BASIS

It would be confusing to go fully into the different systems of discount for electric light payments. Suffice to say that under the city's management of the electric plant they have been so regulated that the small consumer is put on an equal with the large consumer. Under the Holyoke Water Power Company there was a graduated system of discounts by which the larger consumers of electricity were benefited at the expense of the smaller. Electricity was also supplied on part time only—that is to say, during those hours solely when the company found a profit in its distribution. Now it is supplied during the entire 24 hours. Although the price of gas has been reduced and the discounts for electricity rearranged, the number of consumers of both have so increased that the city can make considerable profit.

The city, of course, in its corporate capacity, is the largest consumer of electricity. It uses 263 electric arc lights. For each of these the Board of Public Works pays to the gas and electric department $100 a year, making $26,300 a year. It also uses a large amount of gas in the public buildings. There are about 380 individual consumers of electricity and about 5000 individual consumers of gas in Holyoke.

It costs the city $1.18 and a fraction per 1000 cubic feet to make gas which it sells at $1.20 net per 1000 cubic feet. The revised laws of Massachusetts require that neither gas nor electricity shall be sold by any municipality for less than the cost of making or generating them. Another State law, which is strictly adhered to, provides that 5 per cent. on depreciation of cost of the plants must be charged against the operating expenses. It is this 5 per cent. which adds so greatly to the city's cost of making gas and electricity, and this is why the cost of making gas, for instance, is $1.18 per 1000 cubic feet instead of a much lower rate. When the Holyoke Water Power Company owned and operated the plants this cost was placed on its books at the sum of $100,000. The city has to figure this item at $869,000. The expense of acquiring the plants, the cost of litigation and other outlays all have to be included. In paying their gas and electric bills, the consumers have to pay 5 per cent. on $869,000—that is to say, it is included in the rates charged for gas and electricity.

Right here is a point of contention as to whether the city has really benefited or not by municipal ownership. The Holyoke Water Power Company had to charge off so much less for depreciation that it is claimed that the company could have sold at a profit gas for $1 per 1000 cubic feet, and it is further said that the company would have done so eventually. Whether, however, it would have cheapened gas to this extent is problematical.

The majority of the people here are well satisfied with municipal ownership and operation. The employees in the gas and electric plants express themselves as unquestionably better satisfied under municipal than under private management. Formerly, under the Holyoke Water Power Company, they had to work on two shifts to a day of 24 hours. Now they work on three shifts of 8 hours each, as required by State law. Where the minimum wage before was $1.50 a day, it is now, under municipal ownership, according to law, $2 a day. The city now has to employ one-third more employees than did the Holyoke Water Power Company; it has to pay them more; it has reduced the price of gas and electricity, and made many improvements and extensions, and yet, with all these changes, it will make for the year ending December 15, 1904, an approximate profit on both plants of $31,000. It is reasonably expected that the profit for the third year will be still larger.

The returns of the recent election were transmitted to street cars in Indianapolis equipped with telephone apparatus and read to the passengers by the conductors.

Dixonite is the name of a new fire-resisting material brought out by Messrs. Robert Dixon & Co., of Pittsburg. It is intended for the lining of furnaces subject to intense heat, but not for use where it will come in direct contact with molten metal.

National Electric Light Association Membership

THE National Electric Light Association is about starting an active campaign for new members, and the appointment of Mr. Henry L. Doherty as committee on membership, promises well for its success. The great increase in membership in the past two or three years was largely due to Mr. Doherty's personal efforts and methods suggested by him, and now that he has taken the matter up officially, still better results may be looked for. At the last meeting three new classes of membership were created, and it is in these classes particularly that the increase is expected. Officers and employees of member companies are to be received as members, with the written consent of the member company with whom connected. The entrance fee for such members will be $5, and the annual dues $5. They will, of course, receive the various publications issued by the association throughout the year, so that this is a very low rate for dues. College professors and teachers of electrical engineering may become members at a rate of dues of $4 per year, with no entrance fee.

Annual Dinner of the American Institute of Electrical Engineers

THE annual dinner of the American Institute of Electrical Engineers will be given in the ballroom of the Waldorf-Astoria, New York City, on February 8, and promises to be a most interesting occasion. In view of the recent opening of the subway, thus adding underground traction in America to the domain of electricity, the adoption of electric locomotives for their great Manhattan terminal divisions by the New York Central and Pennsylvania Railroads, the equipment of the Long Island Railroad with electricity, and other signal events, the Institute has decided to devote this dinner to emphasizing the triumph of electric traction.

A number of pioneers and leaders will be present, an original menu has been designed, and some novel features will be introduced, while the list of speakers includes men of national and international reputation. The dinner will be served for $5 per cover without wine or cigars, and as is usual on these occasions, ladies will be present. The participation of the ladies was a feature that elicited Mr. Carnegie's enthusiastic commendation at the famous Institute Library dinner, which he made forever memorable by his million-dollar gift for the United Engineering Building. Notices will be sent to the members forthwith, and it is requested that an early response be made, in order that proper care can be taken of all applications. Over 400 had to be seated at the Edison dinner last year, and the attendance in February promises to be equally large.

Design for an Edison Medal

A MEETING of the jury in the matter of competition for the selection of a design for an Edison medal commemorating the invention of the incandescent lamp, under the auspices of the National Sculpture Society, was held recently at the studio of J. Q. A. Ward, New York City.

Those present were J. Q. A. Ward, chairman, Daniel C. French, Augustus Saint Gaudens, for the National Sculpture Society; Edward D. Adams and T. C. Martin, for the Edison Medal Association and on behalf of the American Institute of Electrical Engineers.

After a further examination of the 29 designs submitted in competition, the committee by unanimous action awarded the first prize of $1000 for the successful design, including its execution in such shape and detail as will permit direct reduction to medal size, to James Earl Fraser. The second prize of $100 to Adolph A. Weinman, and the third prize of $50 to Miss Evelyn B. Longman. The successful competitor, Mr. Fraser, has been requested to develop his design for final consideration by the committee.

Comparative Cost of Steam and of Electric Railroad Operation

A COMPARISON of the costs of steam and of electrical operation of the Manhattan Elevated Railroad, in the city of New York, for one year, shows a decided saving in favor of the latter. The figures, as given in the recent report of the company, are as follows:—

	Per Car-Mile Electric Cents	Steam Cents
Maintenance of way and structures.	1.047	0.927
Maintenance of equipment and power plant	1.325	1.304
Power supply and connecting transportation	6.501	9.346
General expenses	0.595	0.700
Total	9.468	12.277

The saving of the electric system is, therefore, 2.7 cents per car mile.

Mr. Dugald Clerk, in a recent statement, said that in England there had been produced altogether nearly 100,000 internal combustion engines of an average of 20 H. P.

Electrical Innovations in a Modern Hotel

By WILLIAM H. RADCLIFFE

ELECTRICITY, long recognized as one of the most indispensable factors in business life, is slowly but surely solving the problem of domestic happiness. The more complicated the problem, the greater seem to be the advantages possessed by electricity over other competitors; in many cases, however, there are no competitors, and were it not for electricity the problems would remain unsolved.

The Hotel St. Regis, recently constructed and opened for patronage in the city of New York, is probably the most thoroughly equipped modern structure of its kind in existence, and affords an excellent opportunity for studying the more recent applications of electricity to domestic purposes. No attempt will here be made to describe the electrical equipment of the hotel in detail, but a few of the more novel ways in which electricity has there been adopted to smooth the paths of the employees, and to increase the efficiency of the service, are believed to be worthy of mention.

The most ingenious of the electrical novelties installed is that used in the operation of the dumb-waiters. It is called the circular push-control system and, taken in connection with the signaling service, is not to be found in any other American hotel. The system is operated from a horizontal board in the basement, in close proximity to the dumb-waiters, and on which are mounted a number of circular dials, one for each waiter. Each dial is built up much in the form of an adjustable rheostat; there is a movable contact arm which may be turned so as to rest upon any one of a number of metal contacts, and these latter are numbered to correspond to the seventeen floors of the hotel. Extending across the top of the board is a row of 4-candle-power, 110-volt incandescent lamps, used as signals, one for each waiter, and on the board at right angles to the lamps is a row of push buttons numbered to correspond to the various floors.

The system operates in the following manner:—As soon as food is placed upon a dumb-waiter for transportation to a certain floor of the hotel, the contact arm on the dial corresponding to this waiter is moved by the operator until it rests upon the contact bearing the number of the desired floor. This act on the part of the operator causes the waiter to start on its upward journey and continue until it reaches the proper floor, where it stops automatically. The instant the waiter is in motion the signal lamp on the board corresponding to this waiter lights, and it remains lighted until the waiter reaches its destination. As soon as the waiter stops, the signal lamp is cut out of circuit and ceases to give light, thereby furnishing a signal to the operator that the car has completed its journey. The operator then presses the push button on the board, corresponding to the floor to which the waiter has been sent, and so operates a buzzer at this floor, which is there taken as a signal that the waiter is to be unloaded. As soon as this is done and the waiter started on its return trip by the party unloading it, the signal lamp again lights and remains lighted until the basement is reached. The action of the waiter is thus automatically recorded by the signal lamp at all times. In order to keep the food warm during transit the waiters are equipped with electric heaters. Each of these heaters consumes 6.5 amperes at 115 volts, and they are left continually in circuit during the busy periods of the day and night.

In the dining-rooms, electric plate-warmers are installed, one of which is placed on each service table. Each plate-warmer consists of a small electric heater consuming 2.7 amperes at 115 volts, and is enclosed by an aluminium casing. In all, there are about eighty of these, and by means of short, flexible conductors they may be introduced in circuit through connectors mounted at various parts of the walls and floors.

Electricity is employed indirectly in the heating of the entire building; in other words, electric heaters are not used, but blower motors operated by electricity and ranging in size between 7 and 45 H. P. are installed throughout the hotel to maintain a comfortable temperature. Each blower is enclosed within an air-tight chamber, through which, by the action of the blower, cold air from outside the building is drawn, filtered by its passage through a cheese-cloth screen, warmed by its circulation about steam-heated coils of pipe, moistened by its passage over an open water tank, and then forced into the various rooms and halls through registers mounted in the walls just below the ceilings. In every blower set a reserve motor is installed for use in case of emergency.

In summer, the blower motor equipment just mentioned is used to cool the various rooms and halls of the hotel. By means of a thermostat installed in each room for regulating the opening and closing of the register near the ceiling, the temperature, either in summer or winter, may be raised or lowered at will.

A complete system of electric clocks, comprising in all between 400 and 500 timepieces installed throughout the hotel, is interesting in view of the fact that no batteries or movable contacts of any kind are used in the system. The current of electricity which moves the hands of the various clocks is generated by the master clock in the basement which, in turn, is regulated by a Western Union timepiece. A heavy weight attached to the mechanism of the master clock falls, at the end of each minute, a certain distance, and the energy thus developed is used to produce motion between a coil of wire and the poles of a permanent magnet mounted within the clock. The terminals of this coil are connected in series with electromagnets, one of which forms a part of the mechanism in each of the secondary or service clocks. The movement effected between the coil of wire and the poles of the magnet produces an alternating current in the coil, which current passes through the electromagnet in each clock, and is of sufficient strength to cause the respective hands to be attracted forward the space of one minute. Two master clocks are installed in the basement, although but one of them is required to operate the system, the other being used only in case of emergency.

In connection with this clock system, a number of pilot clocks are also installed in the basement, one such clock for every thirty service clocks. These are used to aid in locating any defect that may occur in the secondary timepieces by narrowing down the trouble to a comparatively small known field. If, for example, one of the service clocks be out of order, the corresponding pilot clock would fail to agree with the others, and the troublesome clock could therefore soon be located.

Some idea of the extent to which electricity is applied in the hotel may be obtained from the fact that the building has in its own generating station in the basement, two 200-K. W. and three 300-K. W. compound-wound generators. These machines furnish direct current at 115 volts and may be run either singly or in multiple.

The Forthcoming Convention of the National Electric Light Association

At a meeting of the executive committee of the National Electric Light Association, held in New York last month, the dates fixed for the Denver-Colorado Springs convention were June 6, 7 and 8 at Denver, and 9, 10 and 11 at Colorado Springs. The business sessions, with excursions and other features of entertainment, will be held at Denver. The entertainment at Colorado Springs will include an inspection of the Cripple Creek mine district.

In order that there may be nothing lacking in the entertaining of the delegates and visitors, an organization of the business, railroad and central station men of Colorado and adjoining States has been formed, a general committee having charge of the arrangements.

Henry L. Doherty, president of the Denver Gas & Electric Company, was appointed by President E. H. Davis as the association's representative on the general committee, with power to select, with the help of two other members, the smaller committees of the organization.

In the matter of railroad fares, the railroad members of the organization consider that low rates are assured, the schedule being one fare for the round trip from Chicago and St. Louis and points "common" with them, as well as the intermediate territory, and one and one-third fare for the round trip to these cities from points east.

The general committee consists of Orson Adams, Grand Junction Electric & Gas Co., Grand Junction, Col.; William Mayher, Greeley Power & Light Co., Greeley, Col.; W. E. Renshaw, Seaton Mt. Electric Light, Heat & Power Co., Idaho Springs, Col.; F. E. Webber, Leadville Gas & Electric Co., Leadville, Col.; P. N. Munn, Telluride Power Co., Telluride, Col.; R. S. Campbell, Utah Light & Railway Co., Salt Lake City; John Martin, California Gas & Electric Co., San Francisco; A. Pollock, San Francisco Gas & Electric Co.; F. E. Warren, Cheyenne Fuel & Power Co., C. F. Brown, Roaring Fork Electric Light & Power Co., Aspen, Col.; William T. Wallace, Colorado Electric Power Co., Canon City, Col.; Herman Webber, LaBella Electric Co., Cripple Creek, Col.; C. H. Peters, Durango Light & Power Co., Durango, Col.; George B. Tripp, Colorado Springs Electric Co., Colorado Springs, Col.; Charles Neely, Fremont Electric Light Co., Florence, Col.; M. T. Morrill, electric light company, Golden, Col.; F. P. Dewey, electric light company, Georgetown, Col.; Gen. Fred Walsen, electric light company, Idaho Springs, Col.; H. R. Wray, Chamber of Commerce, Colorado Springs, Col.; J. F. Vaile, electric light company, Pueblo, Col.; E. J. Temple, electric light company, Boulder, Col.; D. O. Freyberger, electric light company, Loveland, Col.; John Doss, electric light company, Ouray, Col.; C. Y. Breck, Telluride Electric Light & Power Co., Telluride, Col.; Nelson Rhoades, Arapahoe Electric Light & Power Co., Littleton, Col.; W. F. Jones, Gold Belt Consolidated Electric Co., Victor, Col.; J. B. Wiggenhorn, Florence & Cripple Creek Railroad Co., Cripple Creek, Col. The following members of the general committee are all of Denver:—G. E. Sethman, Meeker Light, Heat & Power Co.; C. W. Badgley, Crested Butte Light & Water Co.; Gen. Irving Hale, General Electric Co.; O. B. Kohl, Lacombe Electric Co.; John Brannan, Lacombe Electric Co.; J. H. Waters, LaBella Electric Co.; S. W. Cantrill, Denver Tramway Co.; T. B. Stearns, Stearns-Rogers Mfg. Co.; Major S. K. Hooper, Denver & Rio Grande Railway; J. F. Vallery, Burlington Route; W. E. Bridgman, the H. J. Mayham Investment Co.; E. R. Griffin, Union Pacific Railroad; C. L. Wellington, Colorado & Southern Railroad; D. H. Hoops, Chicago & Northwestern Railroad; G. W. Vallery, Colorado Midland Railway; H. B. Kooser, Missouri Pacific Railway; W. J. Jones, Denver, Northwestern & Pacific Railway; Charles B. Sloat, Rock Island Railway; J. P. Hall, Santa Fe Railroad; D. C. MacWatters, Cripple Creek Short Line; Fred H. Bostwick, Hendrie & Bolthoff; J. C. Poole, Stanley Electric Co.; H. L. Woolfenden, Gilbert Wilkes & Co.; R. D. Marthens, Nernst Lamp Co.; Mayor R. W. Speer; E. S. Kassler, Montrose Electric Light & Power Co.; J. J. Cooper and J. W. Stearns, Mountain Electric Co.; Edward C. Means, Adams Bagnall Electric Co.; Edward Pool, American Steel & Wire Co.; J. D. Jackson, Western Electric Co.; W. P. Carstarphen, Carstarphen Electric Co.; H. W. Lawrence, New England Electric Co.; P. J. Brown, General Electric Co.; R. E. Miller, Crocker-Wheeler Co.; Charles S. Onderdonk, Onderdonk Manufacturing Co.; R. B. Sullivan, F. W. Frueauff, H. L. Doherty, C. W. Humphrey, W. J. Barker, E. Y. Sayer, C. N. Stannard, Rufe Gentry, John Craig Hammond, J. Charles Andrews, Denver Gas & Electric Co.; William Maher, Albany Hotel; A. R. Hall, Capital Lamp Co.; C. H. Speers, Colorado Midland Railroad; J. F. Callbreath, J. S. Temple and Arthur Williams, Chamber of Commerce; J. J. Hernan and N. M. Tabor, Hotel Men's Association; Armour C. Anderson and John McNamara, Real Estate Exchange; J. J. Joslin, George Gano, Merchants' Protective Association; W. S. Iliff, C. K. Durbin, G. W. Cook, James Williams, Thomas Smith, J. J. Henry and B. K. Sweeney.

The special committees appointed are:—

Executive.—Henry L. Doherty, chairman; F. W. Frueauff, vice-chairman; G. B. Tripp, H. R. Wray, J. A. Beeler, T. B. Stearns, J. F. Callbreath, Armour C. Anderson, Gen. Fred Walsen.

Transportation.—George W. Cook, chairman; J. S. Temple, Major S. K. Hooper, J. F. Vallery, E. R. Griffin, H. R. Wray, C. L. Wellington, Geo. F. Porter.

Finance.—G. W. Gano, chairman; G. B. Tripp, vice-chairman; Gen. Irving Hale, J. W. Stearns, C. K. Durbin, J. A. Beeler, J. J. Hernan, J. F. Callbreath, A. C. Anderson, Gen. Fred Walsen, J. C. Hammond, G. W. Cook, J. H. Waters.

Entertainment.—Philip Cross, chairman; F. W. Frueauff, W. E. Bridgman, T. B. Stearns, G. W. Vallery, G. B. Tripp, H. R. Wray, R. W. Speer, Gen. Fred Walsen.

Hotel.—W. J. Barker, chairman; J. J. Hernan, J. J. Cooper, J. F. Vaile, S. W. Cantrill, H. L. Woolfenden, Philip Cross.

Advertising.—John Craig Hammond, chairman; John McNamara, T. E. Fisher, S. K. Hooper, J. F. Vallery, N. M. Tabor, D. H. Hoops, J. J. Joslin, D. C. MacWatters, Charles B. Sloat.

Colorado Springs.—Geo. B. Tripp and H. R. Wray.

J. Charles Andrews is secretary of all committees. His address is care of the Denver Gas & Electric Co., 405 Seventeenth street, Denver.

The formal opening of the Hull Corporation telephone system took place recently, and Hull is now the fifth town in Great Britain working a municipal exchange.

Electrical and Mechanical Progress

An Electric Derrick Winch

THE electric winch shown in the annexed illustration was designed by the Quaker City Electric Company, of Philadelphia, to provide a light but powerful lifting mechanism, easily applied and adapted to either guyed or stationary mast and boom derricks.

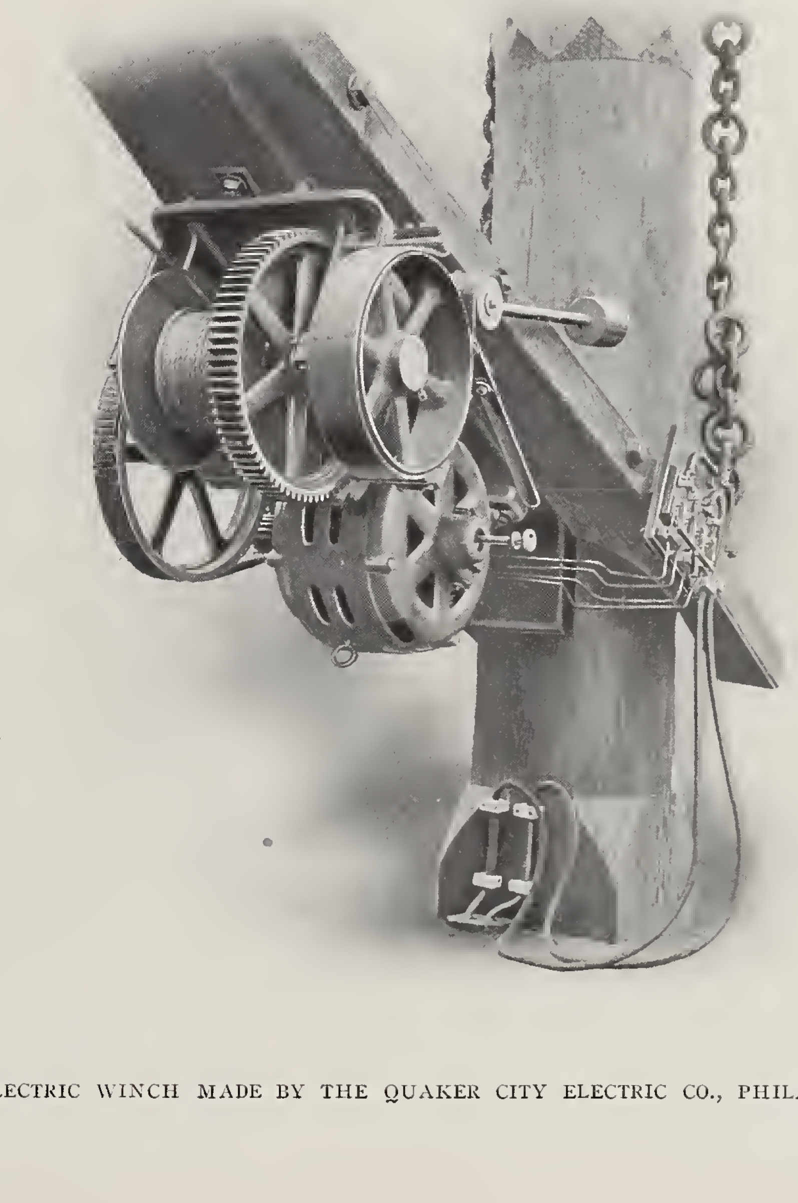
It consists substantially of one main casting forming the bearings for and supporting the cable drum, countershaft, journals and motor. It fits the under side of the gaff or boom, and is held in place by bolts extending through heavy cast-iron straps on the top side of the boom.

The power is transmitted from the motor to the countershaft by silent chain drive, and from the countershaft to the drum shaft by cut spur gears. The motor may be either direct or alternating current of 5 H. P., and may operate at a speed not exceeding 1200 revolutions per minute.

The method of control may be either by an electric controller varying the motor speed, which requires starting the motor from a standstill for each load hoisted, and the use of an electric brake with hand attachment for lowering, or by keeping the motor in operation continuously while the derrick is in use, and controlling the load with a simple but powerful friction clutch and hand-brake. Either of these systems is feasible with direct-current motors, but for induction motors only the latter can be used.

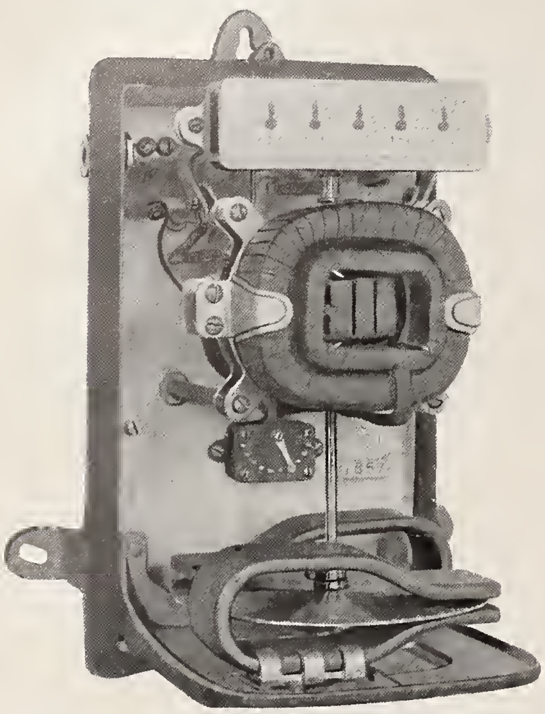
Canadian Power for Western New York

AN announcement of considerable importance as concerning the future application of a portion of the power to be developed on the Canadian side at Niagara Falls is to the effect that the Ontario Power Company has entered into a definite contract with the Niagara, Lockport & Ontario Power Company whereby the former is to deliver to the latter 30,000 electrical horse-power by July 1, 1905, and an additional 30,000 horse-power by January 1, 1907, making 60,000 horse-power in all. The contract is made for a period extending to April 1, 1950, but may be renewed 60 years longer, or until 2010. Under the agreement, this power is to be delivered by the Ontario Power Company at the boundary line in the vicinity of the whirlpool, where the Niagara gorge is narrow, and at which point a transmission line is likely to be erected. The indications are that the Niagara, Lockport & Ontario Power Company will build a trans-



AN ELECTRIC WINCH MADE BY THE QUAKER CITY ELECTRIC CO., PHILADELPHIA, PA.

former station at or near the whirlpool, and under the agreement it is to build a transmission line extending as far East as Rochester by July 1, 1905. The performance of this contract is



A DIRECT-CURRENT WATTMETER, MADE BY THE DUNCAN ELECTRIC MANUFACTURING CO., LAFAYETTE, IND.

guaranteed by the forfeiture of a specific sum as liquidated damages in case of nonperformance.

It is intimated that this contract is made with the Ontario Power Company by the Lockport Company for the reason that it would require a long time to develop power in the vicinity of Lockport, and thus indications are that the long-reported prospective development at or near Lockport is very remote, for this contract is for 50 years, with privilege of renewal for 60 years more. The Ontario Power Company is erecting a power station at the water's edge in the gorge on the Canadian side of the river, and has already installed its first steel flume, which has a diameter of 18 feet. The company's plan is to place three of these flumes, each of which is intended to supply water enough to develop 60,000 horse-power.

A Direct-Current Wattmeter

A NEW type of direct-current wattmeter, made by the Duncan Electric Manufacturing Company, of Lafayette, Ind., is shown in the annexed illustration. The principal results sought in the development of this meter were the increasing of the driving torque and, incidentally, the retardation, so that the accuracy on very small loads could be depended upon to a degree not attainable heretofore. Another important change was one of design, whereby the bearings might be readily inspected and renewal of spindle joints and jewels made with the greatest possible ease, without having to use special tools.

The cover of the meter is removable from the front, permitting the meter to be installed close to the ceiling. It also fits closely into a felt-lined groove and is absolutely dust and insect proof. By way of testing its dust-proof qualities, the makers installed one of them in a flouring mill for several months, and upon inspection it was found to be as clean and free from dust within as when first installed.

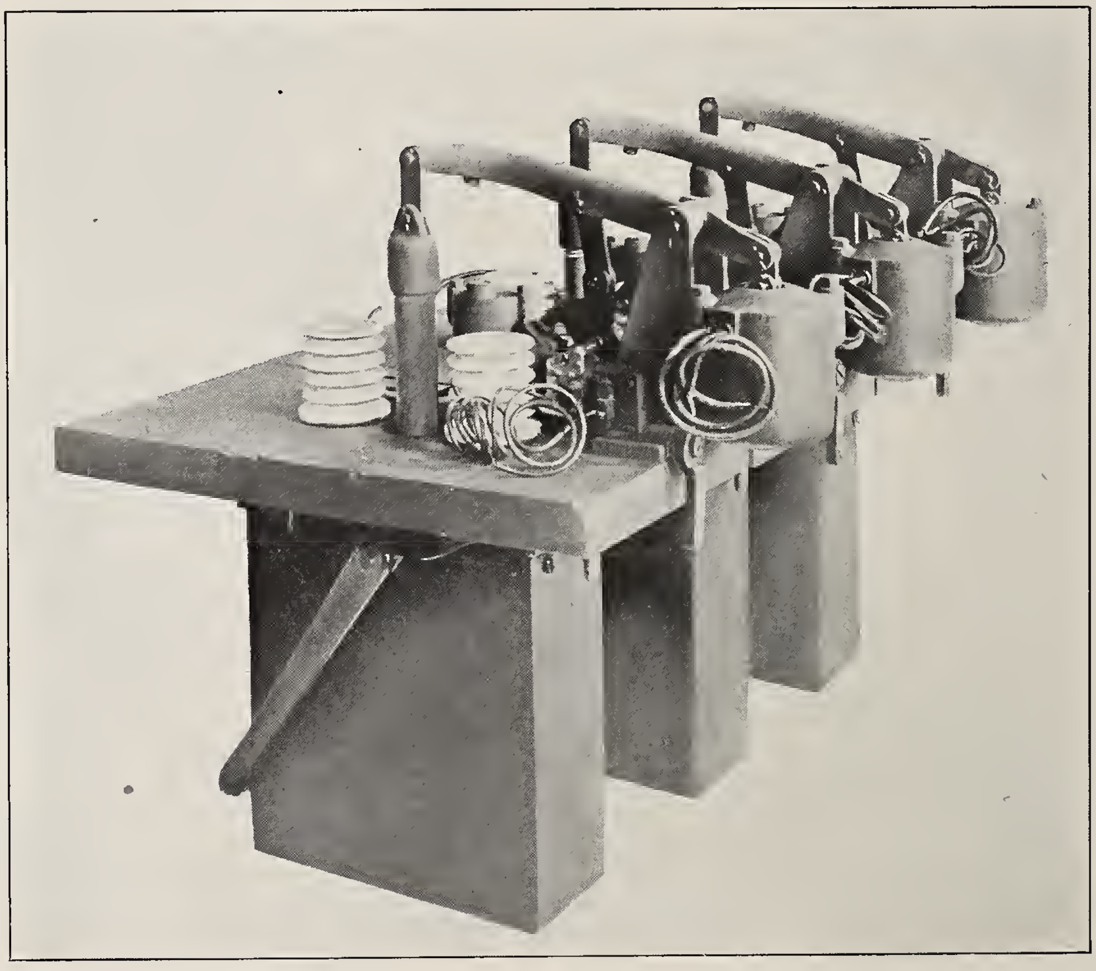
The series field coils are machine wound, then thoroughly taped to insure perfect insulation. The manner in which they are clamped to and held on their supporting rods is a simple one. The armature is wound with 10,000 turns of No. 41 magnet wire, thus giving to the meter, it is claimed, a torque from 20 to 25 per cent. higher, with less consumption of energy, than in the older types.

The retarding magnets are put through an artificial aging process requiring six months and, when put into the meter, are fully guaranteed to be proof against becoming weak, even in the presence of strong external fields. This quality allows the meter to maintain its accuracy indefinitely, the characteristic not changing after the meter is calibrated at the factory. The retarding disc is made from the purest aluminium obtainable and is accurately weighed and balanced before being assembled.

Another prominent feature of this meter is the "visual" bearing and "threadless" jewel post arrangement, allowing the detachable spindle point to be taken out and inserted again without the slightest inconvenience. No special tools are necessary, and the older and more awkward methods of renewing pivots are done away with. The "threadless" jewel post, as the name implies, has no threads, and is held firmly in position by a wire spring. Its insertion or removal requires but a moment, and no trouble is experienced from the stripping or binding of threads.

To prevent the brushes from getting out of alignment and to maintain a constant tension, they are mounted upon a moulded-lava support and firmly secured thereto. The alloy of which the commutator is made prevents tarnishing, and it does not turn black after being in service for a short time.

To overcome the friction of the bearings and enable the meter to measure accurately very small loads, a compensating coil is employed, securely fixed within the front series field coil and in close proximity to the armature. Its supplemental torque effect upon the armature is varied by cutting in or out of circuit a portion or portions of the turns comprising it. The terminals of the various groups of turns or windings of the coil are con-



THREE-POLE OIL CIRCUIT-BREAKER, MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG nected to corresponding contacts of a "multi-point" switch, having a small lever or arm which makes connection with any of the contacts, bringing into circuit any number of turns desirable. To compensate for friction, the lever of the switch is moved towards *F*, thereby cutting in turns of the compensating coil, and to compensate for creeping, the lever is moved towards *S*, thus cutting out turns from the coil. These changes require but an instant and are absolutely permanent.

To prevent the supports for the binding posts taking fire when poor or loose connections are made, the binding posts are made fireproof. No wood or other combustible material is employed, a specially prepared insulating fibre being used that is chemically treated with tungstate of sodium.

The meter is finished a semi-dull, hard-rubber black, with the nameplate silvered. The dials are extremely large and are made of porcelain. They have no constants and read direct in kilowatt-hours.

Wireless Telegraphic Communication at Sea

IN a recent trip made by the Cunard liner "Campania" from New York to Queenstown, says "The Daily News," of London, it was reported that wireless telegraphic communication was established with twelve trans-Atlantic liners, ten of which were bound for American and two for British ports.

When the "Campania" was 1200 miles from New York, wireless communication was established with the Cunard steamers "Saxonia" and "Invernia," the former from Liverpool to Boston, and the latter from Boston to Liverpool. The three vessels continued in communication at the same time for several hours, all the latest news from England and America being sent by the "Campania" to the other vessels.

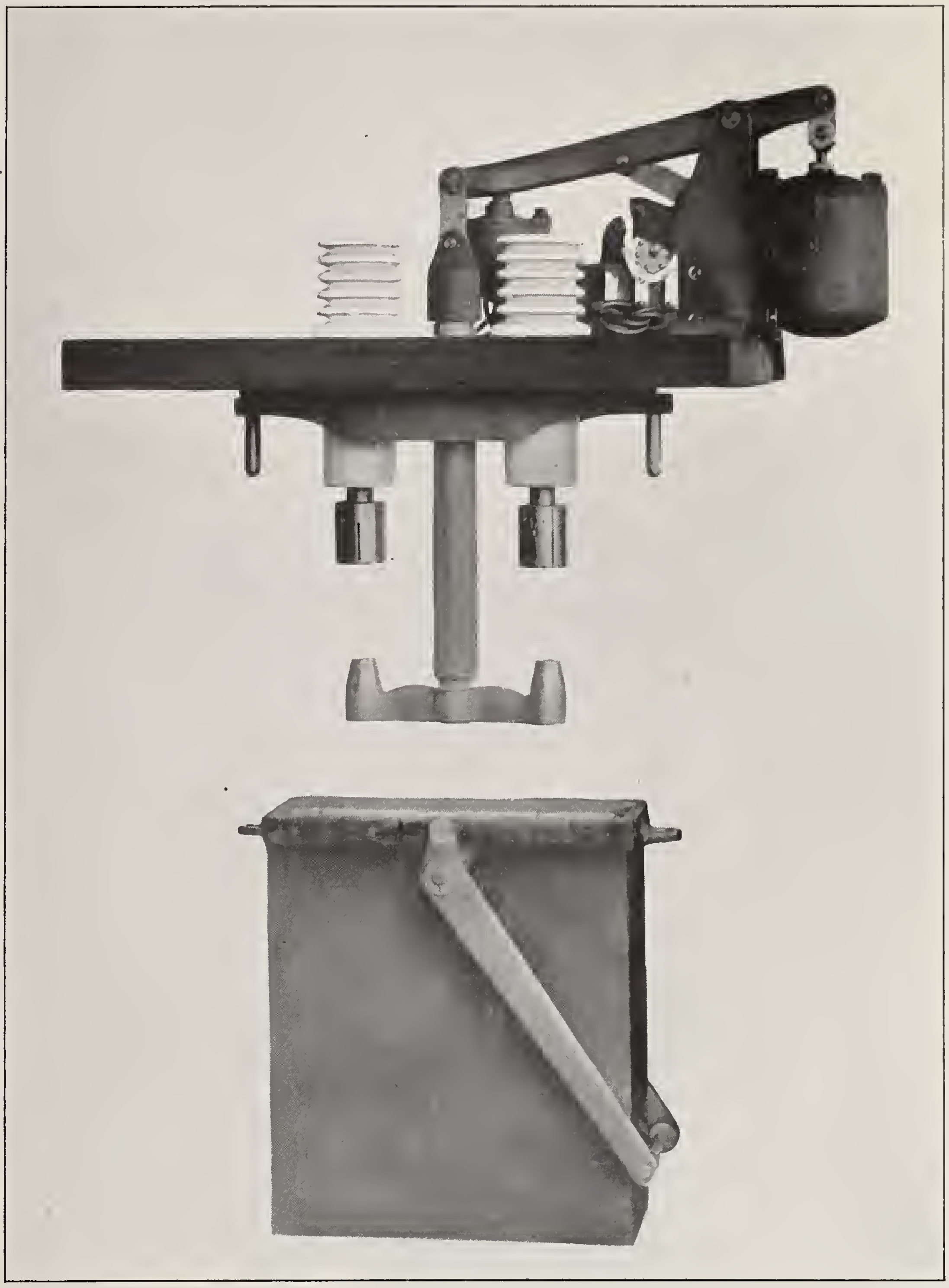
New Oil Circuit-Breakers

A NEW automatic oil circuit-breaker has been put on the market by the Westinghouse Electric & Manufacturing Company. It is listed as their electrically operated type E circuit-breaker, and is adapted to the most modern system of distant control. It is designed for pressures from 3300 to 25,000 volts. Systems of very high voltage and capacity have received much attention from engineers, but a definite demand has arisen for a piece of apparatus of somewhat smaller capacity, which shall be compact, reliable, and suited for electrical operation. The Westinghouse system of solenoid operation is especially adapted to such a form of apparatus and has been used in this new line of circuit-breakers.

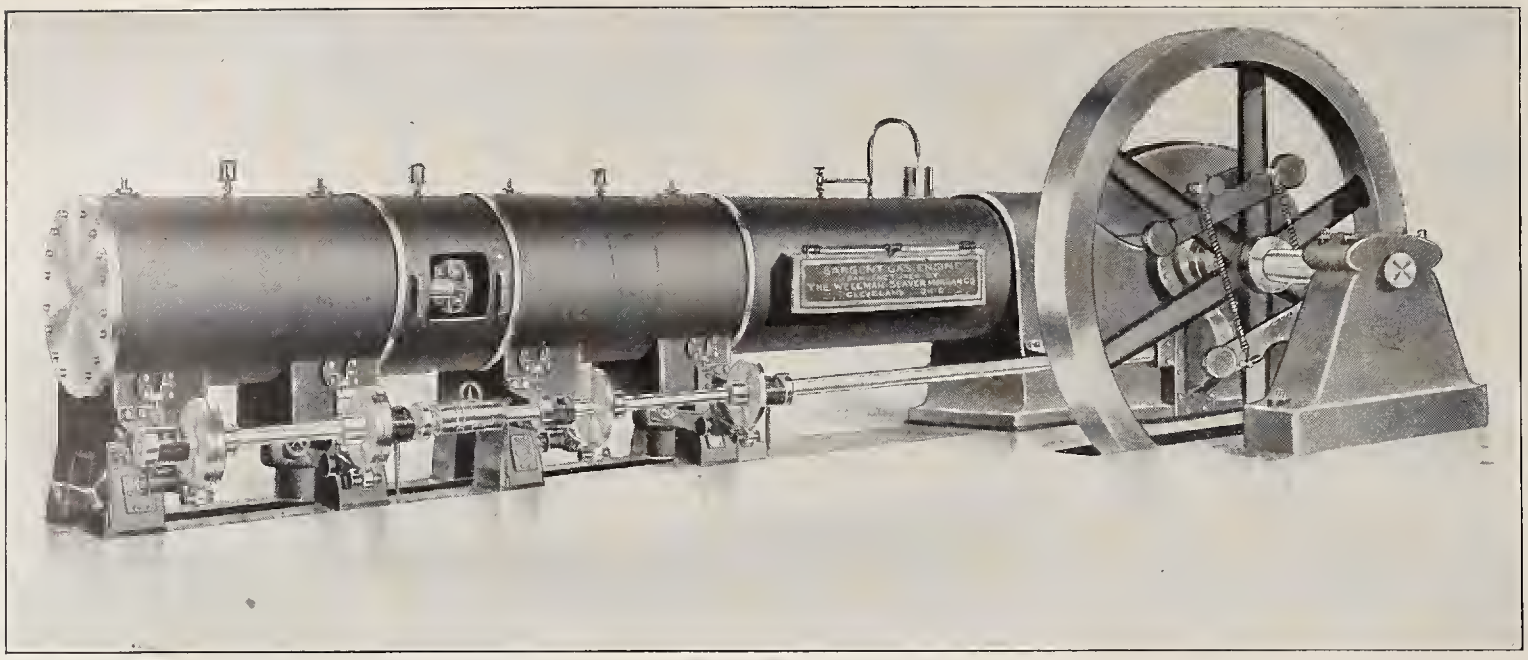
The circuit-breaker is made in single-pole units, each being mounted apart from the switchboard in a brick or concrete compartment. Two, three and four-pole combinations are made by placing the units side by side. The base of each unit is of treated soapstone and holds two heavy porcelain insulators, which carry the stationary contacts and the connection to the external circuit. The movable contacts are at the ends of a U-shaped metal casting, fastened at the center to a rod of treated wood, which is moved up and down by the operating mechanism in closing or opening the circuit. The final arc on breaking the circuit is taken by an arcing tip which may easily be replaced.

The contacts are of the typical Westinghouse design and deserve especial notice. The movable contacts are in the shape of truncated cones and fit into corresponding surfaces in the stationary contacts, which latter are made up of a number of copper springs. This arrangement not only gives a large area of contact, but insures a positive contact over its entire surface, and entirely prevents "freezing" under any condition of overload. The tanks are liberally insulated, and the inner surfaces are so shaped as to reduce the amount of oil required, and therefore the fire risk, to a minimum. The open position is in all cases maintained by gravity.

A simple system of levers and toggles is mounted on top of the base, and a powerful electro-magnet is arranged



THE SEPARATE PARTS OF THE CIRCUIT-BREAKER



THE SARGENT GAS ENGINE. BUILT BY THE WELLMAN-SEAVER-MORGAN CO., CLEVELAND, OHIO

with its movable core attached to the lever system so that when the magnet is energized the circuit-breaker will be closed. The standard voltage used on the solenoid is 125 volts. A second electro-magnet acts as a tripping coil, and this may be controlled by a relay of any desired type. A small single-pole, double-throw switch is mounted on the base and is operated by the motion of the levers in opening or closing this circuit; it controls the tell-tale indicator and lamp, which are mounted in view of the operator.

The entire mechanism is extremely compact and solid in construction, while the insulation has been carefully provided for. As in other Westinghouse oil circuit-breakers, the break takes place near the surface of the oil instead of at the bottom, where there is almost always a certain amount of sediment.

These circuit-breakers have no live parts exposed. The oil tanks are firmly held in position by special holders which, by the simple movement of a lever, may be removed and all contacts examined without disturbing any other part of the circuit-breaker.

The ultimate breaking capacity of the type E circuit-breakers is, for single-phase systems, 6000 K. W.; for two-phase systems, 12,000 K. W.; for three-phase systems, 10,400 K. W. They will open circuits of these capacities under any conditions of overload or short-circuit.

The Sargent Complete Expansion Gas Engine

IN addition to the Cockerill gas engine, described in these pages last month, the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, make also the Sargent gas engine, of which illustrations are annexed and which presents the following features:—

The expansion of burning charge to practically atmospheric pressure, variation of the point of cut-off of the admission inlet with the load, and advance of the time of ignition as the mixture gets weaker and the combustion slower. The advantages thus claimed over the ordinary gas engine are:—Increased efficiency, increased regularity in speed, and smooth running under early cut-offs.

The engine is of the 4-cycle, double-acting, tandem type, and the general design, as shown in the annexed illustration, is such that all the strains come in a straight line, and yet the free expansion of the cylinders and rods is provided for. The sub-base, the top of which comes flush with the floor line, extends from end to end of the engine, thereby giving a flat, planed surface upon which the engine is easily erected and aligned. The sub-base and main frame are bolted to the foundation, and the cross-head guides, cylinders and distance head, which fasten to the main frame, can come and go as the temperature varies, sliding on the hollow supports rising from the sub-base, which not only keeps the cylinders in line, but also conveys the gas and air from the hollow, divided sub-base to the explosion chambers, thus doing away with the pipes, ordinarily so unsightly and in the way.

The crank, connecting rod, cross-head and guides, while enclosed to keep dirt out and oil in, are accessible even while the engine is in operation, and a steady stream of oil can be seen at all times flowing upon every bearing, not only insuring perfect lubrication, but carrying the heat away, allowing overloading without injury to bearings or rubbing parts.

In the ordinary gas engine, the piston at full load draws in a cylinder full of combustible mixture which, after compression and ignition, is expanded to the original volume and released at a pressure of 40 to 50 pounds absolute and a temperature of from 1500 degrees to 1800 degrees F. In the Sargent gas engine the admission of gas and air at full load is cut off from five-eighths to three-quarters of the admission stroke, depending on the fuel used, and, after compression and ignition, is expanded to the cylinder volume and released a little above atmospheric pressure with a corresponding temperature of about 400 degrees F. This, it is claimed, keeps the cylinders at a lower average temperature throughout the cycle, engines below 100 H. P., therefore, requiring no water-cooled pistons or rods. The point of cut-off, also, while constant for the full and most economical load of the engine, is made earlier by the governor as the load gets lighter, or later as the load gets heavier, giving a flexibility unobtainable in the ordinary internal combustion engine.

The mechanism of the Sargent gas engine is distinctively simple:—A side shaft, driven by the crank shaft and governor through gears running in oil, carrying two cams for each explosion chamber, one for the igniter and one to operate the valve, comprises all the moving mechanism except the valves and lever, the other side of the engine being perfectly plain. The section through the valves of one of the explosion chambers is shown on on page 65. By removing six nuts, valve bushing and valves can be removed from the cylinder for regrinding or inspection.

Gas is piped to the chamber *A* in the sub-base and air to the chamber *B*, passing through the cylinder supports to the chambers *A'* and *B'*, and into the mixing chamber when the cam depression *MN* passes the roller and the ports F in the piston valve register with the ports E and D in the bushing. When the piston valve goes down to this position, the confined air in the piston-valve dash-pot forces open the poppet valve, thus giving free admission to the charge. When the point N of the cam reaches the roller, it is forced down, while the other end of the lever goes up, carrying the piston valve, and cutting off the admission. The poppet valve seats and both valves remain in normal position during compression, ignition and expansion, or until the point L on the cam pushes the roller down and the piston up, opening the poppet and allowing the exhaust gases to pass out through the ports K and the elbow W to the exhaust pipe under the floor.

The poppet valve seals the opening in the combustion chamber during the compression and combustion, and the piston valve, holding against no pressure, works loosely in its bushing, cutting off the admission and guiding the exhaust. As the poppet valve controls both the inlet and outlet gases, both the valve and seat keep cool and need to be ground not over once or twice a year. The mechanism is simple and, as the roller is always bearing on the cam, the valve motion is practically noiseless. By revolving the piston valve by the index wheel, the blind port S varies the mixture to suit the gas, whether it has 100 or 1000 B. T. U. per cubic foot.

The speed of the Sargent engine is controlled by a Rites inertia governor in the fly-wheel, which advances the valve shaft ahead of the crank shaft as the speed increases, thus diminishing the mean effective pressure with the load. As the load becomes lighter, the cut-off occurs earlier, taking less of a constant mixture of gas and air into the cylinder, but as the burnt products in the clearance do not get less, the mixture gets weaker and burns out more slowly. If the ignition were at the same point as at full load, as is the case in the ordinary gas engine, the highest pressure would not be obtained till the piston approached the middle of the stroke, where the cooling surface is so increased that the greater part of the heat goes into the water-jacket rather than into the work. In the Sargent engine, the time of ignition advances with the cut-off, getting earlier as the mixture gets weaker, thus maintaining the highest pressure at the beginning of the stroke, irrespective of the load.

While the governor controls the speed through all ranges of load, the gas engine, like the steam engine, is not economical with very light loads. Where a variation in the turning moment is not objectionable, one or more of the explosion chambers may be cut out at will by the engineer, by simply raising to horizontal position a controlling lever, which holds the exhaust open and the gas and air inlets closed. This is very desirable in blowing engines, as they can be designed so that two explosion chambers will furnish air at 15 pounds and four chambers air at 30 pounds pressure. If the engine is cutting off at three-quarters stroke at full load, an overload may be taken care of by a later cut-off, though at a decrease of efficiency.

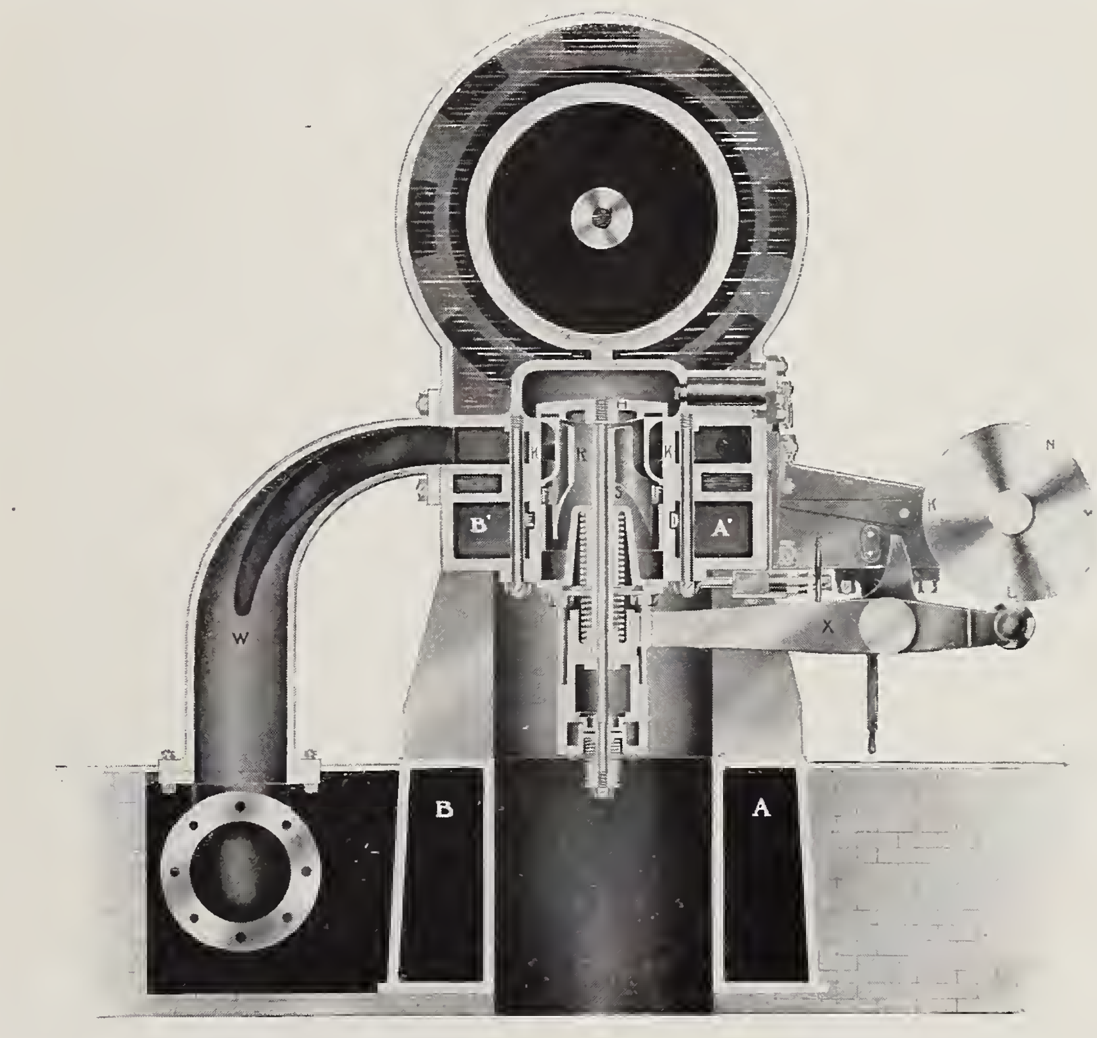
The cylinders are oiled by a force-feed pump or by check-valve lubricators. The valve gets sufficient oil from the cylinders. The side shaft and outboard bearings are self-oiling. The cross-head guides, pin, crankpin and main bearings, which must be thoroughly lubricated at all times, are copiously oiled by the gears which drive the side shaft acting as a pump.

Two electric igniters are placed in each explosion chamber in such a position that they are surrounded with a pure mixture at the time of ignition. Either will fire the charge, and should either become short-circuited, the engineer is immediately advised. The engine is started by compressed air which, when turned on at one cylinder, puts the starting mechanism into operation and at the same time puts the cylinder out of service for use with gas. When the engine is up to speed, turning off the air puts it into commission without changing a valve, cam or lever.

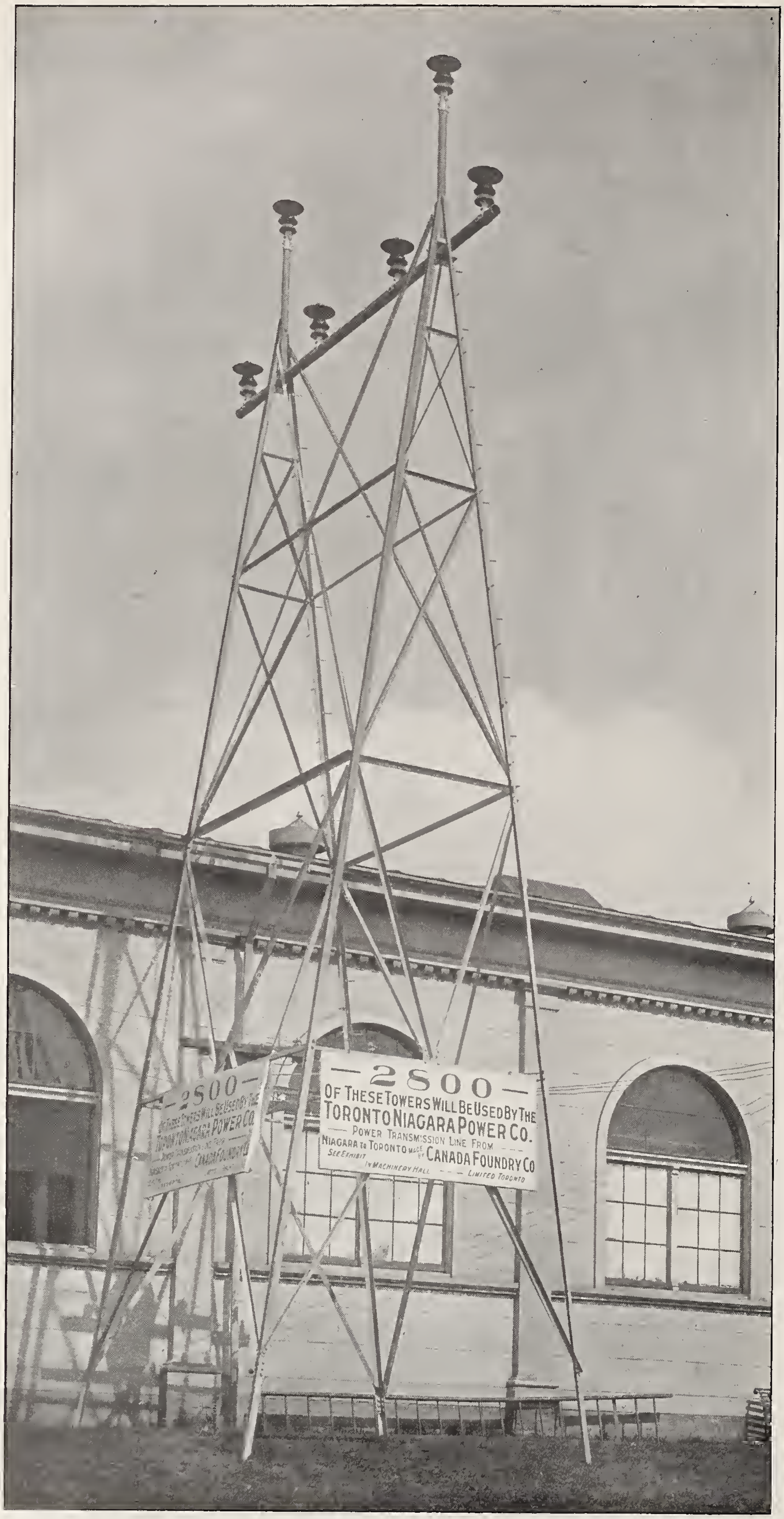
Every part of cylinder walls, heads, piston rod and piston is thoroughly water-jacketed to prevent overheating. Each valve, lever, timing screw and part requiring adjustment is readily accessible. All mechanism is above the floor line and below the center line of the engine. Each explosion chamber is accessible by simply removing the cylinder head, which can be done without further dismantling the engine. The time of ignition of the ratio of the gas and air may be changed while the engine is in operation.

Electric Cranes in a Basic Bessemer Plant

IN a new basic Bessemer works recently erected by the Chatillon-Commentry Company at Neuves Maisons, France, the entire manipulation of the ladle, both for charging and casting, is effected by overhead traversing cranes worked by electric motors. The shop is planned to contain four 18-ton converters and two gas-heated mixers, each of 220 tons capacity; but only three of the former and one of the latter are at present in use. They are all placed with their axes in one line, about 230 feet long, with the mixer at one end. The crane which runs parallel to this line, upon



VALVE SECTION OF THE SARGENT COMPLETE EXPANSION GAS ENGINE



ONE OF THE STEEL TOWERS BUILT FOR THE TORONTO-NIAGARA POWER COMPANY BY THE CANADA FOUNDRY CO., LTD., TORONTO

overhead rails, carried upon pillars about 40 feet high, has a span of 48 feet, with a maximum lifting power of 35 tons, which weight can be lifted 19 feet, moved sideways 33 feet, and longitudinally through the entire length of the shop.

The ladle is suspended by trunnions resting in open hooks at the ends of a pair of screwed rods, which can be raised or lowered by a reversible motor with worm wheel gearing on the traversing platform. The tipping is done by two similar rods, which bear against stops on the outside of the ladle. The metal from the blast furnace, brought by a steam locomotive upon an elevated railway, about half the height of the shop, is lifted by the crane to the receiving mouth of the mixer and poured in; the same ladle also takes the charge for the converters. The finished steel is taken by another ladle to the ingot molds, which are mounted on cars on a transverse line at the opposite end of the building, the same crane being used. This, however, is only a temporary arrangement, as a second crane, in course of erection, is to be provided for handling the finished steel, the first being reserved entirely for the mixer and charging converters.

The crane driving station is upon a platform suspended from one of the main girders, which carries the starting and reversing gear for the four different movements as well as the switchboard. Direct current at 500 volts is used with series motors capable of bearing a considerable overload; the transmission is partly by leathered gearing with raw hide pinions, and partly by leather belts with elastic couplings, in order to insulate the electric from the other working parts. The girder work of the crane has been built by Bietrix, Laflawe & Co., of St. Etienne, and the electrical parts by the Westinghouse Company.

Steel Tower for the Toronto-Niagara Power Company

THE annexed illustration shows an interesting steel tower recently made by the Canadian Foundry Company, Toronto, which, with 2800 similar ones, will carry the transmission line conveying power from the generating station at Niagara Falls to the distributing station in Toronto, Canada. The line will consist of four three-phase circuits, two circuits being carried by each line of towers.

The towers are constructed of galvanized steel angles, bolted together, with bracing similar to the usual design of wind-mill towers. They will be 46 feet high, with a base 14 feet by 12 feet. Lengthwise of the line each tower will have a uniform width of 14 feet from bottom to top, but crosswise the width of 12 feet at the bottom will diminish, the sides coming together at the top. A steel pipe forms a crossbar, carrying three steel pins, on which insulators will be placed on vertical steel pipes, so that the conductors of each circuit form an equilateral triangle, with a horizontal base of 6 feet.

The towers will be sunk about 6 feet in the ground, each support resting on a cedar block and braced with other blocks, upon which the earth will be solidly rammed. Wherever the nature of the soil demands it a concrete foundation will be used. The towers will be bolted together in a horizontal position and will be raised to the proper vertical position by means of a derrick. The tower is designed to withstand a side strain of 10,000 pounds applied at the top.

The towers will be spaced 400 feet apart, and where unusual conditions exist special towers will be provided. At curves the towers will be placed at shorter intervals, and so constructed that they will be equal to the strain without guys.

At the crossing of the Welland Canal towers of special height will be erected to allow the passage of vessels below the conductors, and the same will be done at the Hamilton Bay gap. The insulators will be of glazed brown porcelain, in three or four parts. The parts making up the insulator will be cemented together, and the complete insulator will be cemented to the steel pin. The insulator will be about 14 inches in diameter at the top of the umbrella, and about 14 inches high over all.

A New Single-Phase Integrating Wattmeter

A NEW integrating wattmeter made by the Westinghouse Electric & Manufacturing Company of Pittsburg, for use on single-phase circuits of 7200 and 16,000 alternations, is shown in the annexed illustration.

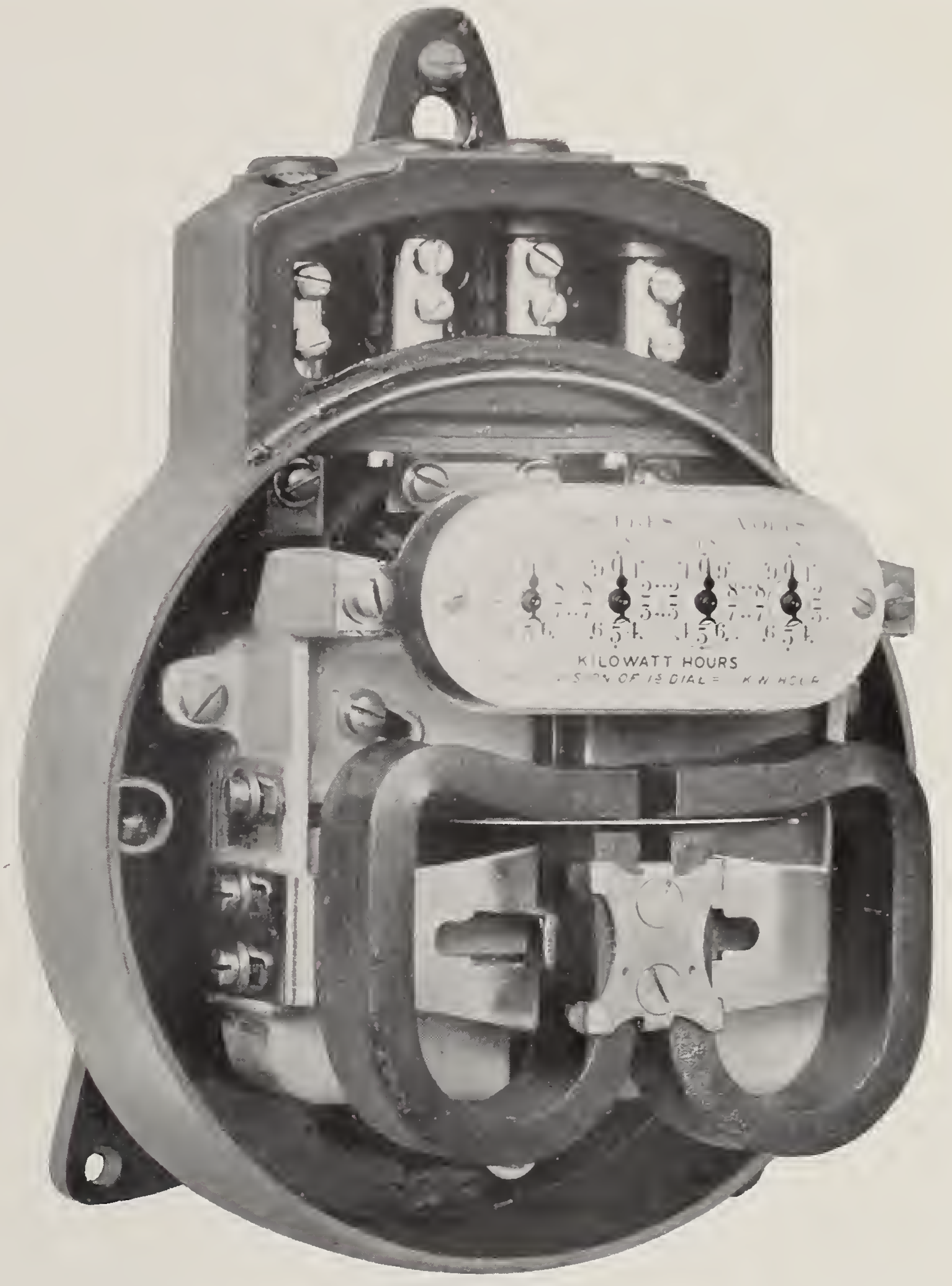
In every essential it follows the Westinghouse standard designs, the greater portion of the field being shunt wound, a small series winding combining with it to produce a torque on the disc. By this means good load-voltage and frequency curves are obtained. By a change in the design of the electro-magnet it is claimed that the effect upon the disc is made double that produced in earlier types, with the same small shunt loss, the same accuracy upon light loads and a minimum amount of variation in performance due to changes in voltage and frequency.

Glass or metal covers may be provided. The meter is compact in form, and can be installed in a small space, the front connections on the top of the meter case adding materially to the convenience in installation. The meter is sealed with the original calibration preserved under the manufacturer's seal, and requires no adjustment when put into service. It is only necessary to fasten the meter securely to its supports by three screws, to connect the line wires to the terminals, and to take the initial reading of the meter—work which an intelligent lineman can do as well as a meter expert. The shunt connection is permanently made inside the meter, so that it cannot be stopped by the removal of a shunt lead.

All of the working parts are attached to a single casting, giving strength and rigidity, insuring a perfect alignment, and reducing the liability of injury from jarring. The moving element retains the lightness of that of previous types, with a greatly increased torque. The magnets are well aged and mounted upon one bracket, insuring perfect alignment. Ajustments for frequency, speed and friction are conveniently located and easily made. At full load the disc makes twenty-five revolutions per minute.

The lower end of the shaft, upon which the rotating disc is mounted, is fitted with a sapphire jewel slightly cupped. A corresponding jewel is placed in the end of the adjusting screw which forms the lower half of the bearing, and in the space between the jewels a hardened steel ball is placed. The ball is slightly less in radius than the jeweled cups, reducing the friction to an inappreciable amount, owing to the smallness of the points of contact.

For the upper bearing, the shaft which supports the disc is drilled out at its upper end slightly larger than



A SINGLE-PHASE INTEGRATING WATTMETER MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., PITTSBURG the pin which is attached to the upper screw. The diameter is reduced at one point in its depth to form a bearing for the pin. At the bottom of the hole is placed a small piece of felt soaked with oil, capillary attraction causing the oil to creep upward to the bearing.

A four-dial counter is employed, its construction and the connection with the disc-shaft being such that no friction effects are perceptible. On meters of less than 3.84 K. W.-capacity the first dial reads in the tenths of K. W.-hour; in larger capacities the first dial records units.

The meter records directly without the use of a constant. It is claimed that the accuracy is not affected by reasonable variation in voltage, and that it records correctly from 2 per cent. of full load to 50 per cent. overload, and under all conditions of power factor and wave form.

Trade News

The J. A. Fay & Egan Company, of Cincinnati, Ohio, the largest builders of woodworking machinery in the world, have just added another triumph to their already long list, having, at the Louisiana Purchase Exposition at St. Louis, captured the "highest award" on band rip saws, the only tool they exhibited.

The complete World's Fair exhibit of the Weber Gas & Gasoline Engine Company, of Kansas City, which was in service in the Steam, Gas and Fuels Building during the Exposition period, has been sold to the Christopher E. Hertlein Company, manufacturers of dress and cloak trimmings, in New York. This plant consists of 150-H. P. Weber engine and 150-H. P. Weber suction gas producer, direct connected to a 75-K. W. Western Electric generator. This is the first producer gas power plant to be located in New York.

The Crocker-Wheeler Company, of Ampere, N. J., through their Pacific Coast managers, the Abner Doble Company of San Francisco, has secured a contract from the California Gas & Electric Corporation for three 4000-K. W., 25-cycle, three-phase, 13,200-volt Crocker-Wheeler type alternators. These machines will furnish current to operate the United Railroads of San Francisco, in accordance with a contract recently secured by the California Gas & Electric Corporation. They will be direct connected to Snow gas engines, the largest in the world for such service. The generators are to be of the revolving-field type of machine recently brought out by the Crocker-Wheeler Company, and the securing of the contract indicates that the important position this company has held in the direct-current field is also to be maintained in the alternating line. The generators are to operate at 88 revolutions. The installation of these three engine-driven generating units in San Francisco will mark an important step for the transmission company, as they will operate in parallel with the water power plants of the company, and thus serve as an important reserve plant for the entire system. One of the units will be used exclusively for handling the peak load on the railway lines.

The National Carbon Company, of Cleveland, Ohio, were awarded a grand prize at the St. Louis Exposition for all of their carbon products, including Columbia carbons for long-burning enclosed arc lamps, Columbia dry cells, carbon motor and generator brushes, carbon electrodes and specialties.

A contract awarded to the Westinghouse Machine Company, of East Pittsburg, Pa., by the Baltimore Electric Power Company, provides for an initial equipment of steam turbines of 4000-K. W. capacity in two units of 2000-K. W. each. Its unit and its auxiliaries have been arranged as a separate plant, though they may be connected when necessary. The turbines will operate under a steam pressure of 175 pounds, with 100 degrees superheat.

An electric elevator was recently shipped by the Otis Elevator Company from its works at Yonkers to the Grand Cathedral at Berlin for the exclusive use of the German Emperor.

The Brown Corliss Engine Company, of Corliss, Wis., have been awarded a contract by the city of Milwaukee for furnishing and erecting, at the North Point pumping station on the shore of Lake Michigan, one triple-expansion, high-duty, crank and fly-wheel, 20,000,000-gallon pumping engine. The amount of the contract is $64,500.

Following the close of the St. Louis Exposition, the 600-H. P. Westinghouse steam turbine generating unit in the Palace of Machinery was shut down after a continuous run of over 3962 hours. On inspection it was found to be in perfect condition, and there were no signs of wear, the bearings still retaining the tool marks as they had come from the shops. The machine was started on its long run at 9:20 o'clock on the morning of Monday, June 20, shortly after its installation at the Exposition, and was stopped at 11:32 o'clock on the morning of Friday, December 2. During the five and a half months that the unit was in operation it supplied current for light and power throughout the Westinghouse exhibits in the Palaces of Machinery, Electricity and Transportation.

The Wirt Electric Company, Inc., of Philadelphia, announce the removal of their New York offices to 15 Cortlandt street, where they carry a complete stock of rheostats, dimmers and brushes.

The J. A. Fay & Egan Company, of Cincinnati, Ohio, manufacturers of woodworking machinery, announce the opening of their new offices in Chicago, in the Railway Exchange Building. The offices will be in charge of Everett S. Kiger. The company will do all business in this territory direct, discontinuing Manning, Maxwell & Moore, of Chicago, as their agents. The company was awarded a medal at the St. Louis Exposition for the operation of one of its tools. No regular exhibit was made, but other companies used the tool in showing the manufacture of their products.

The International Jury of Awards at the St. Louis Exposition have awarded gold medals to the Weber Gas & Gasoline Engine Company, of Kansas City, Mo., for their gas engines and suction gas producers. The gold medal is the highest award made by the International Jury.

The Electric Controller & Supply Company, of Cleveland, Ohio, have been awarded a gold medal for their St. Louis World's Fair exhibit. This consisted of a full line of their regular controllers for crane, charging machine and similar service, a working exhibit of a magnetic switch controller, built for motors of any horsepower, magnetic friction and stop brakes, cushion type solenoids, electric lifting magnets for plates, billets, etc., resistance banks, knife switches, and a working exhibit of their direct-connected, variable-speed motor-drive for planers.

The triplex boiler feed pump made by the Goulds Manufacturing Company, of Seneca Falls, N. Y., and operated by a 40-H. P. electric motor, which was located in the boiler house of Machinery Hall at the St. Louis Exposition, has been purchased by the Lewis & Clarke Exposition Company, to be used for the same purpose at the Exposition to be held at Portland, Ore., in 1905. The company was awarded a gold medal for this pump, which supplied feed water for boilers of 4000 H. P. in the boiler house that furnished the power for Machinery Hall. Three other gold medals were awarded the company, one for the exhibit of power pumps in Machinery Hall, and one each for the exhibit of hand pumps, sprayers and spray fittings in Horticultural Hall.

One of the many attractive exhibits of the recent holidays was an electric kitchen in the large department store of R. H. Macy & Co., of New York, at which were shown many of the electric cooking devices made by the Prometheus Electric Company, of New York. Biscuits were baked and served to visitors, with other dainties and coffee, by the young woman in charge. The devices shown were baking ovens, physicians' sterilizers, radiators, chafing dishes, irons, coffee and tea pots, hot-water kettles, curling-iron heaters, food heaters, milk sterilizers, and discs for heating food in a kettle, pan or other receptacle.

The California Gas & Electric Corporation, of San Francisco, have just ordered from the Stanley Electric Manufacturing Company, of Pittsfield, Mass., two mammoth frequency-changing outfits of 5000-K. W. capacity each, amounting to virtually 20,000-K. W. capacity, divided between four machines operated as two motor-generator sets. These outfits are for use in connection with the contract which the California Gas & Electric Corporation has secured from the San Francisco Street Railway Company, and will change the 60-cycle current from the Bay Counties long-distance line to 25 cycles for further distribution among the sub-stations of the street railway company. The contract awarded the Stanley Company also includes transformers of 12,000 K. W.

The Allis-Chalmers Company has opened new sales offices at Philadelphia on January 1, in the Land Title Building. The offices heretofore maintained by the electrical department of the company, the Bullock Electric Manufacturing Company, in the North American building, have been removed also to the Land Title Building where they have been consolidated with those of the parent company. The new offices are under the charge of Mr. W. A. Wood, who will look after each of the interests of the company. These interests include the Power Department, the Electrical Department, Pumping Engine Department, Hydraulic Department, Saw Mill Machinery Department, Flour Mill Machinery Department, and others which produce rock crushing machinery, cement making machinery, wood preserving machines and plants, mine hoists and machinery of all other kinds for mining and recovering gold, silver, copper and other metals.

The Newhouse Mines and Smelters power plant and concentrator at Newhouse, Utah, just installed, and to be put in operation probably by the end of the month is noteworthy, in that it is the first American mining company's plant to use steam turbines for power work. The plant comprises two 400-kw. Westinghouse-Parsons turbines and is attracting much interest among electrical engineers and mining men in that territory. The Newhouse property, it may be here added, is likely to develop into one of the largest copper-producing mines in that section of the country.

The Abner Doble Company, San Francisco, California, engineers, established 1850, have been awarded the grand prize for their exhibit at the St. Louis Exposition of a 170-H. P. tangential water wheel. The wheel develops 170 H. P. at a speed of 700 revolutions per minute with a water pressure of 300 pounds per square inch, equivalent to a hydraulic head of nearly 700 feet. It is direct connected to a 100-K. W. railway generator and is one of the units of the intramural power plant. The wheel is of the tangential type with the Doble patented ellipsoidal buckets, and is provided with a Doble patented needle regulating-nozzle, operated by a governor. The sides of the wheel housing are made of plate glass so that the action of the water on the wheel can be observed. The quantity of water delivered to the wheel is measured by a Venturi meter with automatic recording instruments and the pressure of the water is registered by a recording gauge.

Recent Westinghouse Contracts

THE turbo-generator contracts closed by the Westinghouse Electric & Manufacturing Company during the last week of 1904 included two 1000-K. W. outfits for the Haverhill (Mass.) Electric Company, to be used in lighting and power work in that city; two 1500-K. W. outfits for the Rochester, Syracuse & Eastern Railroad, and one 1000-K. W. outfit with exciter, for the Springfield Electric Light Company, Springfield, Mass.; also a 300-K. W. turbo-generator with exciter for the Northern Electric & Manufacturing Company, of Montreal. The Springfield Electric Light Company's contract also included two 500-K. W. rotary converters and four 300-K. W. transformers.

The Westinghouse Company has also closed a contract with the Ontario Power Company for an alternating-current generator, with a rated output of 10,000 H. P. at 85 per cent. power factor. This is in addition to three other machines of similar type which the Westinghouse Company is furnishing for this plant. The generators are of the revolving-field, two-bearing type, designed for direct connection to water-wheels; they generate three-phase current at 12,000 volts and 25 cycles, and run at a speed of $187\frac{1}{2}$ revolutions per minute. Among other apparatus included in the contracts are twelve 3000-K. W., oil-insulated, water-cooled transformers, wound for 12,000 and 60,000 volts; two 375-K. W. exciters, and complete switchboards.

Messrs. P. N. Nunn and L. L. Nunn are engineers in charge, and the plant is being built by the Niagara Construction Company, Ltd., of which Gen. Francis V. Greene is president.

Still another Westinghouse contract, recently received through their agents, Takata & Company, of Tokio, is for thirteen direct-current generators, each of 62.5-K. W. capacity, and thirteen spare armatures. Each generator will be driven by a 125-H. P. steam engine, and the thirteen engines will be supplied by the Westinghouse Machine Company.

New Catalogues

Advance sheets of a new catalogue illustrating motors in paper-mill work have been sent out by the Northern Electrical Manufacturing Company, of Madison, Wis. The pamphlet illustrates and describes the plant of the Consolidated Water Power & Paper Company, of Grand Rapids, Mich., with the part played by the electric motor in paper-mill processes.

A new catalogue sent out by the Cincinnati Screw & Tap Company, of Cincinnati, Ohio, contains lists of sizes with illustrations of the many varieties of machine screws, bolts, studs, taps, taper reamers and pins, nuts, twist drills and Stubbs' drill rods.

Cranes and hoists of several varieties are illustrated and described in a new catalogue sent out by the Northern Engineering Works, of Detroit, Mich. The list includes electric traveling cranes and gantries, pillar and locomotive cranes, hand power and air hoist traveling cranes, and jib cranes operated by hand, air and electricity. Electric drum hoists are also illustrated, as are air hoists, electric trolley hoists and overhead track and trolley systems.

"More Juice" is the title of an unusually attractive pamphlet sent out by the American Electrical Heater Company, of Detroit, Mich. Several pages in the front and back of the booklet are devoted to illustrations and descriptions of the company's electrical heating devices, the remaining pages containing short articles on developing electric current sales, with a description of the practical use of electric flat-irons. "More Juice," in its general make-up, is somewhat out of the usual run of catalogues.

The Gisholt Machine Company, of Madison, Wis., is sending out a leaf illustrating and describing its exhibit at the St. Louis Exposition.

Pulverizing machinery built by the Jeffrey Manufacturing Company, of Columbus, Ohio, is illustrated and described in a new catalogue sent out by the company.

Steam turbine alternators, built by the De Laval Steam Turbine Company, of Trenton, N. J., are illustrated and described in a new bulletin sent out by the company. The pamphlet also illustrates turbine-driven centrifugal pumps, blowers, direct-current generators and motor-driven centrifugal pumps.

Suction gas producers are illustrated and described in a new catalogue sent out by Oskar Nagel, of New York. The producers are for use in connection with gas engine plants, and the pamphlet sets forth their advantages for this purpose.

Rotary converters are illustrated and described in a new catalogue sent out by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio. The main features of the machines are shown and briefly described, illustrations being also given of several installations.

A new catalogue of pumping machinery has been issued by Henry R. Worthington, of New York. Pumps for a great variety of service are shown. A diagram is given showing the arrangement of condensing apparatus for steam turbines, the various types of condensers being also illustrated. Steam accumulators, feedwater heaters, meters, electric house pumps and the several types of centrifugal pumps are also treated of in the booklet.

Rock drills and a variety of cutting machines for mine and quarry use are illustrated and described in a new catalogue sent out by the Ingersoll-Sergeant Drill Company, of New York. Several pages are devoted to channelers and gadders. Submarine drills, pile drivers, bolt drivers, an air lift system, air compressors and a drill steel sharpener are also illustrated and described.

The Tropenas converter steel process is illustrated and described in a new catalogue sent out by Powell & Colné, of New York, sole agents for the United States, South and Central America. The process consists in the conversion of pig-iron into steel for casting.

A new catalogue sent out by the Westinghouse Machine Company, of East Pittsburg, Pa., is devoted to the Roney mechanical stoker. This is illustrated and described in detail, many plants in which it has been installed being also illustrated. Illustrations are also given of the Roney triple-roll coal crusher.

Packing for steam and ammonia service is illustrated and described in a new catalogue sent out by the Goodsell Packing Company, of Chicago, Ill. Many varieties of fibre and rubber packing are shown, with a metallic packing made of fine white brass wire.

Condensers, vacuum pumps and exhausters are illustrated and described in a new catalogue issued by the Deane Steam Pump Company, of Holyoke, Mass. A recent development, condensing apparatus for steam turbines, is also described, the manner of connection being shown. Illustrations, data and a description of an automatic exhaust relief valve are also given.

An attractive leather-covered diary for the vest pocket is being distributed with the compliments of the Westinghouse Electric & Manufacturing Company. Aside from the diary proper, the booklet contains valuable information for electrical and mechanical engineers, several pages of maps and a considerable amount of useful miscellaneous data.

McLeod, Ward & Co., New York, are sending out a hanger calendar illustrating the well-known Kinsman specialties. These include electric lamp portables for desk, typewriter, piano, orchestra, pulpit and picture illumination.

The World's Fair judges awarded the F. W. Braun Company, of Los Angeles, gold medals covering practically their entire line of improved apparatus and appliances for assayers, metallurgists and chemists. The Braun Company's exhibit was arranged in three groups, and the highest award, a gold medal, was secured for each group. Among the medal winners were the following: Cary hydro-carbon burner, Marvel crude oil burner, Braun gas burner, Cary furnaces, Braun cupel machine, a complete line of ore-crushing and pulverizing machines, and the Braun ore sampler.

Canadian Control of Wireless Telegraphy

WRITING under recent date from St. Thomas, Ontario, United States Consul Burke says that the communication from the British Colonial Office recommending that the Canadian Government, in common with other British self-governing dependencies, take over the control of the wireless telegraphic systems has been referred to the Postmaster-General. There is little doubt that legislation will be introduced in Parliament to give effect to the wishes of the Imperial Government. The legislation would not, however, apply to the Marconi Company, which was incorporated a year or two ago, but to any others that may hereafter be incorporated. The Imperial Parliament has already passed an act to assume control of wireless telegraphy in the United Kingdom. The British Government's action is inspired by the fear that in private hands the wireless system, in time of national emergency, might be a great detriment to the state, as it would be possible for an enemy to intercept messages and interfere with plans of defense.

The World's Water Power

ACCORDING to George Johnson, statistician of the Dominion of Canada, the amount of water power used for electrical production throughout the world at present is over 2,000,000 H. P. Canada has over one-tenth of the whole. The United States figures are 527,467 and Canada's 228,225.

Magnetic alloys from nonmagnetic metals have been successfully produced in recent experiments. It has been found that with the same manganese that gave a practically nonmagnetic iron alloy a magnetic copper alloy may be produced. The nonmagnetic metals, copper, aluminium and managanese, combined in certain proportions, produce an alloy having considerable magnetic properties, but no combination of copper and aluminium produces a magnetic alloy; hence the presence of magnetic properties must be ascribed to the manganese. The three metals severally all remained non-magnetic when cooled to the temperature of liquid air.

Edwin Wilbur Rice, Jr.

Technical Director of the General Electric Company

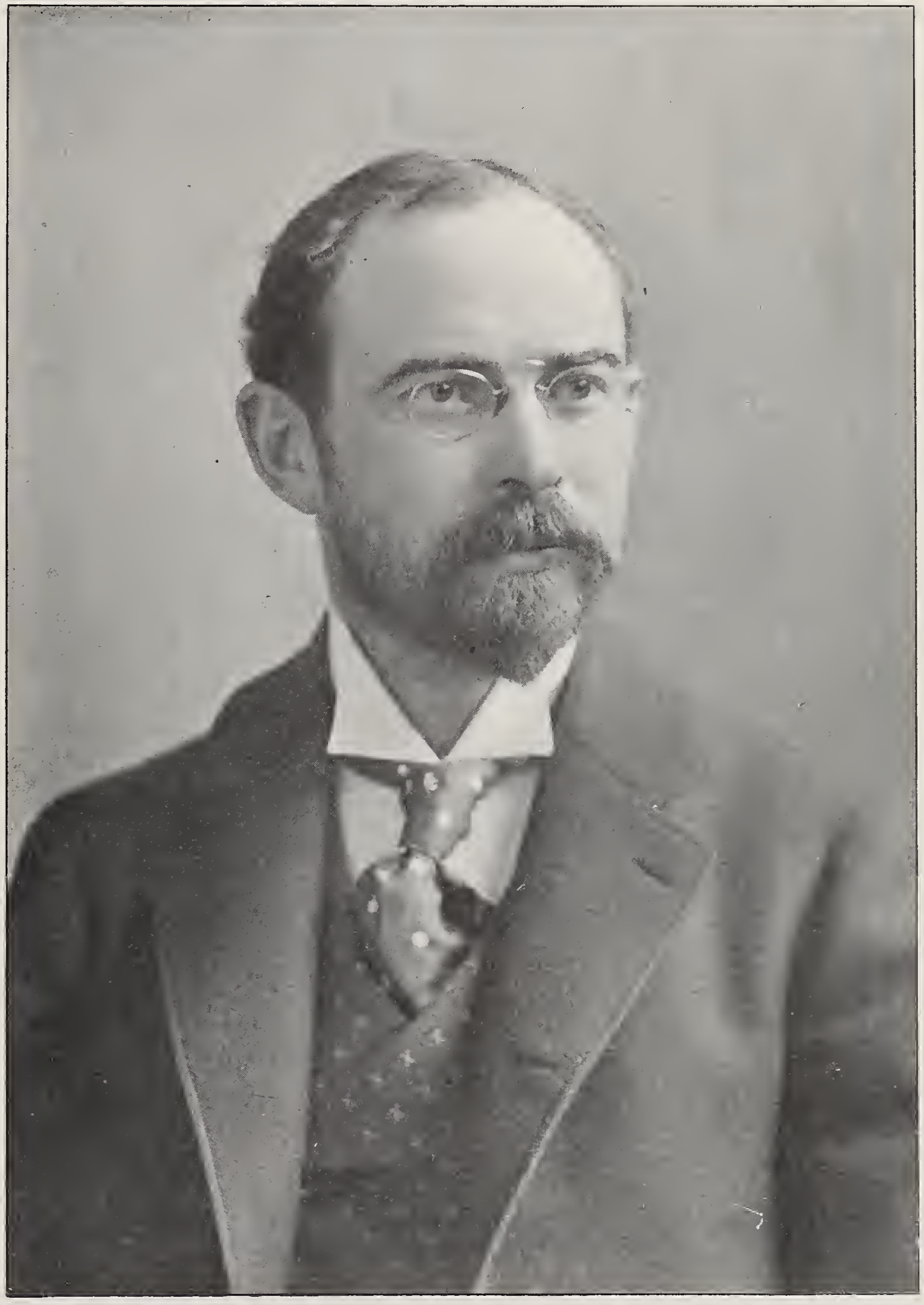
IN the building up of every great manufacturing organization there has to be some one man who is primarily the engineer. Such a man has pivotal individuality, expressed in the conception of ideas and in the overcoming of difficulties that arise in the reduction of ideas to practice. Among the strong personalities that have built up the organization of the General Electric Company, that of Edwin Wilbur Rice, Jr. is one that fulfills, in a singularly complete degree, the ideal of the modern engineer.

At eighteen, Rice graduated from the Philadelphia Central High School. During his last two years of school work he assisted his teacher, Professor Elihu Thomson, and showed an exceptional aptitude in making special apparatus. The fact that he graduated high in his class made the step he took in beginning his practical career a decision requiring a deal of resolution and knowledge of his own mind. This step involved the giving up of a college course, and, instead, the deliberate choice of electrical work with his old teacher, first at the little shop in Philadelphia, where the early arc light dynamos were built, and later at the works established by the newly formed American Electric Company at New Britain, Conn.

The two years that ensued developed the faculties of young Rice in a hard school of deferred business hopes, for "results" did not seem to come, in spite of persistent industry. Then came the memorable business visit of Messrs. H. A. Pevear and Silas A. Barton to the struggling New Britain works. Coming from Lynn to buy an electric light plant, their trip resulted in the acquisition of the business itself and its transfer to Lynn under the name of the Thomson-Houston Electric Company. Mr. C. A. Coffin's ability also became associated with the enterprise, and Rice had time to work at that which was nearest his heart,—the invention, often in conjunction with Prof. Thomson, of essential adjuncts of the "Thomson-Houston arc light system."

Many a bright young fellow, in his situation at this period, would have been stalled in a hopeless rut of mere experimenting. Rice was exceptional, with a progressive mind able to hold every gain in his work and to turn setbacks into useful schooling with its full fruition of experience and character. He lived with the business, becoming a factor, a human pledge of its ultimate success. And success meant that there was no room or time for anything but the most practical work. Dynamos and lamps had to be made quickly, had to find a market, and stay sold,—stern business conditions that kept young Rice's alert intellect well away from the narrow and impracticable, and sharpened his perceptions, by the same high destiny that ruled out the inoperative or uncommercial in the material product of the works. The backward glance upon his personality at this period shows how definite was his trend toward the constructive, how sure his grasp on essentials.

The hard-headed business men who had carried the new enterprise through to the beginning of its larger life had had their eyes upon Rice. They offered him the superintendency of the works, although he was still well under thirty years of age. His training had led up to just the very adequateness that his new work required. From the early days the overcoming of detail difficulties had formed in him the habit of meeting things squarely and giving a good ac-



A RECENT PORTRAIT OF EDWIN WILBUR RICE, JR.

count of them. To the old inventive faculty and resourcefulness he now had to add variants of these qualities,—grasp of the principles of shop system, ability to get work out of men, quick choice of the right course in the face of difficulties. The result is well expressed by his old master and colleague, writing appreciatively of him as he was at this period:—

"Under his able and tactful management, work was systematized, production hastened, and cost cut down."

Rice had arrived at his calling, and it was that of an engineer. When the consolidation of the Edison General Electric Company came in 1892, bringing with it the comparatively great increase of plant to be handled, it was but a more extended field for the exercise of these qualities; the rate of growth of the man fairly matched the larger issues. Expressed in externals, the Lynn methods of organization and factory management developed in scope, without change in principle, at Schenectady. The personal history of the man became the history of the General Electric Company's development of the electrical arts. In 1893 he became chief engineer, adding the duties of this position to his work as technical director, and in 1896 was made third vice-president of the company and placed in responsible charge of its technical and manufacturing departments. During that time,—or the last nineteen years,—he has been the man par excellence responsible for the harmonization of the technical with the commercial development of this corporation.

It is quite possible to trace the success of the man to its source. The channels of work through which Mr. Rice advanced required from the first that he be a discoverer of men and a judge of inventions. His resourcefulness, business ability and training made him eminently competent to handle a busy manufacturing plant; but it is his singular insight that enables him not only to see to the very bottom of the numberless new inventions to which his attention is directed, but to find also the special talents that may be latent in men. This faculty multiplies his personal efficiency enormously beyond that of the mere inventor, however prolific of ideas the latter may be.

The career of Dr. Charles P. Steinmetz, whom Mr. Rice may justly be said to have "discovered," furnishes a striking instance of his knowledge of men on his part. His selective faculty applied to inventions is equally keen. He recognized the essential value of the rotary converter, and led his forces to the successful attack of some knotty problems of its development, the timely solution of which gave his company a commanding position in opening up this field. The development of the modern revolving field generator was a kindred achievement. Although it was almost unknown in this country, he selected it in preference to the "inductor armature," using no moving conductors, which, he intuitively realized, was an extreme construction with inherent shortcomings. At a critical period in the history of the electric railway he favored the radical departure of taking the motor off the car platforms and flexibly suspending it from the truck. This step flatly opposed engineering precedent, but proved to be a long stride in the perfecting of electric traction. His immediate realization of the value of the carbon brush for commutation was a related instance, in which his remarkable ability to see the whole value underlying an invention helped notably to establish electricity in a new field of usefulness. Here was the work of an engineer,—the grasping of vitally important inventions and their use in a masterly, co-ordinate improvement of a whole art.

In the field of actual invention Mr. Rice has also shown much originality, and more than a hundred patents have been granted to him in this country.

His work in connection with the Thomson-Houston arc light system has already been mentioned. The supremacy of his company in the equipment of high-voltage stations and transmission is largely due to his talent and energy in developing devices and methods for handling and controlling high-pressure currents.

Drawn into the commercial execution of his ideas, he proved that he could not only invent and simplify, but could adapt his inventions and improvements to their manufacture, remaining always keenly alive to the commercial requirements of the present and future. From a factory of a few hundred men employed at Lynn when Rice took charge in 1885, grafted seven years later in the Edison Works, there has developed the present General Electric Company,—an organization employing a normal aggregate of over 20,000 men and utilizing 4,000,000 square feet of floor space at its three great plants. Under his hands a small plant for the tentative manufacture of arc lamps and dynamos has become the world's greatest works for the production of all appliances of modern electrical engineering.

With such a task as his a man must be a general, realizing his responsibility as the head of an army of material and financial forces, but undismayed by such responsibility, and clear-headed at all times in executing a steady forward movement amid conditions constantly changing. If disappointments occur whereby the most carefully laid plans are threatened by the failure of others to fulfill their contracts, he must have alternative plans, or must be able to evolve them, whereby the labor and money and material at his command shall suffer no interruption to its continuous employment. The enormous modern growth of electrical applications has intensified the value of this faculty to the electrical engineer, as compared with the builder of bridges or railroads. Indeed, the personal success which Mr. Rice has attained goes far to explain the prominence of electrical engineering among the older branches of the profession.

Mr. Rice is a member of the American Institute of Electric Engineers and of the American Association for the Advancement of Science in this country, and a member of the Institution of Civil Engineers and of the Institution of Electrical Engineers in Great Britain. After the Paris Exposition of 1900 he was created a Chevalier of the Legion of Honor, and Harvard University last year conferred on him the degree of Master of Arts. Quite recently he was made a director of the General Electric Company.

Personal

One of the large number of out-of-town engineers who were brought to New York by the meeting last month of the American Society of Mechanical Engineers was Asa M. Mattice, chief engineer of the Allis-Chalmers Company, of Chicago. Mr. Mattice

ASA M. MATTICE

is one of the several engineers of prominence who have gone into industrial life from the Navy. For a considerable period after graduation from the Naval Academy, in 1874, he acted as assistant to the engineer-in-chief of the Navy, and later, after having entered civil life, made a study of the application of electricity to power purposes. As chief assistant of Mr. E. D. Leavitt, of Cambridgeport, Mass., chief engineer of the Calumet & Hecla copper mines, he supervised the application of electric power to a number of the Michigan copper mines.

William C. Egbert, of Cleveland, formerly with the Globe Electric & Manufacturing Company, of that city, has become identified with the lamp department of the Cleveland office of the Westinghouse Electric & Manufacturing Company.

Horace F. Parshall, of London, who visited this country professionally a few weeks ago, is one of the early Thomson-Houston graduates. He went to England on business about ten years ago, and eventually took up his residence there. The first prominent traction installation designed by him was the Dublin Southern Tramways. This was the earliest installation in Great Britain worked on the multi-phase principle with substations.

H. F. PARSHALL

E. S. Lea, who is widely known as an authority on the subjects of turbines and centrifugal pumps, has resigned his position as sales manager for the De Laval Steam Turbine Company, and has opened an office at 42 Broadway, New York, as consulting engineer. Mr. Lea, prior to his four years' connection with the De Laval Company, had a wide experience in the designing and construction of power plants and water works, and in the manufacture of general machinery. Mr. Lea is a member of the American Society of Mechanical Engineers and an associate member of the American Institute of Electrical Engineers and of the American Society of Naval Engineers.

A. J. Wurts, of the Westinghouse Electric & Manufacturing Company, who recently resigned as manager of the Nernst Lamp Company, has been appointed constructing engineer for the Carnegie Technical Schools, of Pittsburg. In accepting this new appointment, Mr. Wurts does not sever

A. J. WURTS

his connections with the Westinghouse Electric Company, but will continue there in his experimental and development work, which has been of so interesting and successful a character. Not only did Mr. Wurts develop the Nernst lamp into a commercial article, but he also organized and developed a factory for making this lamp, thus carrying the work from its earliest conception through the commercial operations of manufacture. By continuing experimental work Mr. Wurts will keep in touch with the latest advances in engineering, and thus will be able to act more efficiently in his new capacity as instructor. His new appointment refers more particularly to the School of Applied Science where, as the development of the schools progresses, his attention will undoubtedly be more and more concentrated in the department of applied electricity.

C. C. Lewis, who for the last two years has occupied the position of chief engineer of the Schenectady Railway Company, severed his connection with that company on January 1, 1905, to enter the employ of J. G. White & Company, Ltd., at London. Mr. Lewis has been engaged principally to take charge of the work to be carried out by J. G. White & Company at Montevideo, Uruguay, this company having recently secured the contract to electrify the tramways at that place. Mr. Lewis has had an extended experience of over fifteen years in railway work. In 1902 he accepted the position as chief engineer of the Schenectady Railway Company, having charge of the construction and maintenance of the tracks, buildings, overhead and mechanical and electrical equipment, as well as the rebuilding of the electric line between Schenectady and Albany, and the construction of the Troy and Ballston line, which has recently been equipped for the operation by both the direct current and the new single-phase alternating-current systems.

C. W. Whitney has resigned his position as Pacific Coast representative of the McGraw Publishing Company, New York, and has become identified with the Abner Doble Company, of San Francisco, engineers and manufacturers of tangential water wheels and needle regulating nozzles. Mr. Whitney will have charge of the Abner Doble Company's publicity department.

Calvin W. Rice, consulting engineer for the General Electric Company, and attached to the New York offices, was one of the local reception committee on the occasion of the annual meeting, last month, of the American Society of Mechanical Engineers. Mr. Rice's extensive list of

CALVIN W. RICE

friends and acquaintances in the profession fitted him particularly well for the work to which he assiduously devoted himself during the convention week.

Gisbert Kapp, the well-known Anglo-German electrical engineer, who left England in 1895 to become secretary of the Verband Deutscher Elektrotechniker, will return to become professor of electrical engineering at Birmingham University. According to the terms of the appointment, Mr. Kapp will be allowed to practice as a consulting engineer.

W. J. Sando has been appointed manager of the pumping machinery department of the Allis-Chalmers Company, of Chicago, Ill. Mr. Sando was a member of the New York City Commission on Additional Water

W. J. SANDO

Supply and was associated with the Metropolitan Water Board, of Boston. Up to the time of his change to the Allis-Chalmers Company he had been with the International Steam Pump Company.

At the annual meeting of the Engineers' Society of Western New York, at Buffalo, last month, the following officers were elected for the coming year:—President, George H. Norton; vice-president, Horace P. Chamberlain; director, Alfred T. Thorn; secretary, Harry B. Alverson; treasurer, Frank N. Speyer; librarian, William A. Haven.

George S. Rice, who has been chief deputy engineer to the New York Rapid Transit Commission for several years, has been appointed acting chief engineer to succeed William Barclay Parsons, who will devote himself to private work and to the duties of his commission in connection with the Panama Canal. Mr. Rice was first employed by the city of New York in 1887 as the deputy chief engineer of the Aqueduct Commission. In 1888, he was made a Civil Service examiner for the New York Aqueduct Board by Mayor Grant, continuing in that office until he resigned as deputy chief engineer. The Aqueduct Board placed him in direct charge of remedying the defective work on the aqueduct. He occupied the place of deputy chief engineer until 1891, when he was made chief engineer of the Boston Transit Commission. In 1895 the rapid transit work performed by Mr. Rice attracted the attention of Mr. Parsons, and the greater part of the year 1895 was spent in working out with Mr. Parsons the original schemes for rapid transit for New York. At that time, 1895, Mr. Parsons expressed the desire that Mr. Rice assist him in the conduct of the rapid transit work, and in 1900 he was appointed deputy chief engineer. Since that time, during the absence of Mr. Parsons, he has acted as chief engineer. Mr. Parsons has, at the solicitation of the commission, agreed to act as consulting engineer to that body.

W. S. Montgomery, who was for many years sales manager for the Conover Condenser Company, and for the past year New York manager for the Payne Engine Company, has severed his connection with the latter concern and formed a partnership with G. M. Rogers under the firm name of Rogers & Montgomery, and with offices at 147 West Twenty-Third street, New York City. The new firm will deal in a general line of small labor-saving tools and hardware specialties, and are the exclusive United States sales agents for the new line of patented hand and press punches lately brought out by the Gem Tool Works, of Brooklyn, N. Y.

W. A. Layman, general manager of the Wagner Electric Manufacturing Company, of St. Louis, has vigorously pushed the interests of his company during the past year, and is now starting out on a new business campaign for 1905. Under his managership Wagner apparatus is rapidly extending its field of application.

W. A. LAYMAN

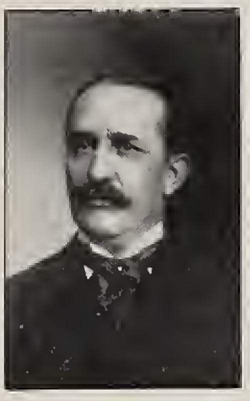
H. Schifflin was recently made assistant manager of the Mining and Crushing Machinery Department of the Allis-Chalmers Company, with headquarters in the New York Life Building, Chicago. Mr. Schifflin's connection with the mining and crushing machinery business began in 1886, when he entered the employ of the old Fraser & Chalmers firm as a draughtsman. After several years' experience there he joined the Chicago Iron Works as draughtsman and estimator, and in 1894, when these works were acquired by the Gates Iron Works, Mr. Schifflin was employed as a draughtsman and later as estimator and salesman. Mr. Schifflin has therefore been in the employ of the Allis-Chalmers Company or some of its constituent companies continuously during the last eighteen years.

H. SCHIFFLIN

O. A. Stranahan, whose experience has been entirely with the Westinghouse Companies, has been appointed manager of the power department of the Allis-Chalmers Company, of Chicago, and will have charge of the sales of steam engines, gas engines and steam turbines. He has been, for the past three or four years, in charge of the engine business of the British Westinghouse Electric & Manufacturing Company, and in that work has met with marked success. He has given much attention to gas engine developments, particularly with regard to producer and blast furnace gas, developments which are very much farther advanced in Europe than in the United States. His office will be at Milwaukee, Wis.

The annual election of officers and committees of the Franklin Institute was held recently in Philadelphia, Pa. The following officers were chosen: President, John Birkinbine; vice-president, Washington Jones; secretary, William H. Wahl; treasurer, Samuel Sartain; auditor, Dr. William H. Greene; managers: Edwin S. Balch, Walton Clark, Thomas P. Conrad, Charles Henry Howson, Louis E. Levy, Charles Longstreth, Isaac Norris and Coleman Sellers. The Institute's committee on science and the arts for the new year will be A. W. Allen, Hugo Bilgram, Amos P. Brown, Frank P. Brown, W. W. Canby, Kern Dodge, W. C. L. Elgin, Daniel Eppelsheimer, Jr., E. Goldsmith, Lewis M. Haupt, Lucien E. Picolet, C. J. Reed, James S. Rogers, Harrison Souder, George P. Scholl, E. Alexander Scott, Mr. Sellers, H. W. Spangler, A. H. Stewart and Martin I. Wilbert.

W. L. Loveland, the newly appointed head of the mining and crushing machinery department of the Allis-Chalmers Company, was graduated from the University of Michigan in the class of 1882, and spent the following eight years as a mining engineer and metallurgist, being actively employed during this time in mining and the erection and operation of mills and smelters. While so employed he gained a practical knowledge of the operation and construction of mining machinery and the requirements of the mining public. In November, 1890, he entered the employ of Fraser & Chalmers, of Chicago, manufacturers of mining machinery, as mining engineer and salesman, remaining in the employ of this company until February, 1897. He then entered the employ of the Winrow Gold Mining Company as superintendent, to erect and operate a concentration mill. In June of the same year he was appointed to the position of manager of the mining machinery sales department of the Gates Iron Works, Chicago. He remained with this company until 1901, when there was a consolidation with the present Allis-Chalmers Company, at which time he was appointed head salesman in the mining machinery department of the Chicago office. Mr. Loveland took up his new duties as manager of the Mining and Crushing Machinery Department on October 18, at the main offices of the Allis-Chalmers Company in Chicago.



W. L. LOVELAND

P. F. Kobbe has resigned as third vice-president of the Westinghouse Electric and Manufacturing Company on account of ill health. He has been succeeded by L. A. Osborne, who has been fourth vice-president, Newcomb Carlton becoming fourth vice-president. Mr. Kobbe will continue a director of the company.

J. W. Jones, of Dallas, Texas, has joined the sales staff of the Allis-Chalmers Company, of Chicago, and will hereafter represent the company and its widely varied products in Texas and its tributary territory. Mr. Jones began his business life as a machinist in the locomotive department of the Texas & Pacific Railroad. Then for nine years he was superintendent for the Paris Gas & Electric Light Company. Subsequently he built the Crook - Record plant at Paris, Tex., and operated it as manager for two years in opposition to the older plant. A combination of the two plants was effected through the efforts of Mr. Jones, who managed the two for a year afterward as superintendent. Later he joined the Southwestern Electrical & Construction Company, of Dallas, Tex., as traveling salesman and superintendent of erection for the plants which the firm installed. Leaving that firm, he was for three years in a similar capacity with Collins & Delaney, of Paris, Tex., and later with the Murray Company, remaining with the latter concern until the time of making his present arrangements with the Allis-Chalmers Company.

J. W. JONES

Charles Lang, formerly with the Wheeler Condenser & Engineering Company, has joined the sales department of the A. D. Granger Company at the New York office, 95 Liberty street. Mr. Lang will make a specialty of pumps and condensers, the A. D. Granger Company having recently acquired the agency for the Barr Pump Company, of Philadelphia, Pa.

John W. Lieb, Jr., vice-president of the New York Edison Company, and president of the American Institute of Electrical Engineers, has been presented with an order by the King of Italy. The jewel is in the shape of a Maltese cross, ornamented with white enamel. On one side is a representation of the crown of the kingdom and on the other the royal coat-of-arms.

P. G. Gossler, vice-president of J. G. White & Company, New York City, has returned from Porto Rico, where he recently went for the purpose of inspecting the property of the San Juan Light & Transit Company, of which concern he is now president.

S. M. Keeble, who has for many years been associated with the Frank Adam Electric Company, of St. Louis, and under whose management their switchboard business has developed into one of the most important of its kind in the West, has resigned his position and has assumed the position of general sales manager of the Cutter Company, with headquarters in Philadelphia. Mr. Keeble's familiarity with the circuit breaker and instrument proposition, the result of his long experience, ought to make his services of great value in his new position.

J. W. McCrosky, who was at one time one of the engineering experts attached to Theodore N. Vail's South American electric traction interests, and who is now on the engineering staff of J. G. White & Company, Ltd., of London, has sailed for Europe, after making a special trip to South America for the White interests.

Calvert Townley, until recently New York general sales manager of the Westinghouse Electric & Manufacturing Company, of Pittsburg, has entered the service of the New York, New Haven & Hartford Railroad and will, as assistant to President Mellen, have direct charge of all of its electrical interests.

Wallace C. Johnson, of Niagara Falls, N. Y., consulting engineer for water power transmission, was appointed by Gov. Odell the engineer member of the River Improvement Commission.

"Electricity vs. Gas" is the title of a pamphlet just issued by the National Electric Light Association for the use of its members who are threatened with Welsbach competition for street lighting. This paper was originally written by W. F. White for the 1900 meeting of the Ohio Electric Light Association. Mr. White has practically rewritten the paper, and has brought it down to date by adding data recently collected from cities and towns all over the country. The pamphlet is illustrated with reproductions from photography showing graphically the difference in street illumination by the two methods. It should prove of great value to the members of the association.

The new government laboratory at Manila is being fitted up with eight Bossert distributing panel boards and one switchboard made by the Bossert Electrical Construction Company, of Utica, N. Y. This company has made decided advancement in the lines of panel boards, switchboards and junction boxes, especially the last named, tending to increase economy and efficiency.

Salesmanship as an Applied Science

By R. U. CONGER

An Address Recently Made to the Agents and Inspectors of the New York Edison Company

THERE was a time and state of society when the business of selling,—merchandizing, was looked down upon. Trade was deemed ignoble and an occupation unworthy of gifted intellects and refined natures, but that time has long since passed away. At best, it was never more than a silly prejudice, based upon ignorance and narrow judgment.

Aside from a few small classes, there are but two methods of earning a living—acquiring or accumulating wealth—one through the production of commodities, and the other through the distribution of commodities, and, in final analysis, even the producer is a distributor, so that looking at it from that standpoint, we are all of us distributors—salesmen. We are engaged in a profession which, judged from the standpoint of possibilities and financial rewards, is the greatest profession in the world. Our merchant princes and captains of industry are but salesmen on the highest rounds of the ladder. Very many of them started in the most humble way, without pull or preference. They worked in harmony with the natural laws of success, either consciously or unconsciously, and their rise in the business world was natural. They, by dint of their daily effort, became a part of the cream of the business world, and cream will rise to the top, in obedience to a natural law. You cannot keep a squirrel on the ground, and you cannot keep a good man down.

Latent in the minds of successful men, there have existed laws, truths, and principles which make for success, and if we will only follow in the footsteps of these men, we, also, may be successful.

Herbert Spencer defines the word "Science" as "organized knowledge" —merely organized knowledge—and Spencer is a mighty good authority. Given knowledge—pertaining to any branch of thought or industry, correlate it, systematize it, analytically arrange and logically present it, and you have a science.

Before there existed any such science as astronomy, we had merely a chaotic mass of facts and truths pertaining to the heavenly bodies, known as astrology, and before there existed any such science as chemistry, we had a like mass of confused facts pertaining to the vital properties of matter, known as alchemy.

All knowledge is not scientific, as in these early stages this knowledge was not. Knowledge becomes scientific only when it is systematized, correlated and organized.

The world is a little confused as to the difference between the meanings of the words "science" and "art." Going back to their derivations, however, for an explanation, this confusion is easily cleared away. The word "science means knowing, the word "art" doing. We practice the art of music when we seat ourselves at a piano, but underlying that art of music is the science of harmony. We practice the art of selling, but underlying that art of selling is the science of salesmanship. This science of salesmanship underlies the selling of all things—railroads, or ribbons, threshing machines or electricity—just as the science of harmony underlies the art of playing any musical instrument, piano or violin, guitar or mandolin.

During scores of years, the same quality of mind which converted the commonplace observations of everyday life—the falling apple, the steaming kettle, the flash of lightning—into great and eternal principles has been engaged in behalf of the production of merchandise. In a similar manner, the details of successful experience have been wrought into equally broad principles governing the disposition of that merchandise for profit, and the vast number of facts and factors which lead to more successful salesmanship have been correlated, systematized, organized; in other words, a science of salesmanship has been created.

The intensity of competition, with its ever-increasing concessions, rebates and narrowing margins of profit, calls loudly for greatly increased efficiency in the selling service of every center of commerce. They call loudly for every man in that selling service to make himself genuinely fit.

The practical application of the laws and principles of salesmanship is the strongest factor in any conspicuous success.

The old customs are passing away; a new era in the sale of goods confronts us. The application of the principles of any science constitutes a profession, and a thorough realization of this fact will imbue us with the capacity and pride of the engineer, the zeal of the inventor and the emergency reserve of the superior executive. It will stimulate ambition—crystallize a more earnest purpose in life.

The first step in the organization of any science is, naturally, to arrive at a basis for the classification of knowledge, and in salesmanship this is very simple. But let us first define salesmanship. In its broad sense, salesmanship is the sale of goods for profit. It is the element of profit, great or small, which makes the transaction worth while. It is easy enough to dispose of goods, but it is to dispose of them at a profit that requires the exercise of salesmanship. Looking at it from that standpoint, the salesmen of the world are our business establishments. Their object is the sale of goods for profit, and, therefore, they are composite salesmen, and every one from the president of a company to the office boy, is a part of that composite salesman. He has his duties to perform, which go towards increasing or diminishing the margin of profit, and it is upon the share that he takes in this profit making that his salary or commission is based.

A few years ago I was in California and went into the redwood districts. I often noticed great oxen teams hauling redwood logs. Sometimes there would be as many as forty oxen yoked in one team. If they all pulled together, they could pull a mighty big load. Sometimes there would be a loafer in the team, one who simply walked along, and sometimes a bucker would lie back in the yoke. These loafers, or buckers, might not prevent the hauling of that log, but they hindered power, and it is just so in business. A few loafers or buckers might not wipe out that margin of profit, but they can materially diminish it.

There are but four kinds of salesmen. There is first the wholesale salesman, who sells in large quantities goods to be resold again; second, the retail salesman, who sells to the individual for his own use, consumption, or profit from an established base; third, the specialty salesman, who sells to the individual also, for his own use, without that established base where his customers comes to purchase, and fourth, the promoter, who initiates and organizes new enterprises. Wherever in business life we find ourselves, we must enroll in one of these four classes.

The next step in this classification of knowledge pertaining to salesmanship, is to determine how many factors enter into every sales transaction. There are just four of these also. There is first the salesman; second, the customer; third, the article to be sold, and fourth, an abstract thing—the sale itself. Yet it must exist, otherwise the first factor has not accomplished much.

It is a fact that all the laws and principles which govern success pertain to one or another of these four factors, and in what else I have to say, I shall merely take them up one at a time and endeavor to show some of these laws and their methods of application as we see them.

In a very broad abstract sense, salesmanship is the power to persuade others to buy at a profit that which we have to sell. It is the power to persuade people, and, therefore, it is this power of persuasion which we want to possess to a more intense degree.

Emerson said: "Not he is great who can alter matter, but he who can alter my state of mind," and, therefore, looking at it from that standpoint, the salesman is, unquestionably, the most important of these four factors.

In that word "salesman," the emphasis belongs on the last syllable—it belongs on the man. If you can make the man right, business is going to improve. I recognize, however, that it is a very easy thing for me to stand up here and say make the man right, and yet it is a very difficult thing of accomplishment. No one man can make another man right; he can only help that man to improve himself. We are not all born with equal capacities, but any of us can increase our efficiency from the standpoint we have already reached, by properly directed study, and that study should first begin upon ourselves. Here is an instance where we have sound premises to build upon. We know more about ourselves than any one else, and we can analyze ourselves as we can analyze no one else.

I occasionally have sessions with Conger, and when I get him upon the carpet I find there is but one way in which to go about this making Conger right, and that is, to analyze him. I can find but three divisions of him. There is his body, mind and soul. You can call the last the subconscious side of the mind, if you like, but there is something which we all agree is absolutely independent of reason and judgment, and the soul is as good a name for it as any other. Of course, from a physical sense, my body is made up of blood, bones and tissue, and so on, but in the abstract sense we are composed entirely of faculties and qualities. Our minds have the qualities of reason and judgment. Our bodies health and strength; our subconscious sides—qualities of loyalty, faith, courage and love in the sense of brotherly kindness.

There is a duality which runs all through nature. We have the positive of heat, with its negative cold; the positive light, with its negative darkness; and this duality runs all through these faculties and qualities. We have the positive of reason, with its negative irrationalism; positive judgment, with its negative injudiciousness; the positive health, with its negative illness; the positive strength, with its negative weakness; positive courage and its negative fear; positive faith and its negative doubt; positive love and its negative hate; and so on.

In this analysis, if we will be absolutely honest with ourselves, get clear away from the sin of self-justification, we will find we have many of these negative qualities, which hinder power, as well as the positive ones, which make for it, and we will find that these negative qualities are always our weak spots. In this making the man right, it is not enough to stamp out the negative, but we must build up and develop the positive qualities. We each have within us germs of all these positive qualities, and it is comforting to realize this fact, comforting to know there never was a man so hateful that he did not have flashes of love; so obtuse, that he did not have flashes of intuition; so fearful, that he did not have flashes of courage; and comforting, also, to know that we can develop these positive qualities by a scientific method of character building.

The two foundation stones of success in commercial life—in salesmanship—are character and health broadly defined. By character is not merely meant goody-goodism; a man may have a lot of that and go to the almshouse. Character is that central force of real manhood and true womanhood, born of a combination of these desirable positive qualities and faculties, and the net result of which is power to influence; and by health is not merely meant being able to eat three square meals a day, but that harmonious condition of the triune man—body, mind and soul—which enables the physical organs to perform their functions properly, and promotes the development of these positive qualities, to a marked degree, and it is this marked degree matter that counts.

These two foundation stones rest upon the bed-rock of education, and by education I do not mean alone that which they keep on tap in our universities; but going back to the derivation of the word for a clear understanding of the term, we mean the filling-in process of knowledge plus the drawing-out process of our own latent faculties and qualities, and the development of them. Colleges are not the only places where they have a corkscrew to draw these out. We are all but in the kindergarten of knowledge. Education, or the drawing-out process, goes on all through life.

Our colleges are good institutions. Harvard is all right. Yale is all right. Pennsylvania is all right. Knox is all right. But in the dear old college of hard knocks we get a great deal of this drawing-out process, and, as one of our living philosophers said, "We are all privileged to take several post-graduate courses in this institution." I have no patience with the man or woman who folds his or her hands and says: "Father was too poor to send me to college, and so I have not had a chance to get an education." If you cannot get an education, get it anyway. If a thing is impossible, do it anyhow. As Napoleon said, when confronted by the Alps, "There shall be no Alps," and there were no Alps for Napoleon.

In the brief time that I have, I can but merely challenge your attention to a few of the methods which mean most in the science of character building, in this drawing-out and development of our latent faculties and qualities.

The most potent factor in the science of man building is the law of suggestion. A little study of psychology makes this clear to us. I know that a great many people are scared away from the study of psychology, because it has such a long name, but the study of the human mind, it seems to me, is of wonderful importance.

The mind is the dynamic force which propels this human engine of ours, and why should a man not study that dynamic force, as he would study the dynamic force which propels a generator, were he an electrical engineer. There is much which the finite mind of man will never know about itself; yet there is much which has been taken out of the category of hypothesis and placed in the columns of demonstrated facts.

Scientists are well agreed that our minds are composed of two separate divisions, one the objective mind, and the other the subjective mind. Our objective mind is made up of the knowledge which we obtain through our five senses. I see you, I know you are present. I hear the street car, I know it is in the neighborhood. I smell the smoke, and I know a cigar is present; and so on. Then I reason a thing out by deductive or inductive reason and come to a definite conclusion, and this conclusion is a part of my objective knowledge. Thus knowledge, plus reason and judgment, makes up my objective mind.

These impressions are stored away in the other side of the mind—the storehouse of memory, which is a part of the subjective mind. The subjective mind is also a storehouse of the finer faculties and qualities, such as courage, faith, loyalty. Now this is an absolute law of nature. The subjective mind is amenable to suggestion, that is, it will obey suggestion. The subjective mind will obey suggestion from other minds and from environment, and we can also suggest from our own objective mind, to our own subjective mind. This is auto-suggestion.

Here is the gold in the ore. We can suggest to our own subjective minds that we have courage. We can make this positive statement, knowing it to be a scientific statement of fact. We know this is so and can convince ourselves by positive suggestions that we have courage and that we will be courageous. This makes it easy to do the simple things that require courage, and by doing them as they confront us, it becomes easy to do greater things requiring courage, and we can develop this quality of courage in exactly the manner that we develop the muscles of our arm. Bind this arm and what happens to it? It withers and becomes useless. Exercise it and it becomes strong. That within us which we do not use is dead for all practical purposes. We must use each faculty and quality and exercise it if we wish to develop it to a marked degree, and it is worth while keeping this in view.

Benjamin Franklin understood the effect of this principle, although probably not the principle itself, and he practiced it. He developed, without question, one of the strongest characters America has ever produced. You will probably remember he had a little chart beginning with courage, faith, loyalty, perseverance, honesty, which every morning he would read over, saying to himself: "I will be more courageous to-day. I will be more faithful to-day. I will be more loyal to-day. I will be more persevering to-day," and so on. And we can well afford to dwell upon this subject.

Courage is a great commercial asset with which few others can compare. It is essential in the administration, even in the household, in the government of servants. It marks the great editor. It marks the great merchant. It marks the great salesman. Its absence upon the part of a salesman absolutely kills his usefulness. Its absence is pitiable in a professional man. I do not mean physical courage, I mean mental courage, moral courage; and it can be cultivated just as surely as the rose in our garden.

I realize we cannot expect to develop all the faculties and qualities to a marked degree. If we did, we would be ideal men, and that is beyond the pale of our wildest dreams.

The difference between the ordinary and the extraordinary man is marked by the degree to which he has some of these positive qualities developed. A man will succeed who has some of these qualities developed beyond the ordinary man.

The mystery of the greatness of great men decreases in direct proportion with our nearness of approach to them, and why? It is because we recognize in close association which of these positive qualities have been developed as to make them stand out beyond their fellows.

I realize also that a man will succeed who has some of these negative qualities developed to a marked degree, but he succeeds, not because, but in spite of them. We all have known men who had some of the negative qualities, such as intemperance and licentiousness, developed to a marked degree, who were successful; yet they were successful, not because of their intemperance and licentiousness, but absolutely in spite of them. How much more successful would they have been had they the qualities of virtue and temperance developed in their places.

Some of the positive qualities are combinations, such, for example, as tact. Tact is the product of the positive qualities of intuition, judgment and brotherly kindness, and becomes a part of the salesman's personality, when intuition, judgment and kindness have been so cultivated as to enable him to quickly appreciate all the present and prospective circumstances surrounding the situation, and to say or do, with adroit skill, that which is most appropriate to the person, the occasion, the business in hand, or the ultimate end in view.

A cripple does not want any one to call attention to the fact that he is a cripple, as it would hurt his feelings. If he were to talk business with him, it would, therefore, be a lack of tact to do so. We all have weak spots and are cripples in a sense, and kindness, necessarily, must be an element of tact. This quality of tact you can readily understand is never available except through character reading, and this brings us to the second factor in a sales transaction—the customer. It is of tremendous importance that we should be able to read human nature, to mentally measure the customer—to get his mental diameter and mental circumference.

In the school of experience, we get much of this knowledge of human nature, and we have no great respect for the long-haired cranks in phrenology and physiognomy. I doubt if a man would allow us to feel the bumps on his head, if we so desired, when we called to sell him goods. There is much, however, to be learned from a study of basic and decided types, and as hard-headed business men, you cannot afford to cast aside the researches of scientific men along these lines.

Has it ever occurred to you that the world is divided into easily distinguishable classes of men—lookers and thinkers—and that it is very dangerous to attempt to handle the looker as you would the thinker, and the thinker as you would the looker? In this scientific reading of human nature, there is something which goes farther than anything else, of which we have thus far spoken, that is, the silent voice of intuition, which tells us what to do, and when to do it; it is the silent voice of the soul. Intuition is a sub-conscious faculty, absolutely independent of reason and judgment. I know a great many people think that women have a "corner" on this commodity, but they have not. It is a fact that women are more highly developed than men, but there is a reason for it. It is a generally accepted fact, that the intuitive faculty develops in direct proportion with the development of the other positive qualities, moral and spiritual. Custom, prejudices, heredity, and habits of life, have made women better than men. They are more moral and more spiritual, and, naturally, would be more highly intuitive.

It seems to me here is a place where the moral and spiritual in business life ripens into a wonderful commercial asset, for no man can estimate the dollars and cents value of the faculty of intuition.

We do not know the whys and wherefores, but we know that in our experience we have had our reason and judgment tell us to do one thing and our intuition another, and we found, after a lapse of time, that our intuition was right.

There is but one more point I wish

to make in connection with this second factor. Did it ever occur to you there are but two channels by which we can reach the minds of men? One is through the reason and judgment, the other through the emotions. How many salesmen make the great mistake of pounding away at the head all the time, forgeting that they might, occasionally, plant a solar-plexus blow upon the heart.

There is an old saying that every heart is a harp of 1000 strings. Professor Vaught says there are but 42, but 42 are a great many, and it is our duty as salesmen to reach and play upon those chords, and we can do so consciously, if we consciously know the methods.

Now for the third factor—the article to be sold. Science does much for us in this connection, and it is in the study of the simple laws of the science of analysis, synthesis and logic that we can accomplish a great deal. This will help us to know more about our own particular business. There are scientific methods by which a man can analyze that which he has to sell. If he will develop these analytical powers, he will be enabled to mentally dissect, literally pick to pieces, his proposition, so that every one of its salient selling features will be clearly and distinctly defined in his mind, and then, with the knowledge of synthesis, he can re-construct this analysis into logical arguments. He can so present its features that they will naturally appeal to the minds of his customer.

There are only a certain number of reasons why any man should buy any particular thing, and a thorough analysis from all standpoints of cost, standpoints of utility, standpoints of durability, standpoints of use, application principles and so on, will enable any salesman to fill his sleeve clear to the shoulder with salient selling features, and then he can let these out in their proper order, if he trains his mind to think in a logical manner.

The world to-day wants hard-headed logical thinkers and talkers.

The verbal cyclone, the human windmill, and the animated talking machines are out of date in the business of selling.

A pound of logic is worth a ton of talk.

Taking up the fourth factor—the sale itself, here is where the profits are made, and science does much for us, especially the science of psychology. I shall take up but one of these laws, however, because lack of time prevents my going very deeply into this, and it is the mental law of sale.

Did it ever occur to you that we, none of us, ever acquire anything by gift that our minds do not pass through certain definite processes? For instance, I may be walking in a garden; my attention is attracted to a rose. I take an interest in it. I desire it. I resolve to possess it, and I reach down and pluck it. Or, my wife picks up the morning paper, her attention is directed to a big headline "bargains." She reads a little further and takes an interest in it; still further, she desires it; still further, and she resolves to possess it; and the next morning she takes her little purse and trots downtown and does buy it. Her mind has passed through those four processes—attention, interest, desire and resolve to possess.

In the rapidity of their action at times, these processes may be so close together that they seem simultaneous, but there is a dividing line. This is the law—attention properly sustained develops into interest. Interest augmented becomes desire, and desire intensified ripens into resolve to buy. You cannot get away from this law any more than you can get away from the law of gravitation if you jump off the top of a barn. This law was very forcibly illustrated a few years ago during the bicycle craze. You have all seen men riding to work on the backs of bicycles who could not afford to have a warm lunch, when those machines cost anywhere from $100 to $125. Their attention had been attracted to them, their interest aroused, their desire created, and their resolve to buy intensified until they bought those bicycles in spite of their reason and better judgment, in obedience to this natural law.

Advertising is but salesmanship by a literary method, and sometimes resolve to buy has been created before the salesman sees the customer, and in this case all he had to do was to wrap it up and get his money. Then the clerk of the order-taker type does the business, but, assuming that the advertising had only called the subject to the attention of the customer, or even aroused interest, it is up to the salesman to intensify that interest into desire and to make it resolve to buy. The highest type of salesmanship is that which is required to carry a customer's mind through all four of those processes.

He must command attention, arouse interest, create desire where desire did not exist before, and make that resolve to buy.

This is an exact law of nature. The influence of your suggestions upon the sub-conscious mind of a man, are in direct proportion with the intensity of his attention. People sometimes might consider this as hypnotism, but a slight review will clear our minds. Hypnotism is merely suggestion carried to its ultimate. You remember we said the sub-conscious mind will obey suggestion. If we can set aside the objective mind of a man entirely, our suggestions will go direct to his sub-conscious mind and he would obey them. All who have seen a hypnotist work, will remember that he will focus the eyes of his subject upon some very bright light, or will close the eyes to make the optic nerve inoperative; he would have nothing odoriferous around; he would have everything absolutely quiet to shut off the sources of the objective impressions. Then he must have a willing subject, one who is willing to be hypnotized, one whose reason and judgment are in harmony with the operator's. Now, if just for the space of a second he can get the objective mind set aside and have his will and judgment in harmony with his, if he says to the subject, "You are a king upon the throne," he is a king on the throne in his mind. If he says "You are a ditch-digger," he will get right down and dig a ditch. Why? Because his subjective mind is amenable to suggestion and will obey suggestion.

Now this condition you cannot get in a business transaction. In the first place, we do not have very willing subjects, and in the second place, the mind of a customer is trained to focus his objective forces upon a business transaction, and, in the third place, it would be impossible to get a condition where there were not detracting influences or interruptions.

We could not hypnotize a man to do business with him if we wanted to, and we would not want to if we could. But the influence of your suggestion upon the sub-conscious mind of a customer is in direct proportion with the intensity of his attention, and this thought is well worth while remembering.

"The world stands aside for the man who knows where he is going." It is for us to know where we are going.

Lincoln, at 22 years of age, said: "I will study and get ready, and then maybe the chance will come." Opportunity is our next door neighbor. She is like a wise young woman who engages the attention of many men, hoping to find one who is fit to develop her latent powers, but opportunity is a mighty good judge, and we must make ourselves fit, if we would wed opportunity.

So all these laws, principles and truths of which I have spoken, would be as faith without works were it not for one other law, that is the eternal law of "hustle."

It is this law of hustle that makes us realize that the reason most men do not accomplish more is because they do not attempt more.

It is this law which makes us realize that genius is only energy intensified.

I never think of that word genius that I do not recall what Paderewski said to Queen Victoria. She had commanded him to play before her, and afterwards complimented him upon his genius, and he answered:

"Yes, your Majesty, the world now calls me a genius, but there was a time when I was only an ordinary piano player, yet I made up my mind that the world should call me a genius; so I practiced hours, days, weeks, months and years, and finally the world called me a genius. But before I was a genius I was a drudge, and that is what we all must be, not in the sense of slaves, but in the sense of loving labor for labor's sake and the rewards that it brings."

I never think of this law of "hustle" that it does not make me realize the value of the margins of time.

You remember what Garfield said when asked why he was the best Latin scholar in the university. "You know Jones, who recites next best to me, well, his room is right across the campus there, and I can see his light, and I have learned that he studies his Latin lessons the same hour I do, which is just before we retire, so I watch his light, and when I see that light go out, I study fifteen minutes longer, and there's where I've got him." That is the principle that carried Garfield from the canal boat to the White House.

Other things being equal, it is the hustler who hustles as long as the next best hustler, then hustles fifteen minutes longer, who breaks the record.

This philosophy is summed up in Hamilton Wright Mabie's expression, "Practice makes for skill, discipline for character, and the accumulation of knowledge for intelligence; but none of these processes bear their ripest fruit until by vital assimilation they pass on into culture and become a part of the man himself."

Knowledge has definite stages. A man must not only look, but see; not only hear, but understand. Knowledge passes from the stage of knowing to understanding, and then to the next stage, realization, and there is a vast difference between knowing a thing and realizing it.

Then, on to the stage where it becomes a part of man. This last stage is faith. There are five links in this chain of faith: First, faith in God; second, faith in ourselves; third, faith in our fellowmen; fourth, faith in our business; fifth, faith in our employers. When we have the chain complete it becomes literally true, that "According to your faith, be it unto you."

Faith is founded upon knowledge, and to have that knowledge we must read, study and think more than is absolutely necessary. We must not be content with knowledge sufficient for the present need, but must seek additional knowledge and stow it away for an emergency reserve. It is this emergency reserve which fits us to meet the ever arising conditions which daily confront us and make men of us.

The world wants men—large hearted, manly men—men who will join in chorus and prolong the songs of labor and of love.

The age wants heroes—heroes who will dare to stand together in the solid ranks of truth.

Electrification in the Cascades

BOTH the Northern Pacific and the Great Northern Railroad companies are seriously considering the problem of using the water power in the Cascades to haul their trains over the mountains. The coal consumption is so enormous in the mountains that the railways would be glad to adopt electric traction if the electrical engineers could prove the economy of it. According to "The Iron Age," an expert from one of the largest electric manufacturing companies has recently spent several weeks on the coast investigating the possibilities of electric traction on the Northern Pacific in Washington. The Great Northern's motive power department has also given a great deal of attention to the problem.

The Northern Pacific owns coal fields on both sides of the mountains. It has mines on the western side of the Cascade in the Carbon River district about 35 miles southeast of Tacoma. Its principal mine is at Roslyn, on the eastern side of the mountains, a few miles from the Stampede tunnel. This mine is producing 1200 tons a day. The coal costs the company about $1.35 a ton. The Great Northern is not so fortunate in its coal supply in the mountains. It buys a great deal of coal from the Northern Pacific. The development of its mines at Crow's Nest Pass, British Columbia, on the Canadian Pacific, will make it more independent in its coal supply. It now has a branch running north from Rexford, Mont., to its mines. The greater part of the coal for the Great Northern is brought through the lakes from Ohio. It also brings about 250,000 tons of coal a year from Illinois mines. This coal costs considerably more than that brought through the lakes, but it furnishes northbound tonnage for the Burlington.

Along both the Northern Pacific and the Great Northern in the Cascade country there are a great many water powers which could be utilized in generating electricity. On the Northern Pacific there are fifteen or twenty points from which it could get electric power. Coming out of the Stampede tunnel at its eastern end the attention of travelers is called to a cascade that drops down the face of the mountain from a great height. There is sufficient water power at this point to install an electric power plant. The question of installing electric plants in the Northern Pacific's coal fields is also under consideration.

At the meeting of the Conference Committee on the United Engineering Building, held on January 7, Alfred R. Wolff was unanimously appointed consulting engineer for the heating and ventilation of both the United Engineering Building and the Engineers' Club, to be erected at Thirty-ninth and Fortieth streets, under the Carnegie gift to engineering of $1,500,000. C. O. Mailloux was selected as the consulting electrical engineer for the United Engineering Building and the firm of Bates & Neilson were selected as consulting electrical engineers for the Engineers' Club. All these gentlemen are well known in connection with the execution of large work of the class named in New York and vicinity, in addition to which they are prominently identified with the organizations that will occupy the buildings in question. Mr. Wolff and Messrs. Bates and Neilson are also members of the Engineers' Club of some years' standing, and Putnam A. Bates was for a long time district engineer for all the Crocker-Wheeler installations in the New York territory.

The National Electric Light Association has just issued a report on thawing water pipes by electricity. This report is compiled by George S. Haley, of Rutland, Vt., and comprises data received from seventy-five different companies who have already had experience in this direction. The report will be gladly welcomed by those members of the association located within the frost belt.

It is reported that portions of the West Shore Railroad are to be electrified within the next year. Connections are to be made at convenient points between the West Shore proper and the new suburban trolley system which the Vanderbilt interests are developing in the central part of New York State.

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The Jungfrau Electric Railroad

By D. A. WILLEY

THE railroad which has been so nearly completed to the summit of the famous Jungfrau mountain, in the Bernese Alps, in Switzerland, presents many interesting features of electric railway construction. While Guyer - Zeller, who conceived the idea, did not live to see the line utilized for transportation, it had been so far completed before his death as to prove the practicability of the project. Thus far, nearly ten years have been occupied in the construction of the line, and it is not unlikely that cars will be running to the terminus within the next two years. As it is, the system is ready for operation to what is known as Eismeer station, and by far the most difficult portions have been constructed.

The crest of the Jungfrau is 13,668 feet above sea level. The railroad which is to transport tourists to within 242 feet of its highest point begins at an altitude of 6772 feet, and when completed its total length will be $7\frac{3}{4}$ miles. From the station of Kleine Scheidegg to the proposed terminus, the route may be likened to a gigantic fish-hook or horse-shoe, one arm of which is more than double the length of the other, for the lower portion describes a long curve before entering the heart of the mountain itself. By following this route considerable tunneling was avoided, but, as it is, some of the most extensive tunnel work in the world can be seen on the middle and upper portions.

The principal excavation is located between the stations known as Eigergletscher and Eismeer. This is 6 miles long and, in addition to the excavation for the roadway itself, contains several stations chiseled and blasted out of the solid rock. Each is of such dimensions as to provide space for an office, a restaurant and a waiting room. Two of them might be called underground hotels, since they have sleeping accommodations for the few tourists who may desire to remain over night to view the scenery. A pass or gallery has been cut from each station to the side of the mountain, so that tourists may obtain the proper points of vantage. The upper section of the line will terminate in the mountain directly beneath the summit. There an elevator is to be constructed which will carry passengers 242 feet from the station to the observatory to be constructed at the top.

With grades ranging from 6 to 25 per cent., a rack rail system was determined upon, with electricity as the motive power. Electricity is employed also for heating and lighting and for operating the elevator already mentioned. The three-phase transmission line, consisting of three bare copper conductors one-third of an inch in diameter, is supported by porcelain insulators carried on wooden poles 33 feet high and 100 feet apart.

The working pressure of 500 volts is obtained through transformers in stations at Scheidegg, Rothstock, Eigerwand and Eismeer. From the entrance of the large tunnel onwards, the high-tension line runs in a recess in the side of the tunnel wall, and is closed in and guarded against accidental contact by means of a close metallic network.

The trolley wires consist of two copper wires about a third of an inch in diameter, supported at a height of 13 feet above the rails by $\frac{1}{4}$-inch steel span wires attached to poles at the right and left of the track. The trolley wires are doubly insulated from the earth,—once at the insulators supporting them, and once at the attachments of the span wires to the poles. In the tunnel the span wires are attached to bolts cemented into the walls. The rails constitute the third conductor.

At present the necessary current, not only for operation but also for the construction of the railway, is transmitted from the power station at Lauterbrunnen, a distance of 6 miles from Scheidegg. The watercourse known as the White Lutschine furnishes the motive power for driving the generators. The water is carried through steel piping 6 feet in diameter. The total head is 135 feet. The hydraulic plant consists of three turbine sets—two 500-H. P. twin Girard turbines, supplied by Messrs. Rieter & Co., of Winterthur; two 800-H. P. Francis turbines, supplied by Messrs. Escher, Wyss & Co., of Zurich, and two 25-H. P. exciter turbines, also supplied by Messrs. Rieter & Co.

The electric installation consists of two 500-H. P. and two 800-H. P. three-phase generators, running at 380 revolutions per minute, 38 cycles, and supplying current at 7000 volts. All the generators are direct connected to the turbines by means of flexible couplings. With the exception of one 800-H. P. generator, furnished by Messrs. Brown, Boveri & Co., of Baden, the whole electrical plant, including the switchboard and apparatus, was supplied by the Maschinenfabrik Oerlikon, of Zurich.

The transformer sub-stations contain either one or two transformers, each having an output of 200 K. W., and provided with switch gear and

ONE OF THE GREAT GLACIERS ON THE LINE OF THE JUNGFRAU RAILROAD

measuring instruments. The stations at Scheidegg and Eigergletscher have also a small 30-K. W., 7000-200-volt transformer for the lighting and heating of the station and adjoining buildings. Another plant is being built, for which power will come from the Black Lutschine. This will give a capacity for the two stations of 5000 H. P.

One of the interesting features in connection with the generation is that the streams have their source in glaciers. Consequently the volume of water is greatly diminished in winter. As a substitute for the turbines when sufficient water is not available, a gas-engine plant has been installed at the White Lutschine station, gas being furnished by a producer.

A normal train is composed of an electric locomotive, a "suspended" car and a trailer. The "suspended" car runs ahead of the locomotive, and

A RESTING PLACE AT ONE OF THE UNDERGROUND STATIONS

is fitted with two axles at one end, the other end being connected to the locomotive by a coupling which allows freedom of movement in rounding curves. The train weighs 28 tons and runs at a speed of 5 miles an hour on a 25 per cent. grade. The horsepower required at the rack-gear shaft is 230.

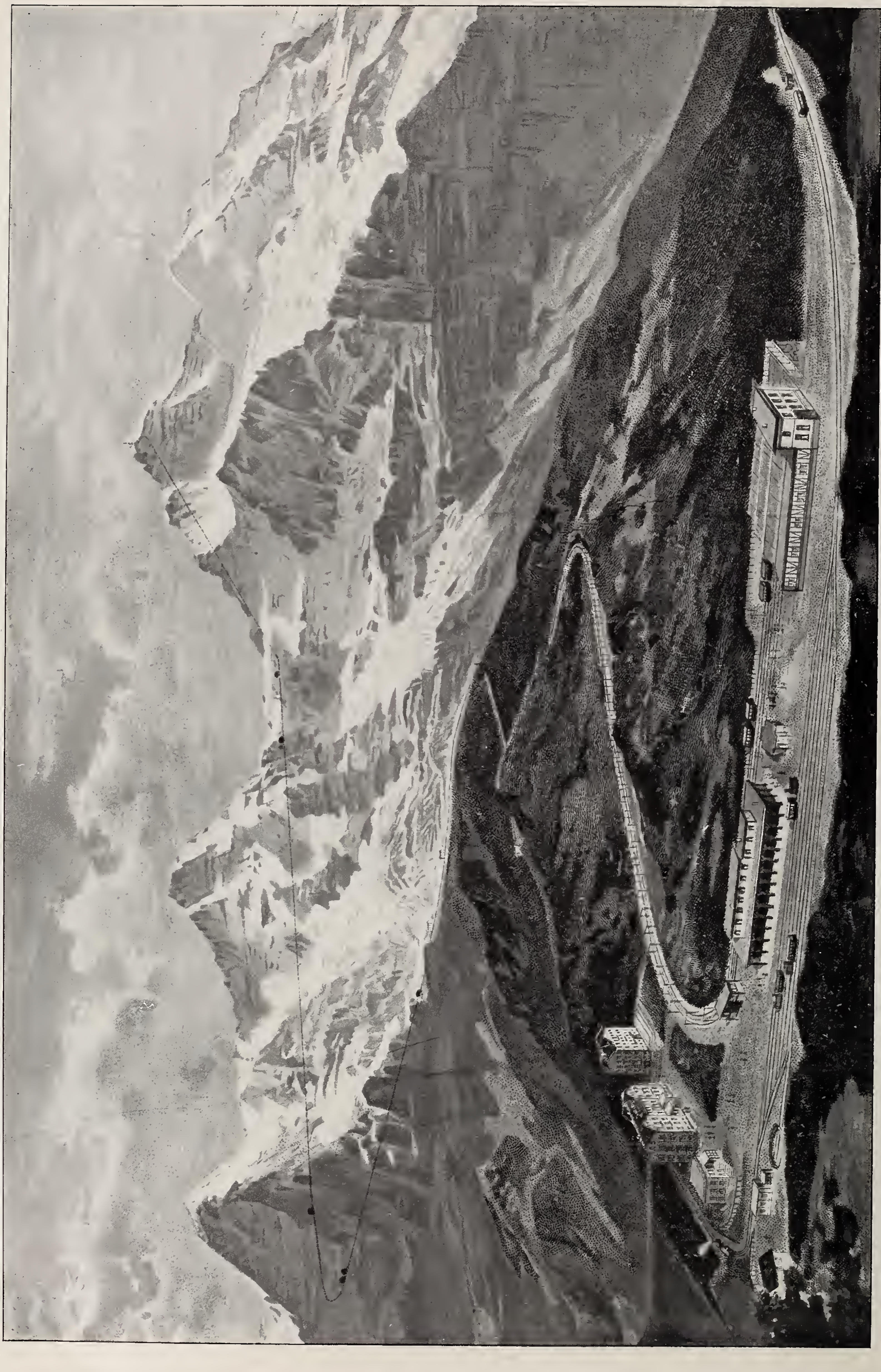
The locomotives first employed were supplied jointly by the Swiss Locomotive Works, of Winterthur, and Messrs. Brown, Boveri & Co., of Baden. Each locomotive weighs 14 tons and is mounted on four wheels. Two rack gears on separate axles mesh with pinions on intermediate shafts, and large gears at both ends of the last-named mesh with pinions at both ends of the motor shafts. The starting resistances are placed over the motors in a ventilated iron case, and the switch for reversing is placed under the roof. A speed indicator is driven from the motor shaft. Drums are placed on either side of the rack-gears and brake-shoes are pressed against these by hand-operated screws. A double strap-brake also acts on two drums on the motor shafts. This can be worked by hand, by pressing slightly on a lever, but it also acts automatically if the maximum permissible speed is passed. If the current supply is interrupted, it is also actuated by means of solenoids.

When running on the down-grade, the motors serve as generators and act as brakes, the speed being limited to that of synchronism. The breaking action may be further increased by breaking the motor circuits and inserting resistances to absorb the current generated.

The Maschinenfabrik Oerlikon supplied the electrical equipments of the other type of locomotives in use. Each locomotive is driven by two three-phase induction motors, each developing 120 H. P. at 450 to 550 volts. The trolley poles for these locomotives have aluminium sliding contacts, which do not require shifting when the locomotive runs in a reverse direction. In this later type of locomotive the braking on the descent by means of the motors is somewhat similar to that in the first type, but closer regulation of speed is obtained. The starting resistances are thrown in and absorb the current generated. Further braking is secured by an electrically operated brake, the current for which is generated by a small direct-current dynamo on one of the motor shafts. The locomotive speed may thus be controlled on descents when the trolley poles are off the wires and without the aid of any of the ordinary forms of mechanical brakes.

The total weight of this type of locomotive is 13½ tons. Two lightning arresters are mounted on the roof of the cab. The cars were furnished by the Swiss Industrial Company, of Neuhausen, and are 23 feet long, 8 feet wide and 9½ feet high above the rails. They are of the enclosed type and are electrically lighted.

On completion of the line the entire journey, from end to end, will, it is thought, occupy less than two hours. At several of the stations en route, one can step out on glaciers which are miles in length. Eismeer, meaning in English the sea of ice, is so called after the glacier of the same name,—one of the largest in Switzerland. Eigergletscher station is on the border of the glacier of that name. The railway carries passengers to points in the Alps which hitherto could be reached only by a long and weary climbing over snow fields and up rocky ascents, dangerous even when under the leadership of the most experienced guides. While the lower terminus of the line is over 6000 feet above sea level, it is easily reached by



THE LINE OF THE JUNGFRAU RAILWAY. THE UPPER TERMINAL WILL BE 13,426 FEET ABOVE SEA LEVEL

THE STATION AT KLEINE SCHEIDEGG. TWO TUNNEL OPENINGS ARE SHOWN IN THE MIDDLE DISTANCE

LOOKING DOWN UPON THE JUNGFRAU RAILROAD

means of the Wengern Alp steam railway, of the rack type, which is in operation from Scheidegg to Grindelwald.

Evening Lecture Courses in Mechanical Engineering

A SERIES of twenty-seven lectures, designed to cover the most important phase of mechanical engineering, is announced to be held at the Brooklyn Polytechnic Institute on assigned evenings from January 24 to April 11. A corps of consulting engineers has been organized to deliver the lectures, consisting of the following:—Gardner T. Voorhees, refrigerating engineering; Geo. C. Whipple, sanitary and industrial water supply; William J. Baldwin, thermal engineering; Reginald P. Bolton, mechanical installation; Walter B. Snow, aerodynamics; Harry H. Stoek, commercial fuels.

The only place in the United States where the magnetic separation of magnetic iron ore is done on a large scale is at Mineville, and Lyon Mountain, N. Y. At these two points from 2000 to 3000 tons of ore are handled every day.

The Cost of Municipal Electric Lighting

IN view of the present agitation in the city of New York on the subject of a municipal electric lighting plant, special interest is attached to a letter which Mr. E. H. Davis, president of the National Electric Light Association, has written to the "Brooklyn Daily Eagle" in answer to a previously printed communication concerning the municipal lighting plant of Chicago by Mayor Carter Harrison of that city. Mayor Harrison, as a municipal lighting advocate, naturally presents the municipal ownership status in the most attractive possible way. Mr. Davis, on the other hand, says:—

Mayor Harrison falls into the common error of municipal bookkeeping, in that he charges to the operating cost of Chicago's plant only those items which relate to the generation of the electric current, such as coal, labor and minor repairs, and admittedly excludes items of equal, if not greater, importance—interest, depreciation, insurance, taxes and water.

The omission of these items is characteristic of all municipal plants, excepting those of Massachusetts, where the cost of operating the municipal plants, per unit of illumination given for an expenditure of one cent, is less than is obtained by any of our large cities, such as Boston, Philadelphia or New York, where the electric light is purchased from private companies. Likewise, contrary to the general understanding, and according to eminent accountants, the city of Chicago has paid more for its electric light upon the streets than has been paid in the cities here mentioned.

The present value of the Chicago municipal plant, including real estate, it has been estimated, is $2,000,000. It may be a little more or a little less. These figures are taken as representing the consensus of expert opinion. With them is given opportunity to inquire into the cost of street lighting during 1903, the last year in which figures are available, and to say whether the plant has been operating at a gain or a loss. So far as practicable the figures of Mayor Harrison are used.

He states that during 1903, 4827 lamps were used upon the streets and in some of the public buildings, and that the price paid the private electric light company (which is now supplying something more than 600 lamps for the city) is $103 for overhead service; $137.50 is charged where the lamps are supplied by underground mains. Upon this basis the annual cost of the service, if supplied by the private company, would be $497,181.

The cost of operating the municipal plant, shown by Mayor Harrison's figures, was $262,888.38, leaving an apparent difference in favor of the city of $234,292.62. But from these figures must be deducted, admittedly, interest, depreciation, insurance, taxes and water. These sums aggregate as follows:

Interest at 4½ per cent	$90,000.00
Depreciation at 7 per cent., allowing nearly sixteen years of active and useful life of the plant	140,000.00
Taxes at 1½ per cent. upon the full valuation	30,000.00
Water, according to the statement of Chicago's expert before the Comptroller of New York city	9,000.00
Insurance, fire, 1½ per cent. on $500,000.	7,500.00
Insurance, accident, for both employees and the general public, 7½ per cent. on the annual pay-roll of $92,465.16	6,934.88
Total	$283,434.88

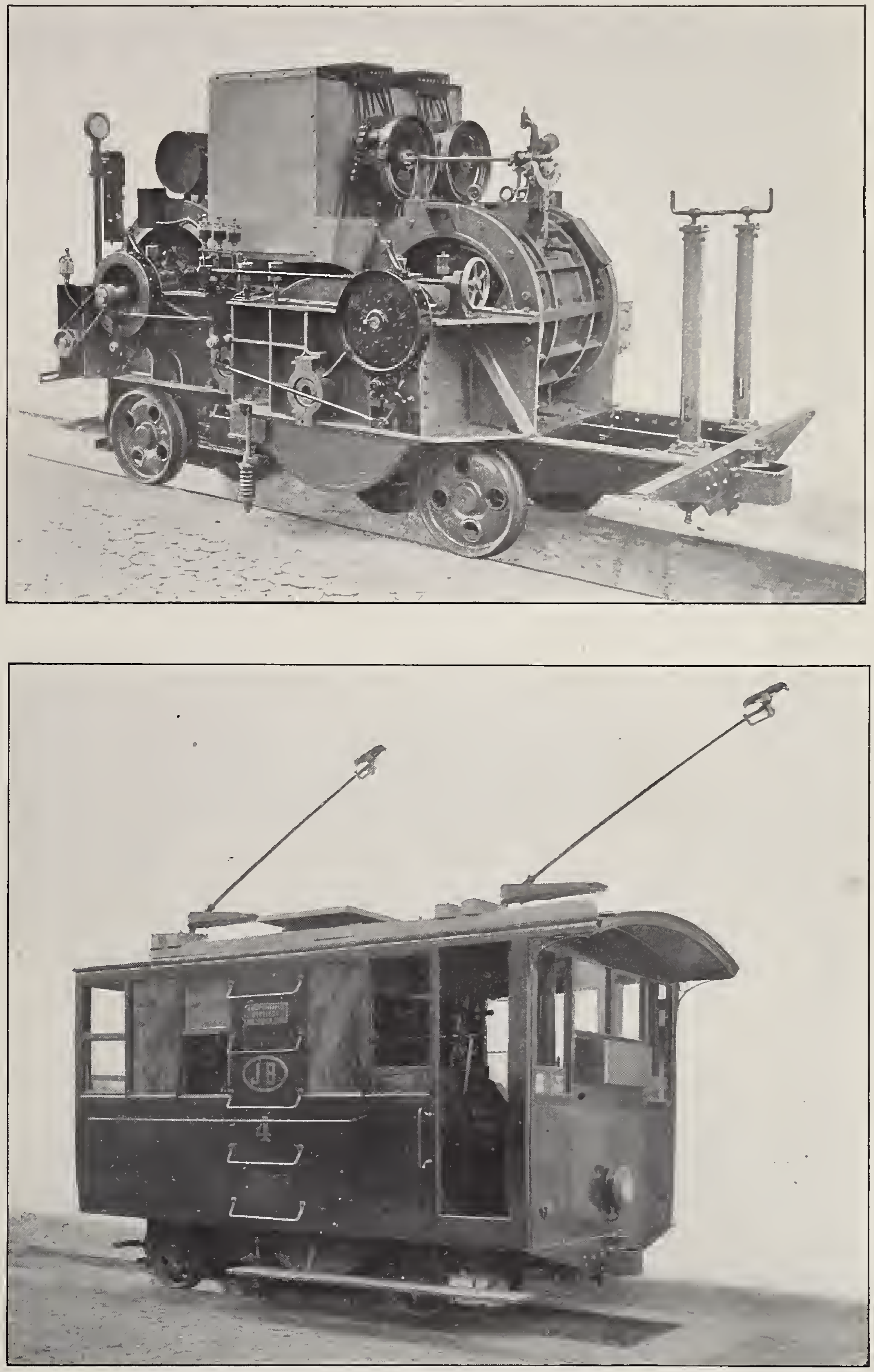
Thus, based upon these conservative figures, it is apparent that, compared with the cost of obtaining corresponding service from private companies, the city was last year subject to a loss of not less than $49,142.26.

That to the municipality this is less than the real cost of this experiment, in an undertaking inherently private in nature, is probable. For no allowance has been made for legal expenses, and an absurdly small sum—approximately $4000—has been taken as the cost of bookkeeping and the statistical work of the plant—or, rather, series of plants—of this size and importance. It is also true that the lamps upon which the relative cost of private service is based are either all those owned by the city or all that are connected with the circuits. These include a large number in the various buildings of the electrical department, which would not be required and would not enter into these calculations were the service rendered by a private company. This item in itself probably adds more than $5000 to the estimated cost of the service if rendered by a private company.

In these days it is not necessary to dwell upon the subject of depreciation, or to defend its conclusion as an item of expense in the foregoing figures. Recognition is made, universally, that depreciation does not necessarily, or merely, represent the loss of the physical life of the plant; it is also the loss of the useful or efficient life. And this continues only so long as the service rendered cannot be obtained better and cheaper through another agency.

Conservative engineers usually estimate that electrical machinery depreciates at the rate of 10 per cent. annually, allowing an average of ten years of active and useful operation of all parts of the plant; but in this instance you will observe we have taken as this life nearly fifteen years. It is probable that the actual depreciation has been, and will continue to be, more rapid. Were the local lighting companies of our cities assured of equal permanence of service, rendered under even approximately equal conditions, there is no question but that they could offer much more advantageous terms than the present, and Chicago's relative loss of last year would be even greater, because the gap would be widened between the comparative figures of municipal and private service.

In confirmation of the foregoing conclusions, the eminent accountants, Haskins and Sells, have found that from the first this municipal plant has been operating at a loss.



THE JUNGFRAU LOCOMOTIVE, WITH AND WITHOUT CAB, BUILT BY THE OERLIKON MACHINE WORKS, ZURICH, SWITZERLAND

After an extensive investigation at the instance of the Reform Club of New York City, they found that for the thirteen years ending with 1900 the public lighting of Chicago cost an average of $165.62 annually per lamp, and that if during that entire period the service had been taken from the private companies of that city, there would have been a net saving of nearly $50,000—the exact figures are $49,423. In other words, they show that between the years 1888 and 1900, inclusive, the total cost of operating the municipal plant was $2,556,533.61, while the cost, if the light were purchased from the private companies (the price per lamp ranging from $200 in 1888 to $105 and $137.50 respectively for overhead and underground supply in 1900), would be $2,507,110.50.

Taking the yearly figures from the Reform Club report they are as follows:

Year	Chicago's Statement of Cost	Cost as Found by the Accountants
1888	$84.80	$164.69
1889	129.62	266.44
1890	78.81	155.93
1891	131.52	216.50
1892	102.53	179.76
1893	101.73	177.18
1894	103.29	181.48
1895	103.27	189.02
1896	90.53	162.38
1897	78.81	138.11
1898	62.60	123.81
1899	54.44	97.86
1900	62.09	99.88
Average	$91.08	$165.62

The difference between the admitted average cost of $91.08 given by the city authorities, and the actual cost of $165.62, discovered by the accountants, is $74.54. If we add this difference for the past three years to the operating figures given by Mayor Harrison, we have the following:

Year	Chicago's Statement of Cost	Estim'd Costs Based on the Accountants
1901	$57.48	$132.02
1902	53.41	128.05
1903	54.50	129.04

Usually in making statements of the comparative costs of municipal lighting, utter disregard is shown concerning comparative conditions. The advocates of municipal lighting ownership quote in comparison with the prices of New York, Boston and Philadelphia, the cost of lighting in some town in the West, where water power is used and the current is distributed by overhead wires; seldom, if ever, do they compare the candle powers of the various localities or the number of hours annually which one city requires in comparison with another; not infrequently quotations are made where the lights are operated only part of the night on a "moonlight" schedule, with the demands of the large cities which call for full illumination a stated number of hours every night in the year.

DIFFERENCE IN THE LIGHTS

Likewise the systems are not considered relatively; the expert from Chicago, testifying before the Comptroller of New York City, stated that the lamps used in that city received 450 watts, which is equivalent to 1800 K. W.-hours annually; in New York City the lamps receive at their terminals 696 watts, which is equivalent to 2784 K. W.-hours annually—in each instance burning actually 4000, though under a lighting schedule of 3950 hours.

The well known accountants to whom I have referred found that the cost of operating the municipal plant of Chicago is 2.57 cents a lamp hour, which is equal to 5.71 cents a kilowatt hour. If we use this figure as the basis of cost in New York City—though admittedly many of the costs of that city are materially higher—we find that the service of each lamp, if supplied at Chicago's costs, would amount to $158.96 annually, instead of $146, as at present.

I am informed that the electric lighting department of Chicago is not charged with the expenses of relaying the pavement of the streets after constructing the subways, or making repairs, while in New York the charge is $8 for the first yard relaid and $4 for each additional yard. The electric light companies are not permitted to do the work themselves, but for that purpose must employ the paving companies.

Then again the entire electric light service of Manhattan Island is underground, whereas, in Chicago two-thirds of the city's lamps are supplied by overhead circuits. Bearing upon this point, permit me to give you as a single illustration the following figures, which I have obtained from one of the local lighting companies, upon the costs, wholly incidental to the underground service, of getting ready to serve some street lamps. Because of the isolated and somewhat dangerous character of some of the streets on the extreme westerly side of the city the authorities desired to introduce electric light. The neighborhood is one in which there is no present or prospective demand for commercial service. Sixty-eight lamps were required, to supply which an investment was made of $35,600 in subways, and $24,100 in cables, a total of $59,700; say $60,000 in all. Allowing only 10 per cent. for fixed charges, interest, depreciation, taxes and insurance and the subway rental of $1000 annually for each of the three miles of subway constructed and occupied, the annual cost becomes $9000 as a fixed charge alone without a cent of operating cost from which the entire income to the electric light company is only $9636 annually. No charge whatever is included for generating plants, buildings and real estate, nor for the general street system of mains and feeders by which that distant section of the city is supplied. And you will observe that in the foregoing are included none of the "operating costs," coal, labor and repairs, which alone entered into the calculations of Mayor Harrison upon the Chicago plant.

In Chicago the street posts are of wood, standing in cast iron bases, bolted to the edge of the sidewalk; in New York they are of iron throughout, ornate in design. The relative cost between the two is at least 4, possibly 5, to 1. Night inspection is not a feature of Chicago's service; in New York each lamp is inspected not less than five times nightly. Within comparatively short distances in Chicago, large numbers of the street lamps may be found out of service. Many have questioned whether the abnormal criminal record of that city is not due, at least in part, to the unsatisfactory character of much of the street lighting.

Then, again, the lamps now used in Chicago are of a type long pronounced obsolete. Originally, the New York system was the same, but it has been entirely replaced, from the lamps back to the generators, and even to the engines and boilers. Were the affairs of Chicago placed in the hands of engineers familiar with modern methods of construction and operation it is not unlikely that the entire system would be abandoned and replaced with one modern, operating with higher economy and giving greater satisfaction to the general public—or, a still greater probability, that the city would secure this service from the private companies of that city.

Ozonizing the New York Subway Air

According to the "American Machinist," a particularly brilliant idea has been advanced by Edward F. Chandler in favor of the quality of the air in the new subways of New York.

His argument is to the effect that the subways are merely large tubes, similar in their nature to those which are regularly used for the production of ozone by the action of electricity upon air. Mr. Chandler states his belief that every flash or discharge of electricity which takes place between the contact brushes and the third rail, or between the wheels and the rails, develops a certain amount of ozone at a point in the tube which makes it especially likely to be fatal to microbes. In consequence, the subway air is likely to be even better for consumptives and others than the ordinary air of the streets of the city.

Paying for Electric Light Plant Extensions

By A MANAGER

THE average lighting station has grown from small beginnings, by successive patches and piecemeal additions, applied only as the necessities of the business imperatively demanded increase of plant. The time when an investment in an electric light plant was little more than a gambling risk is well within the recollection of all of us, and we cannot blame the hard-headed business men who backed the early ventures for failure to foresee and anticipate the tremendous growth of the industry, resulting in the yearly hand-to-mouth increases of capacity above referred to.

Few indeed are the lighting companies that each November fails to find with every piece of apparatus loaded to the limit and no reserve for a breakdown or for the holiday increase. This condition is by no means confined to the small companies. The lighting load has grown by leaps and bounds, and the power output of many plants that did not supply a dozen motors ten years ago, now amounts to a third or more of the entire output.

An annual increase of load of 25 per cent. or more is quite the usual thing, and few plants with energetic business management will average less than 15 per cent., the net earnings generally increasing in a somewhat greater ratio. After the felicitations due to such a gratifying state of affairs are over, the board of directors frequently has to face the fact that the net earnings for the year have been absorbed by the cost of extensions of plant required to take care of the increase in business.

Strenuous and pointed are the inquiries as to why this should be necessary, but while explanation may silence, it does not always seem to convince, for more than one fiscal year at a time, at least. It is easy to say that a growing business necessitates growing capital, but investors prefer a business where they can draw dividends and at the same time provide out of the earnings for all increases.

It is for the purpose of setting forth a few facts, as well as with the hope of arousing a discussion that will be of general interest and benefit to the financial members of our circle, that I have written these lines.

A first-class, modern, condensing plant of 1000-K. W. capacity or more can be installed, complete with electrical and steam plant, pole lines, services, meters and lamps for about $175 per kilowatt of station capacity. A non-condensing plant, with cheaper apparatus and simpler design, can, of course, be installed for a much lower amount, but I believe that $125 per kilowatt would be about the limit.

The investment in existing plants, particularly those that have been in operation for twelve or fourteen years, is generally very much greater, for the reason that small and obsolete, or inefficient apparatus has been discarded, sold at scrap prices and replaced, from time to time, with larger and more up-to-date appliances, and this, together with the costly mistakes inevitable in a new and rapidly expanding art, and the high prices that used to prevail, has resulted in a total expenditure of often twice or even three times the amount named above. Of course, renewals and depreciation should be provided for by a fund set aside for that purpose, but it is exceptional to find a company that really provides for such a fund. Most old plants are therefore handicapped by heavy fixed charges, while they are frequently quite as seriously hampered by the original design and construction of the station and line, making increases in capacity disproportionately costly.

However, in considering a plant supplying an overhead system, if we assume $150 per kilowatt of capacity, including distribution system as well as station, as an average cost for such increases as may be necessary, we will be sufficiently near the facts for the purposes of this paper, and figures given hereafter may be modified to suit existing cases.

Now it is obvious that an installation increasing the maximum load at the station by 1 K. W. may not require an immediate increase in plant account of $150. Possibly it might require only a service line, meter and lamps, the existing station, line and transformer capacity being sufficient. Nevertheless, sooner or later we reach the point where the other items must be increased, and we will therefore have to allow for them in considering the ultimate requirements and not merely the immediate present.

The average gross receipts of such a lighting and power plant of about 1000-K. W. capacity, loaded to the limit at peak, are not likely to exceed $100 per annum per kilowatt of maximum load. It is true that there are notable instances of greater returns, and plants in large cities must make much greater earnings to justify the much greater investment required; but we are considering probabilities rather than possibilities, and plants of small and medium size, located in places where the amount of business available is limited.

The operating expense would probably be about 50 per cent. of the gross earnings, making the net returns from operating $50 per year per kilowatt of maximum load. From this must be subtracted the interest on the bonds, if any. Assuming the cost of the plant at $150 per kilowatt, that it is bonded for an equal amount at 5 per cent., and that the capacity is just equal to the requirements, the net earnings applicable to surplus would be $42.50 per kilowatt. A 20 per cent. increase in load would mean an ultimate expenditure of $30 per kilowatt of present capacity for increase in plant, leaving a balance of only $12.50 per kilowatt.

If 8 per cent. on the cost of the plant is allowed for depreciation, and I think most station men will admit that this is low enough, there will be no cash left over for surplus account. This is the principal point of interest to the stockholders; not book profits, not earnings invested in plant, so that the plant must be sold to realize, but the surplus in bank at end of the year.

If the plant is bonded for two or three times what it would cost to replace it, as is too frequently the case, or if the additional capacity involves expensive changes in the station, it is plain that the cost of the increase will have to be "financed" in some way, either by a stock issue, a temporary loan, or a bond issue.

The following table gives the amount of net earnings per kilowatt of maximum load at station required to provide for fixed charges, dividends and increase in plant under the conditions assumed:—

Increase, Per Cent	Cost of Increase in Plant	Bond Int. 5 %, Depreciation 8 %, Dividend 6 %	Total
25	$37.50	$28.50	$66.00
20	30.00	28.50	58.60
15	22.50	28.50	51.00
10	15.00	28.50	43.50
5	7.50	28.50	36.00

Now let us see what the rates must be to realize any such net return.

We will assume $2\frac{1}{2}$ cents per kilowatt-hour as the cost delivered to customer, including taxes, insurance and office expenses, as well as operating and distribution expenses. It is true that certain expenses do not enter into the cost of operation for certain kinds of service, but we are here dealing with averages, not special cases, and with totals, not items. Assuming that $66 per year net must be earned to provide out of our earnings for increase in capacity, depreciation, investment and bond interest, we have the following table, based on a demand load of 1 K. W.:—

Hours Use of Maximum Demand Per Day	Manufacturing Cost of Current Delivered	Gross Earnings	Rate per K. W. H.
300	$7.50	$73.50	.25
600	15.00	81.00	.135
900	22.50	88.50	.0963
1,200	30.00	96.00	.08
1,500	37.50	103.50	.069
2,000	45.00	111.00	.056
2,500	62.50	128.50	.052
3,000	75.00	141.00	.047

The first glance at the rates given in the last column makes it evident that the salvation of an electric lighting plant is in such long-hour business as signs and motors, and, what is vastly more lucrative, such business as can be kept off the peak.

Now, so far as lighting is concerned, the customer will use his lights when he needs them and not otherwise, so that while special rates, intended to stimulate long-hour consumption, may induce him to turn off a few gas jets in the basement and halls and substitute electric light, the total available increase from this source is limited.

It seems to the writer that the best-paying lighting universally available is such sign business and window lighting as can be taken on flat rates, so as to make the guaranteed income per kilowatt large, and remove the temptation the meter offers to the consumer to economize by turning off his lights early. Many signs can be installed on a flat rate basis under agreement that they shall not be turned on until 6 P. M., thus taking them off the peak load.

To the objection that will be raised by many at the mere mention of flat rates, I would say that what a station must look to is large returns per kilowatt of demand, not to the high rates per kilowatt-hour that are the means of driving away the most desirable business. As an illustration of the inconsistency of many who will not consider a flat rate, take the question of city street lighting. Most station men would be glad to take on city lighting at $80 per 2000-candle-power all-night lamps. Yet at this flat rate the return is only about 4 cents per kilowatt-hour, and the cost of trimming, carbons, repairs of lamps and other items not entering into the cost of supplying incandescent lamps at flat rates, is nearly 50 per cent. of the cost of the coal required to produce the energy. If we can afford these extra expenses in the one case, we could surely afford to employ a man to turn on and cut out the flat rate lamps at the time appointed by contract, thus doing away with that bugbear, "the abuse of flat rates."

But there is a much more fertile field for the lighting company in the motor business, and particularly in such motor business as can be kept off the peak load. Many station men will say at once that this latter is impractical, but a little consideration will show that it is not nearly so bad as it may look at first blush. Most factories shut down at 5 o'clock, and as the period during which it is necessary to keep their business off the peak is only half an hour per day during three or four months of winter, the total loss of time would be only 52 hours out of the year at the very worst. But even during this period the time thus lost may be made up either by opening the shop half an hour earlier, or by cutting off half an hour at dinner time.

In such cases there is a most striking difference in rates admissible up to the time when the day load is equal to the winter peak. While it is not likely that many of our stations will ever reach this point, the writer has been informed that it is practically the case with the Montreal Light, Heat & Power Company, for which this plan was introduced by Mr. P. G. Gossler.

The cost of extensions is limited even under the most unfavorable conditions to pole lines, transformers, service lines and meters, or a total of about $50 per kilowatt of demand load. We do not need to figure any interest, depreciation, or bond interest on the station equipment, since we are merely using apparatus that would otherwise be idle, although these items are included in the table given below.

The increase in station expenses is practically confined to the items of coal, water and repairs, as little or no additional labor would be required in such a station as we are discussing. The distribution items would increase in approximate proportion to the added load, but the general expense items would not be affected. It is safe to say that for a station whose average cost of energy delivered to the customer is $2\frac{1}{2}$ cents per kilowatt-hour, the average cost of any increase of output outside of the peak load period would not exceed $1\frac{1}{2}$ cents per kilowatt-hour, while it might and probably would be less. Our table of net earnings per kilowatt of load at station required to provide for precisely the same net earnings from operating and for the increase as well, will then be as follows:—

Increase Per Cent	Cost of Increase per K. W. of Peak	Bond Int. 5 %, Depreciation 8 %, Dividend 6 %	Total
25	$12.50	$28.50	$41.00
20	10.00	28.50	38.50
15	7.50	28.50	36.00
5	5.00	28.50	31.00

The rates per kilowatt-hour will be correspondingly reduced, and for the maximum increase above mentioned will be as follows:—

Hours Use of Maximum Demand Per Year	Manufacturing Cost of Current Delivered	Gross Earnings	Rate per K. W. H.
300	$4.50	$45.50	$0.152
600	9.00	50.00	0.083
900	13.50	54.50	0.06
1,200	18.00	59.00	0.049
1,500	22.50	63.50	0.041
2,000	30.00	71.00	0.035
2,500	37.50	78.50	0.031
3,000	40.00	81.00	0.027

The determination of the maximum demand need not involve very serious problems. In the case of sign lighting the connected load is, of course, the demand load. Where a change of rates for an old customer is under consideration, one has plenty of data. In other cases it can be very closely approximated from knowledge of the proportion of demand to connected load in similar cases. For motor customers, my experience is that it is best to make a test of several weeks at least, under working conditions, before signing contract, using a recording ammeter or a maximum demand meter. Few customers will object to this if they know that the purpose of the test is to obtain as low a rate for them as possible. Where they do, the offer to give them the current required for the test will generally turn the scale.

Of course, the plan of dealing with power customers above outlined necessitates keeping a stock of motors on hand, but this is the best investment a central station can make. There is never any difficulty in disposing of the motors, and the station manager is frequently enabled to replace other motive power in case of a breakdown, where it would be impossible if two or three weeks' delay were involved in the purchase and delivery of the motor.

The new tunnel under Boston Harbor, from the mainland to East Boston, was recently opened to the electric trains of the Boston Elevated Railroad.

An organization to be known as the Canadian Street Railway Association, was formed recently by several prominent electric railway men of Canada.

The Electric Motor in a Modern Newspaper Office

By GEORGE HOWE, M. E.

WHEN, at the present time, one speaks of great engineering achievements, it seems natural to inquire at once as to the extent to which they are indebted to the agency of the electric current, and it is my purpose in this paper to sum up briefly one phase of this topic,—in the newspaper office, drawing such conclusions as seem timely from some data that I have collected, including many tests and investigations personally conducted. It has been my experience that very little accurate technical information relating to the power requirements of a newspaper pressroom, particularly that relating to the operation of large newspaper presses, is readily obtainable; certainly very little exists in published form. Such data as do exist are scattered and usually closely guarded by those who possess them.

For the benefit of those who are not familiar with the making of a newspaper, it may be explained that the news matter to be set up, when sent to the composing rooms, is divided up among the various linotype machines, the results from which are about the same as those obtained by an ordinary printer in setting up type. The type matter next is arranged in forms or chases on large tables in the manner in which it is to appear in the newspaper. These forms or chases are then locked and brought to the matrix presses, where a soft paste-moistened specially prepared sheet of paper, resembling pastebaord, is pressed down upon it, receiving an exact impression. This matrix, which is incombustible, is next dried and baked and is then shaped to fit the cylinder of a printing press, serving as a mould into which hot type-metal is poured, forming a stereotype-plate, which is finally trimmed, and placed on the cylinder of the newspaper press. This series of operations consumes but a short time, and it is said that a newspaper "extra" is often reeling off from the presses in less than fifteen minutes after the time when the news enters the editorial rooms over the telephone.

Newspaper machinery may be classified as follows: (1) Linotype and photo-engraving machines; (2) matrix machines; (3) stereotpye and electrotype machines, and (4) printing presses.

LINOTYPE MACHINES

These machines, which have been brought to a high degree of perfection at the present day, have added wonderfully to the typesetting capacity of a printer. A good operator may set with one of them 8000 ems per hour, whereas it is a good printer indeed who can set up by hand more than 1500 ems per hour. Many forms of linotype machines are now in successful operation, and each has gradually been adapted to the electric motor as a source of power. The machine, in its merits and in its importance in a newspaper office, deserves more comment than that which we can give it here.

Fig. 1 shows a direct-connected Sprague motor, driving a Mergenthaler linotype machine. The mo-

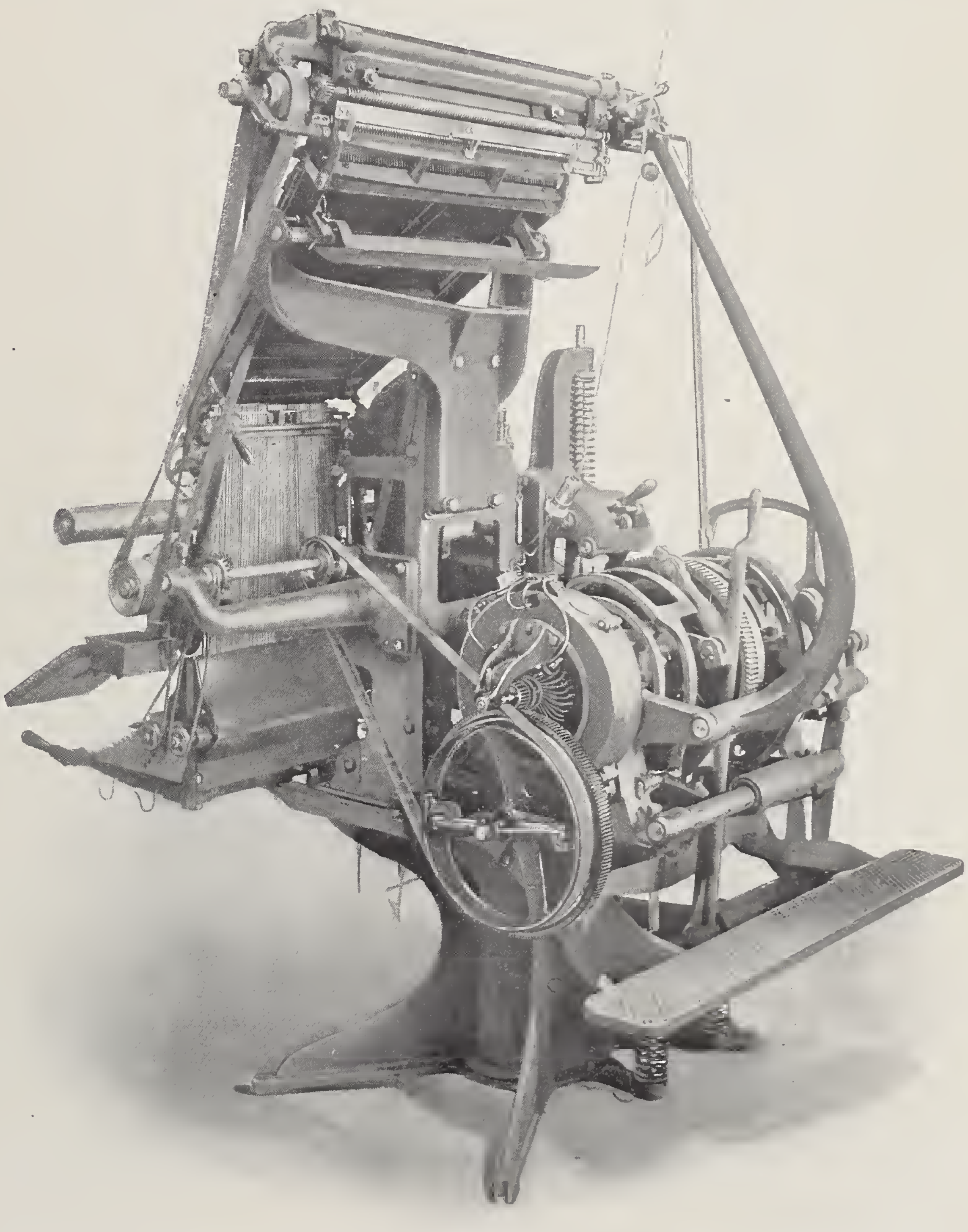


FIG. 1.—A MERGENTHALER LINOTYPE MACHINE DRIVEN BY A DIRECT-CONNECTED MOTOR MADE BY THE SPRAGUE ELECTRIC COMPANY, NEW YORK

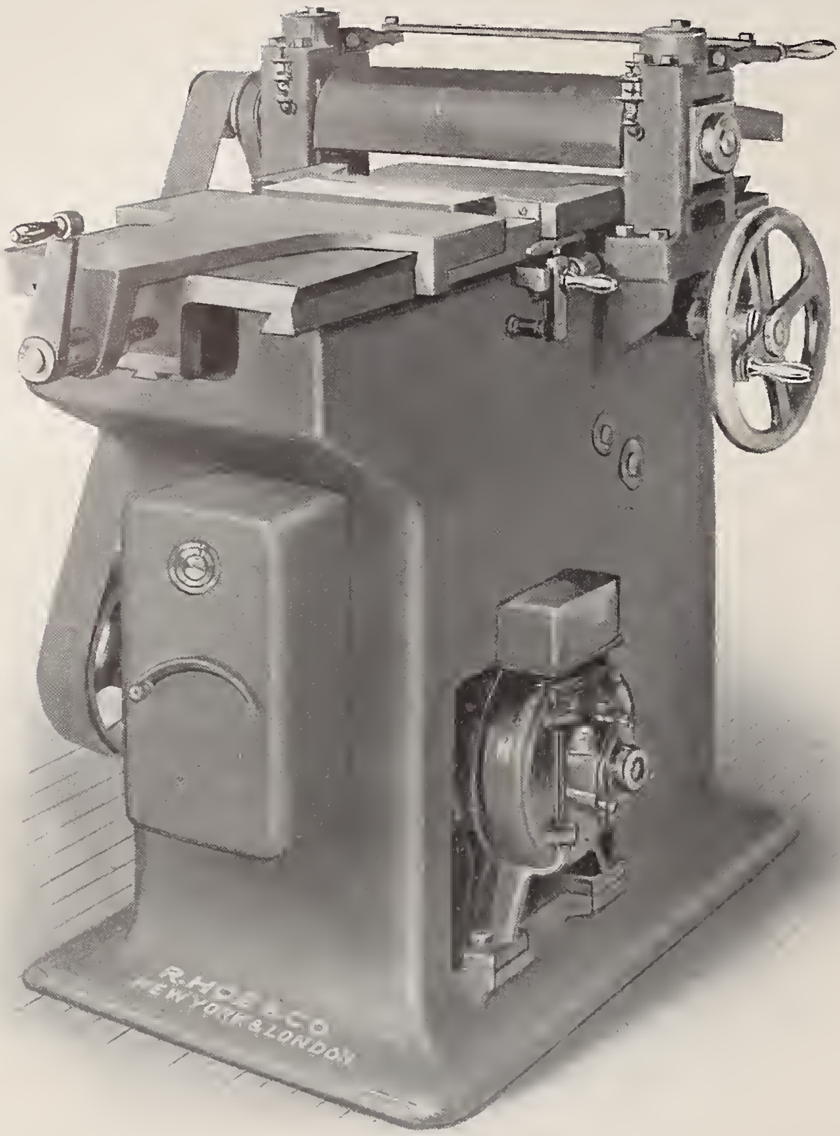


FIG. 2.—AN ELECTROTYPE PLANING MACHINE DRIVEN BY A SPRAGUE MOTOR

tor is of $\frac{1}{4}$ H. P., and its speed is 650 revolutions per minute. An unusually large gear ratio, about 10 to 1, is used with excellent results, between the motor shaft pinion and the main driving gear. In order to reduce the cost of operation of these machines to a minimum, the electrician of the New York "Journal" ingeniously devised a treadle upon which the operator must keep his foot in order to operate the motor. Should he leave the machine and thereby release the treadle, the motor stops.

Economic tests of linotype machines show a consumption of current ranging between 0.2 and 0.25 K. W.-hour per 100,000 ems.

PHOTO-ENGRAVING MACHINES

Simultaneously with the sending of news to the linotype rooms, photographs which are to be printed along with it are sent to the photo-engraving rooms, from which a photo-engraving is returned in about thirty minutes, ready to be placed in the chases along with the news matter. Photo-engraving machines comprise planers, saws, trimmers and routing machines. All of these are small machines requiring from 1 to 2 H. P. for their operation. As the length of time during which any one machine is being used is small, it is highly desirable to have each operated by a separate motor, and much progress has been made in this direction.

Fig. 2 shows a good form of electrotype-plate planer connected to a 3-H. P. motor. The starting-box is seen to be entirely enclosed, and the equipment practically "fool proof."

MATRIX MACHINES

When the type and photo-engravings have been clamped in the chases, the latter are taken to the matrix press, which is usually operated by a 5-H. P. motor, and here the matrix impression previously mentioned is taken. The actual consumption of current in a matrix machine is very small, as the percentage of the time during which it is in operation is extremely limited. For every matrix the roller on the machine moves backward and forward once, taking about eight seconds for the operation. To make sixteen matrices, one for each page of a sixteen-page newspaper, would require in all about two minutes of actual operation of the matrix press per day, consuming about 0.15 K. W.-hour, or about 0.01 K. W.-hour per matrix. The great economy of operating this machine with an electric motor is obvious, when the large waste in power is considered which occurs with countershafting and loose pulleys running continuously.

STEREOTYPE MACHINES

The entire stereotyping operation which was formerly done by three

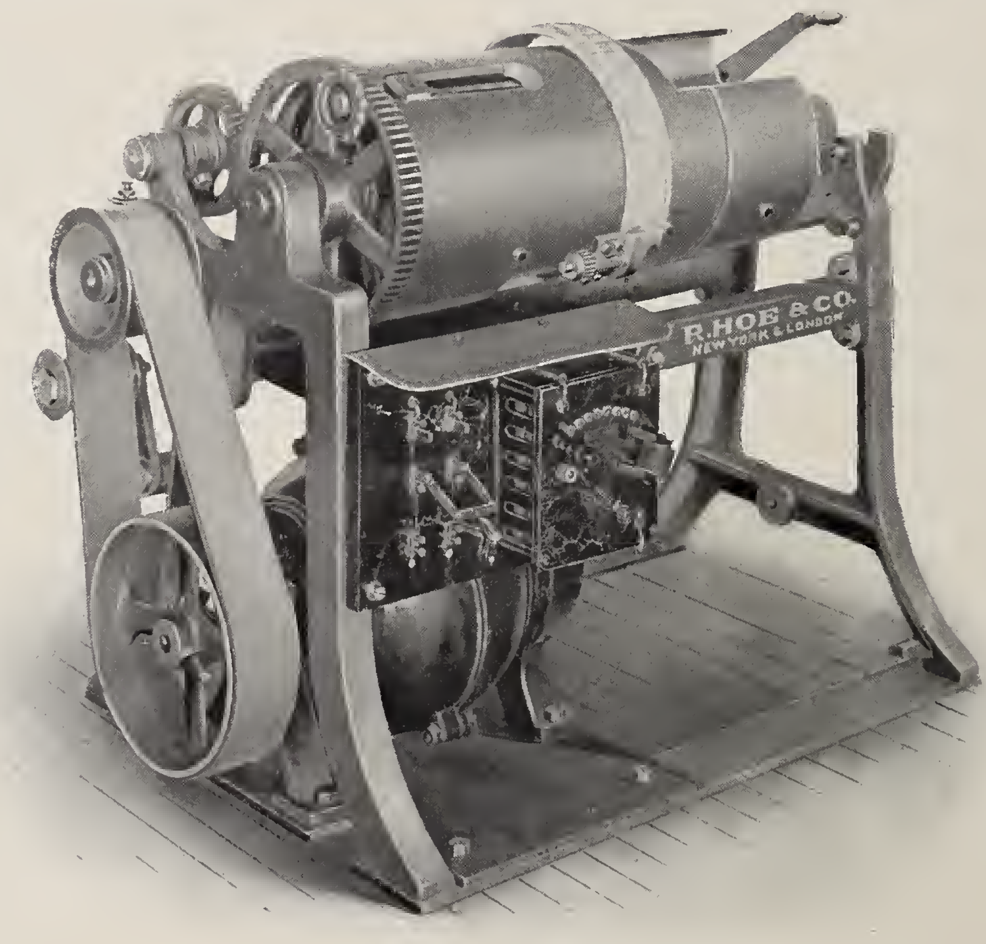


FIG. 3.—A STEREOTYPE PLATE TRIMMING MACHINE DRIVEN BY A SPRAGUE MOTOR

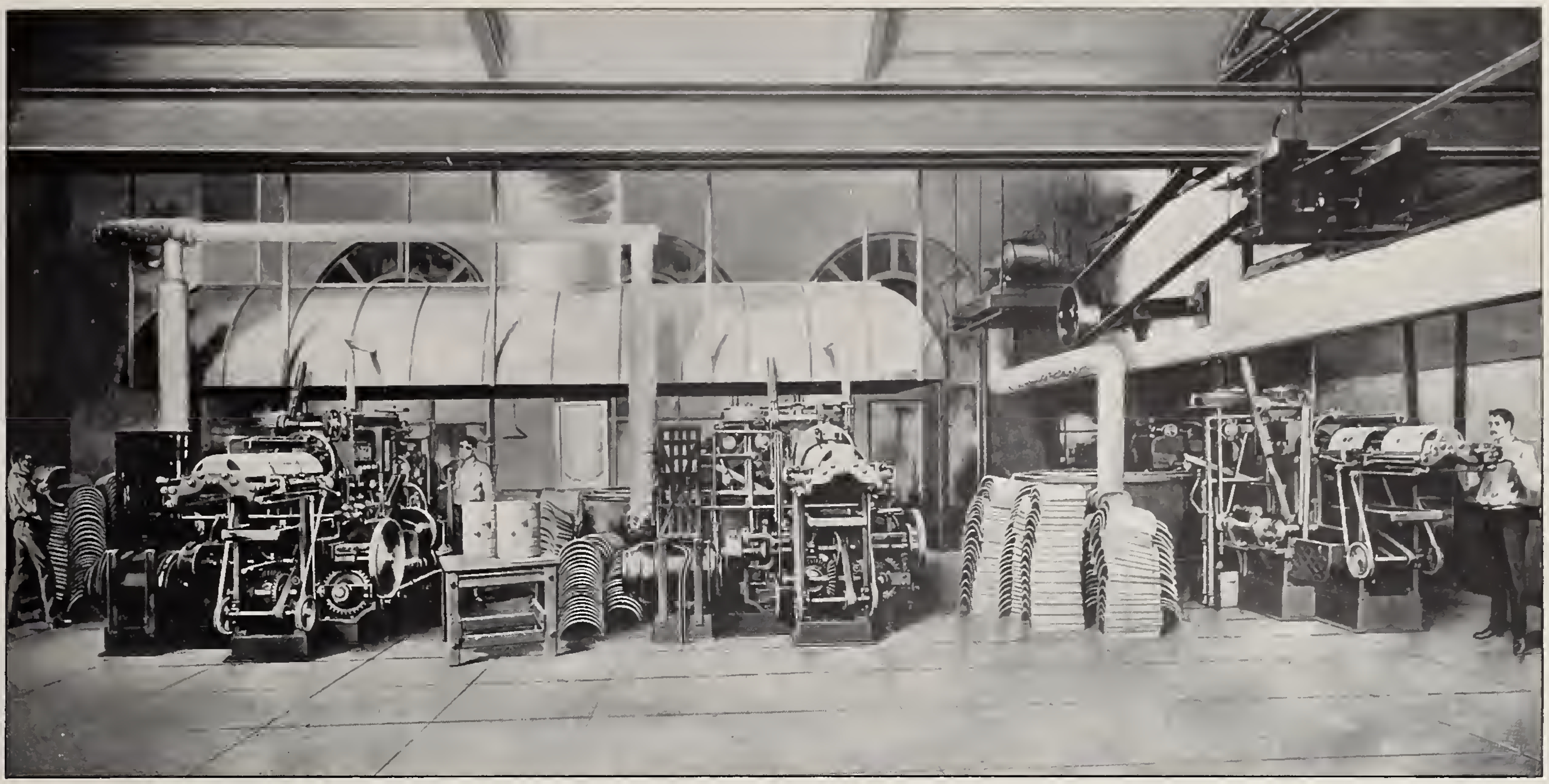


FIG. 5.—THE AUTOPLATE EQUIPMENT OF THE NEW YORK "HERALD," INSTALLED BY THE CAMPBELL PRINTING PRESS AND MANUFACTURING COMPANY, NEW YORK

sets of machines, namely, moulding, trimming, and shaving machines, is now accomplished by one single machine called the Wood autoplate machine, built by the Campbell Printing Press & Mfg. Company, of New York. The type-moulds used with the old process were hand-operated, metal being poured into them from large ladles. The matrix was placed in this mould in a curved position, and the plates cast were, in the rough, of the proper shape and size for insertion on the cylinders of a printing press. But before this is actually done, their edges must be trimmed by a machine like that shown in Fig. 3, called a trimmer, and the inside face of the plate must be shaved away until it is of the proper thickness by a machine like the one shown in Fig. 4 called a shaving-machine. Each one of these machines when used is driven by a 5-H. P. motor.

In the autoplate machine the plates are automatically cast, trimmed, shaved and delivered in a finished condition. The autoplate machine is usually connected to a 10-H. P. motor, and the control for starting up this motor when the machine is to be set in motion should be such as to give a high starting-torque, as the starting load of the machine is rather high; in fact, the usual starting-box method is being abandoned for some special control suitable to this class of work. A test of a Wood autoplate machine at the offices of the New York "Herald" gave the following results:—

Minimum load (when the plate mould alone is being operated)................3.2 H. P.
Average load (when both the plate mould and plate-shaving machine are in operation) ....4.69 H. P.
Maximum load ....7.1 H. P.

Fig. 5 shows the autoplate equipment of the New York "Herald," consisting of one belted and two direct-connected motor-driven machines. One of these is the first motor-driven machine of its kind ever constructed.

It may be said that the autoplate machine, with its economies of time and labor, is destined to supplant every installation of the old system in the near future.

ELECTROTYPE MACHINES

Electrotype plates, as is now pretty well known, are made by depositing

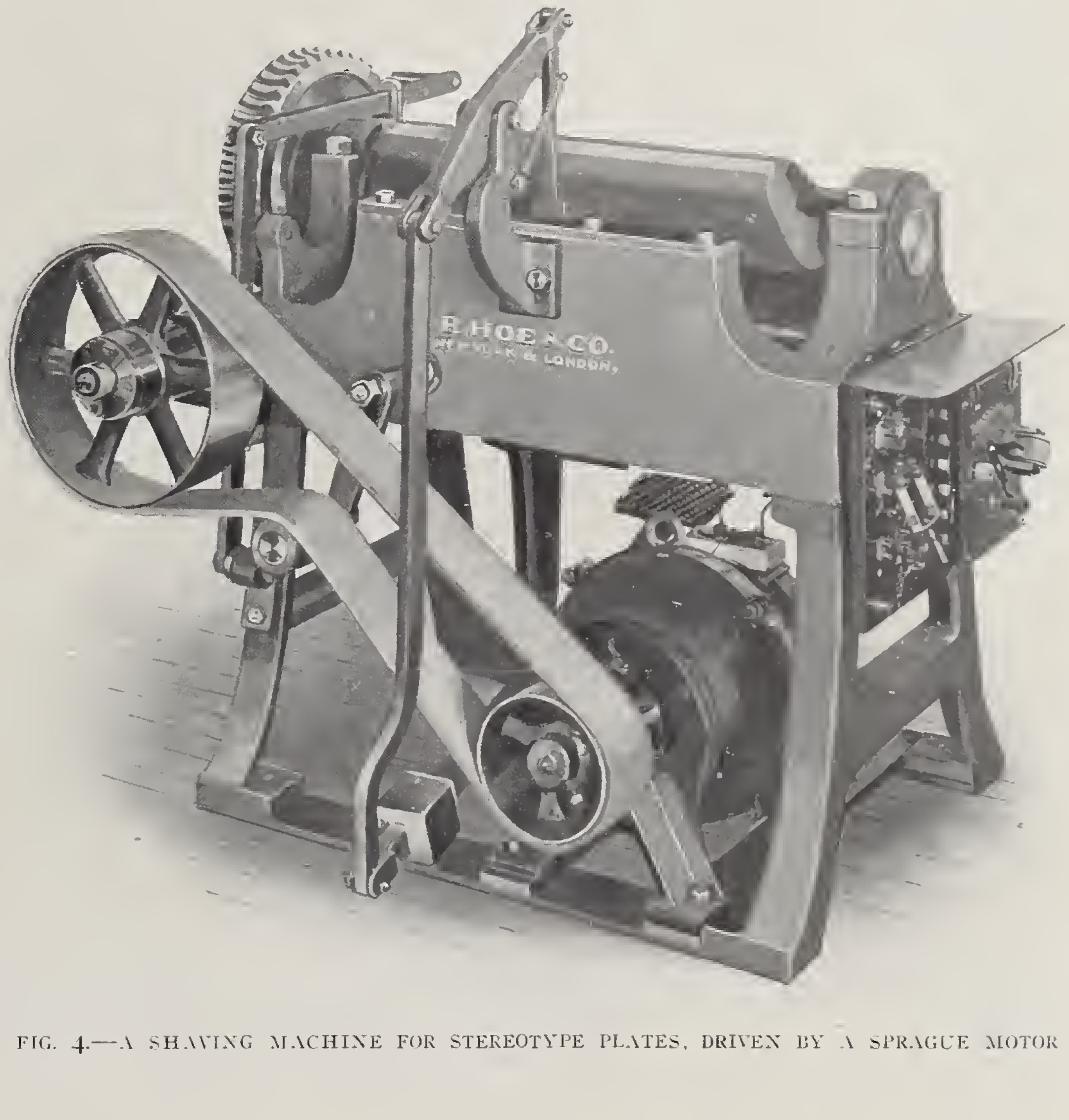


FIG. 4.—A SHAVING MACHINE FOR STEREOTYPE PLATES, DRIVEN BY A SPRAGUE MOTOR

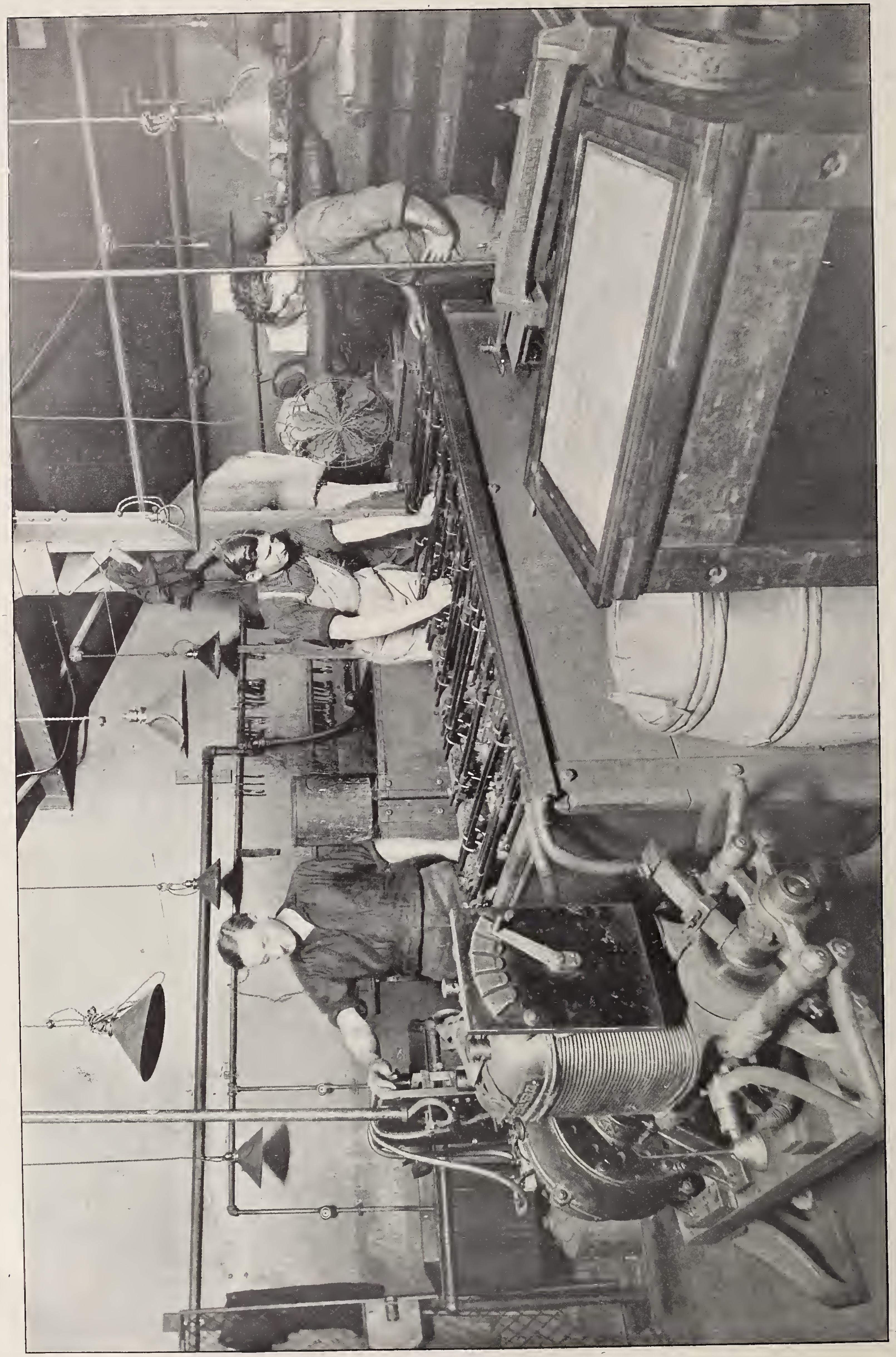


FIG. 8.—THE ELECTROTYPING EQUIPMENT OF THE NEW YORK "HERALD." SPRAGUE ELECTROPLATING MOTORS ARE USED FOR THIS WORK

metal, usually copper, in wax moulds, by electrolytic action. Electrotypes for newspaper work are made of the same size and curved to the same shape as stereotype plates, and are usually employed on color presses.

Electrotype machinery comprises small plating-dynamos, type saws, routing machines (Fig. 6), wax shaving machines and forming machines.

Fig. 7 shows an installation of Crocker-Wheeler motors driving the various machines in the electrotyping department of the government printing office at Washington. Fig. 8 shows the electrotyping dynamos used at the New York "Herald" office.

PRINTING PRESSES

The newspaper press may be treated of under the three following heads, —(1) control; (2) power requirements; and (3) economy of operation.

Control.—In considering the matter of control, it is well to understand the nature of the peculiar difficulties and special problems which must be met and solved, before any degree of success can be claimed. The torque required in the driving mechanism which must set in motion a large newspaper press is enormous, and many times as great as that required to operate it after having attained full speed. To overcome this, where the press is to be driven from countershafting by means of belts, a slow-motion device is provided by the press manufacturer, by means of which an auxiliary belt-driven pulley starts the press up very slowly through a reducing gear. After it is once in motion, the main driving pulley is gradually brought into service and pulls the press ahead of the slow-motion device, which is connected to the main drive by a pawl and ratchet, and the pawl rattles away continuously after the driving of the press has been taken up by the main driving pulley.

If an electric motor is used to supply power to a press by the ordinary countershafting and belt drive, the slow-motion device may be retained and the only apparatus needed for starting the motor would then be the regulation starting-box. However, this is uneconomical. Countershaft losses are always enormous. I recently made a test of four sextuple presses driven by a 250-H. P. motor where the constant motor and countershaft losses amounted to 37.6 per cent of the total power consumed. This loss in countershafting is one of the best arguments in favor of electrical transmission of power; therefore when this is installed, it would be folly to neglect its principal advantages, and the direct-connected motor

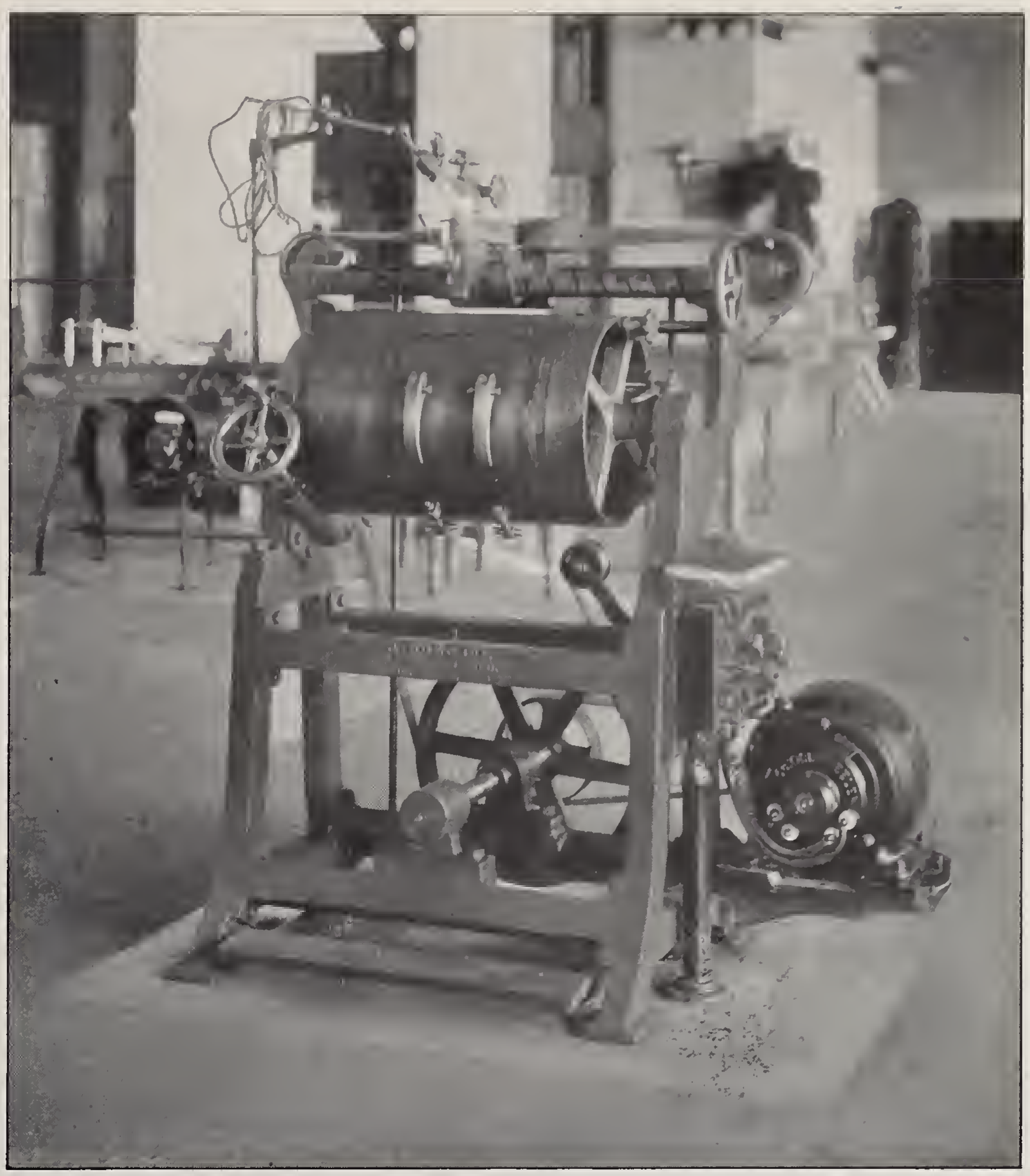


FIG. 6.—A MOTOR-DRIVEN MACHINE FOR ROUTING CURVED CYLINDER-PRESS PLATES. THE MOTOR WAS SUPPLIED BY THE CROCKER-WHEELER COMPANY, AMPERE, N. J.

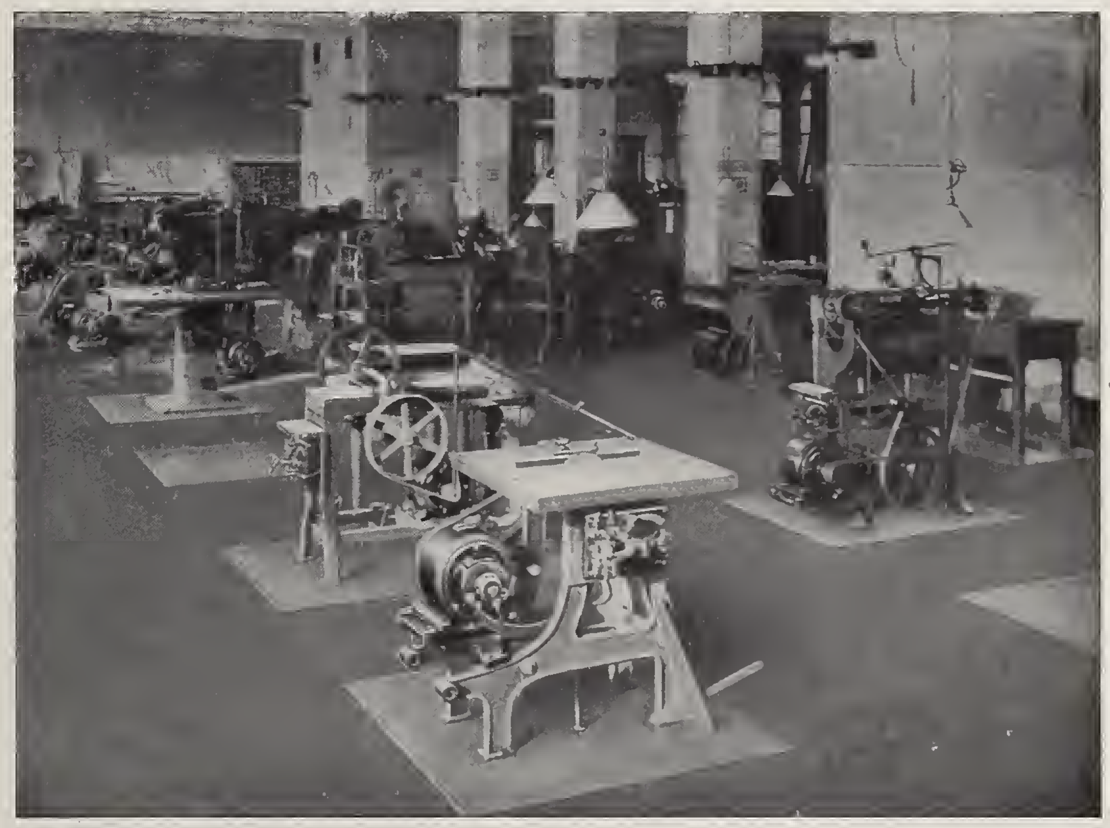


FIG. 7.—ELECTROTYPING ROOM IN THE GOVERNMENT PRINTING OFFICE AT WASHINGTON, D. C., SHOWING MOTOR-DRIVEN ROUTERS AND OTHER MACHINES. THE MOTORS HERE ALSO WERE SUPPLIED BY THE CROCKER-WHEELER COMPANY

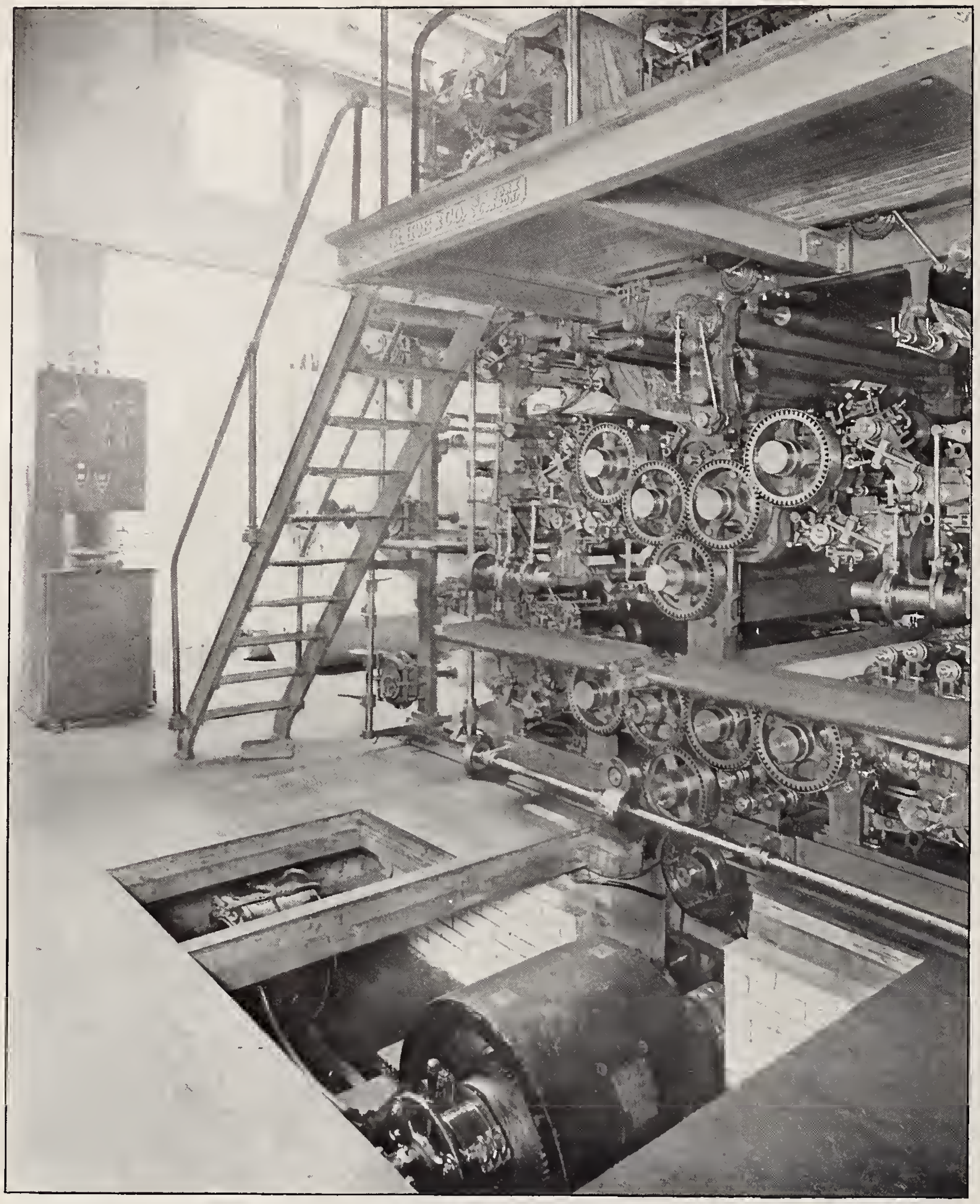


FIG. 9.—A 50-H. P. TEASER EQUIPMENT ON A HOE PRESS. SUPPLIED BY THE BULLOCK ELECTRIC MANUFACTURING COMPANY, CINCINNATI, OHIO

is thus the only method of drive that should be considered. The design of its control should be such as to comprise within the motor equipment itself the features of a slow-motion device, entirely eliminating the latter, which usually takes up a considerable amount of floor space on the side of the press.

A difficult problem, which must be met by any controlling device, is that of moving the press cylinders very slowly and stopping almost instantly at any point; in fact, such a device should be able to start the cylinders, move them through a small fraction of one revolution, say an inch of their circumference, and then stop. This is very important and saves a considerable amount of time when the pressmen are adjusting the plates on the cylinders. It may be said, for the benefit of the average reader, who, perhaps is not familiar with the machinery of a large press, that each cylinder contains a double set of plates, and for every revolution of the cylinders of a large press, two complete newspapers are printed. Therefore, should any defects develop in one of these plates while the press is in operation, it is important to be able to bring it into any desired position in order to correct these defects.

The slowest continuous speed of operation ever required by the pressman for the making-ready processes is 5 per cent. of the maximum speed. This maximum speed is usually 12,000 revolutions of the cylinders per hour, or 200 per minute. Therefore the slowest running speed demanded by the press manufacturer is 10 revolutions per minute. With a number of starting devices which have been tried, everything else has been obtained but this low speed of constant operation, and for that reason many of them have been discarded. Minimum speeds as high as 18 and 20 revolutions per minute are used successfully; but the desirability of a lower value is evident.

Finally, it is often desirable, after the press has been made ready, to operate continuously at various running speeds, depending upon the quality of paper which is to be used. If the web of the paper is poor, it is impossible to draw it through rollers at the same high rate of speed which a tough quality of paper could stand; and, if an attempt be made to do this, the frequent breaks that occur consume much more time than if a slower speed, more adapted to the quality of the paper, were employed. The driving motor must then be designed to operate with good economy at various speeds.

The problem of reducing the speed of a motor is simple enough if a starting-box is placed in series with the armature. Any percentage of reduction in speed may be thus ob-

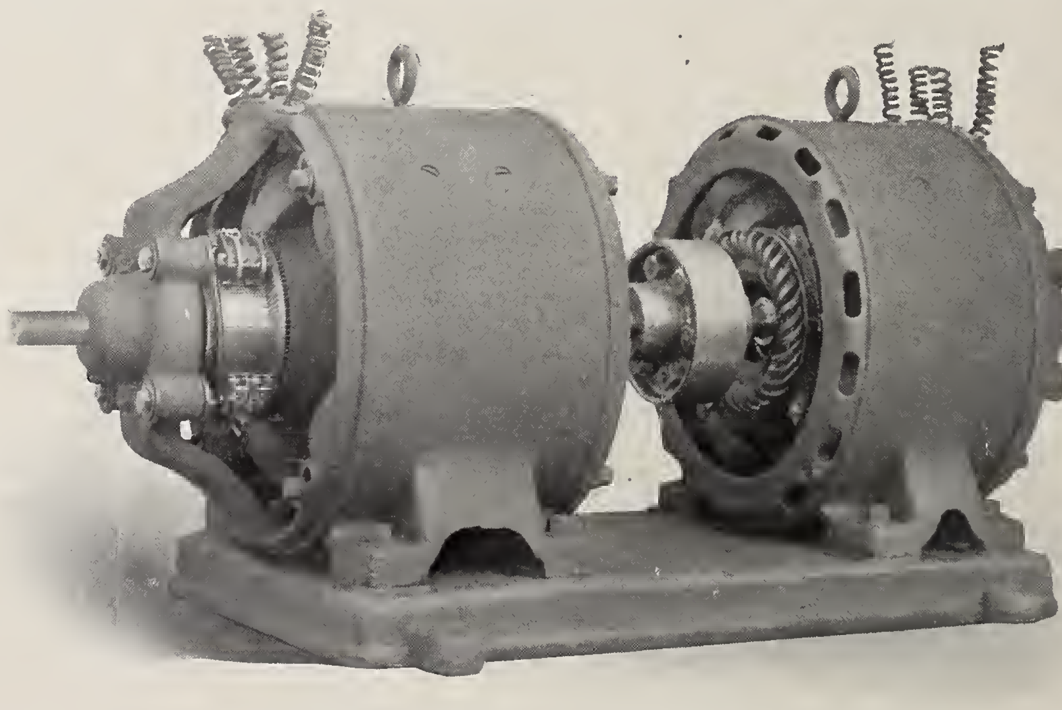


FIG. 10.—ANOTHER VIEW OF A BULLOCK TEASER SET

tained; but this method is manifestly uneconomical; and where a press is to operate for several hours, or even several days, under these conditions, the loss of power would be enormous. I recall a recent case where such a condition of affairs existed and where the loss of power in a controling rheostat in series with the armature was more than 45 per cent.

Field control of the motor is, therefore, the only one of the simple forms of speed control that can be permitted. The limit of shunt field control in good practice should be about 35 per cent. Equipments which give a wider range of field control than this usually resort to some auxiliary method, such as using a compound-wound motor and cutting out the series field before weakening the shunt field. The various methods will be taken up later.

To sum up briefly, then, the special features of a perfect motor control for printing presses are:—(1) It must provide a starting-torque at least twice as great as the running-torque; (2) it must be able to start and stop instantly, moving but a fraction of a revolution; (3) it must give a constant speed as low as 5 per cent. of the maximum; (4) it must have a range of running speeds with constant maximum efficiency.

To meet these requirements the engineer at once recognizes that one of the following four general methods may be employed:—First, a motor-generator system, which may economically supply current at any voltage, and therefore give any desired speed to the press motor; second, a series-parallel system, such as has been so successfully employed in the operation of street car motors, where two motors, or two windings on the same motor, together with a number of external resistance coils, are combined to give a series of speeds and torques; third, two separate motors, one a main driving motor, with variable speed control, and the other an auxiliary motor, to take the place of the auxiliary starting pulley in the regular mechanical slow-motion device used with countershaft drive; fourth, a multi-voltage system of distribution, such as is giving such good results for the operation of machine shop tools.

The Motor Generator System.—This method has been embodied with much success in the Ward Leonard apparatus, and also the Bullock teaser system. Both have been, and are now, much employed and are constantly being added to and improved.

As its name implies, the Bullock teaser system consists of a motor-generator set connected to the main line and operating at a constant speed. The motor connected to the press is supplied at starting from the motor-generator with current at very low voltage, this voltage being readily

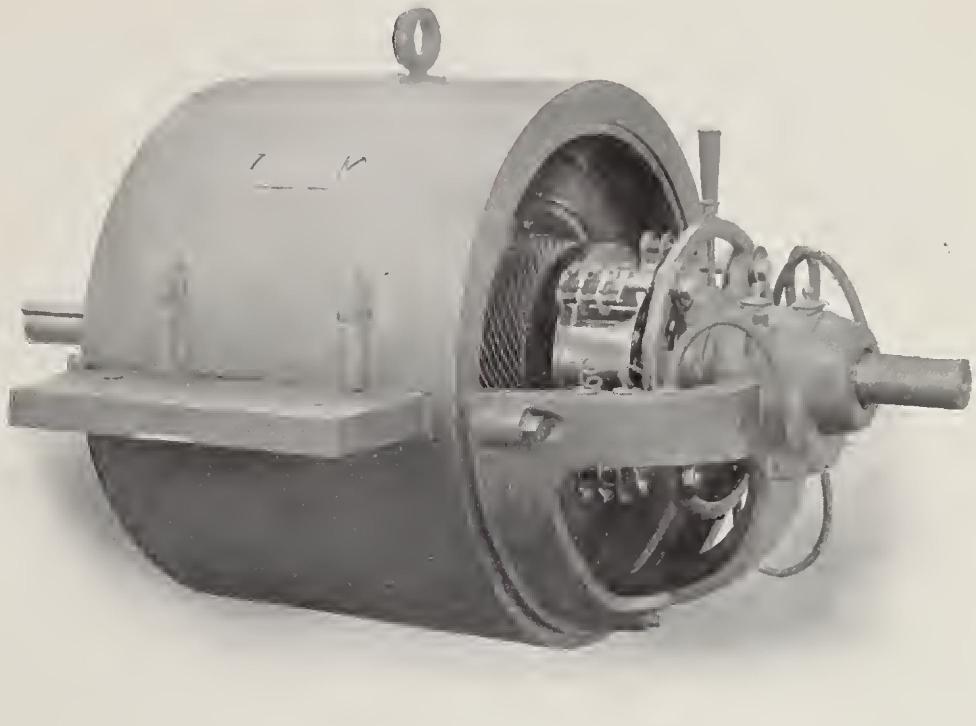


FIG. 11.—A BULLOCK MOTOR

controlled by field regulation of the generator. Gradually the voltage, and with it the speed, of the press motor is increased until finally the

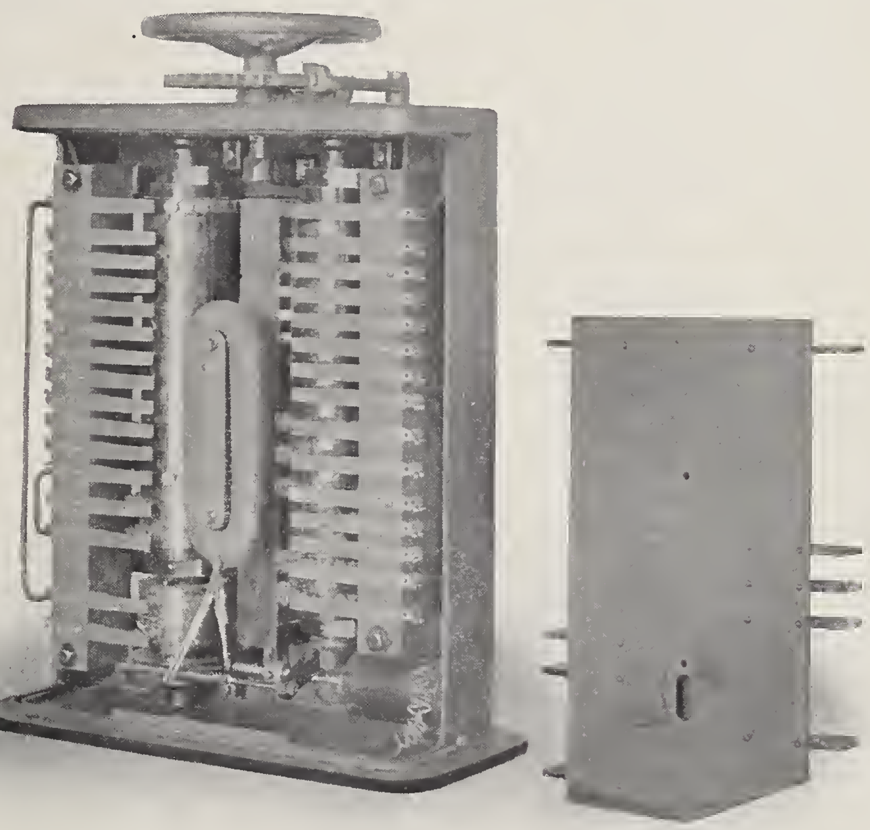


FIG. 12.—A BULLOCK CONTROLLER USED IN CONNECTION WITH THE BULLOCK TEASER SYSTEM

press motor is cut loose from the motor-generator and thrown directly on the main line. If any increase of its speed be then desired, its field is weakened. As no heavy currents are sent through resistance boxes, the economy of the system is self-evident.

Fig. 9 shows the method of connection of the Bullock motor. It will be noticed that in all motor installations the motors are placed beneath the press floor, permitting the use of the space above them for other purposes. Figs. 10, 11 and 12 show, respectively, the booster teaser set, the motor, and the controller which make up the Bullock equipment.

A recent test by me of a Bullock control used to operate a 60-H. P. motor direct-connected to a sextuple press at the press rooms of the New

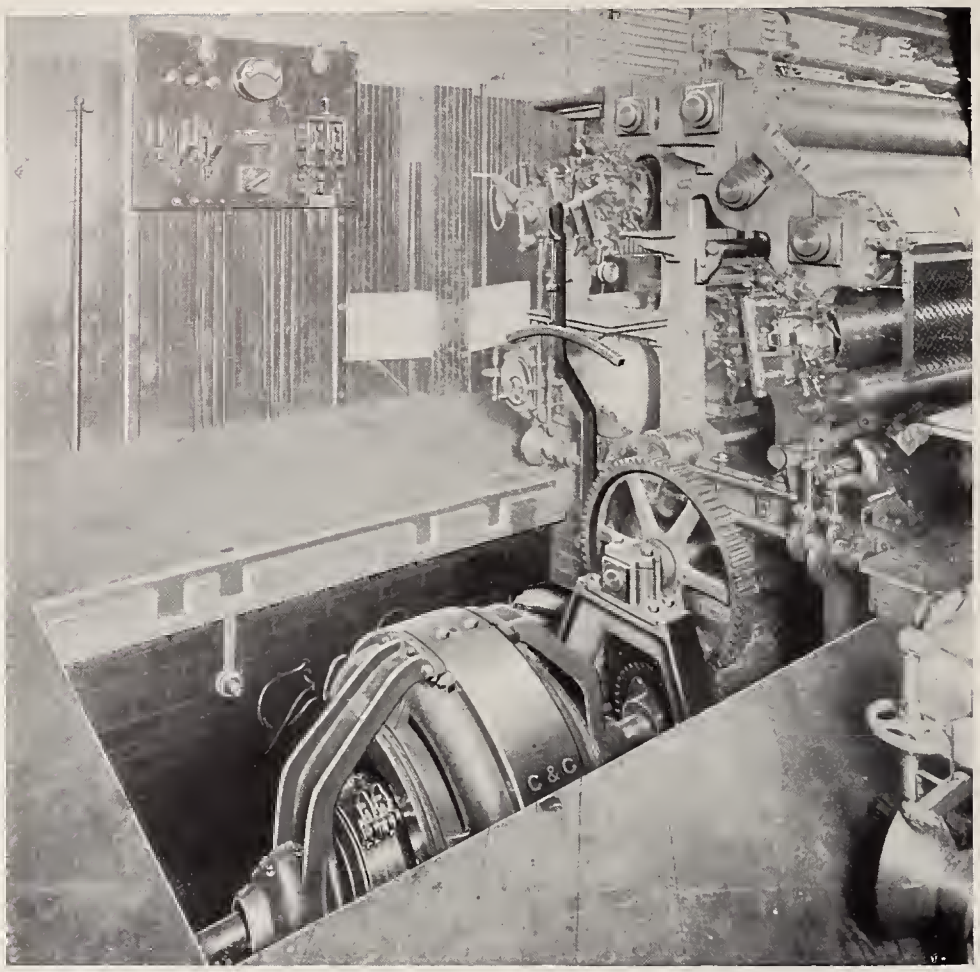


FIG. 13.—A 50-H. P. SERIES-PARALLEL EQUIPMENT INSTALLED FOR THE "EVENING TELEGRAPH," OF PHILADELPHIA, BY THE C. & C. ELECTRIC COMPANY, NEW YORK

York "Journal," gave the following results:—

Notches	Low Voltage	Amperes Inrush at Starting	Amperes Running Current
1........	240	40	15
2........	240	30	15
3........	240	25	15
4........	240	25	18
5........	240	40	30
6........	240	60	30
7........	240	75	50
8........	240	85	60
9........	240	90	80
10........	240	100	85
11........	240	110	90
12........	240	90	90

Note.—Maximum speed of cylinders, 9000 revolutions per hour.
Paper contained 18 pages, 18 x 20 inches.
Press running with single delivery.

Like the Bullock, the Ward Leonard system, also a motor-generator method, has been mustered extensively into service, particularly in Europe.

The Series-Parallel System.—The principal exponent of this method is the C. & C. Electric Company, of New York. Fig. 13 shows a 50-H. P. equipment of their design installed in the rooms of "The Evening Telegraph" at Philadelphia. Fig. 14 is another view of this same installation. Fig. 15 is a diagram of the connection to a printing press. Fig. 16 shows a 150-H. P. motor of this type.

The motor contains two separate commutators, one at each end of the armature. Each commutator has a separate set of windings, thus dividing the armature in reality into two separate armatures. When the motor is to be started up, the windings are thrown in series through a starting rheostat, which is finally all cut out, leaving the windings in series across the full voltage of the line. To obtain a higher speed the windings are then thrown in parallel through the external resistance, which is again cut out, leaving the windings in parallel across the full voltage of the line. Should a still higher speed be desired, the field is weakened by the introduction of resistance.

This arrangement will be seen to insure a very high starting torque and a number of points of high-speed economical operation. Its simplicity is not less attractive than the good practice upon which it is based.

I made an interesting test recently at the offices of the New York "Morning Telegraph," where two $37\frac{1}{2}$-H. P. motors of this type were used to operate a double quadruple press. By means of gearing, the motors can be made to operate one-half of the press separately, or may be coupled together to operate the press as a single unit. They were connected in this latter way during my test.

While on this point, I take the opportunity to express my belief that it is wise to drive all large presses with two motors. Not only is uniformity of stress obtained, but when only one-half of the press is needed, it may be driven by a motor which is operating at high efficiency, and not by a motor half-loaded and therefore inefficient. The C. & C. control has solved the problem nicely. The problem of so adjusting the fields of two motors that they will divide a load proportionately between them, is, on its face, a difficult one, calling for a high order of design and workmanship and deserving of much credit when accomplished.

The web of the paper during the test in question would not permit the operation of the press at its highest speed, and therefore this point could not be observed. It would probably have shown the instantaneous starting currents scarcely greater than the maximum running current. The press started up smoothly and rapidly attained full speed. The following

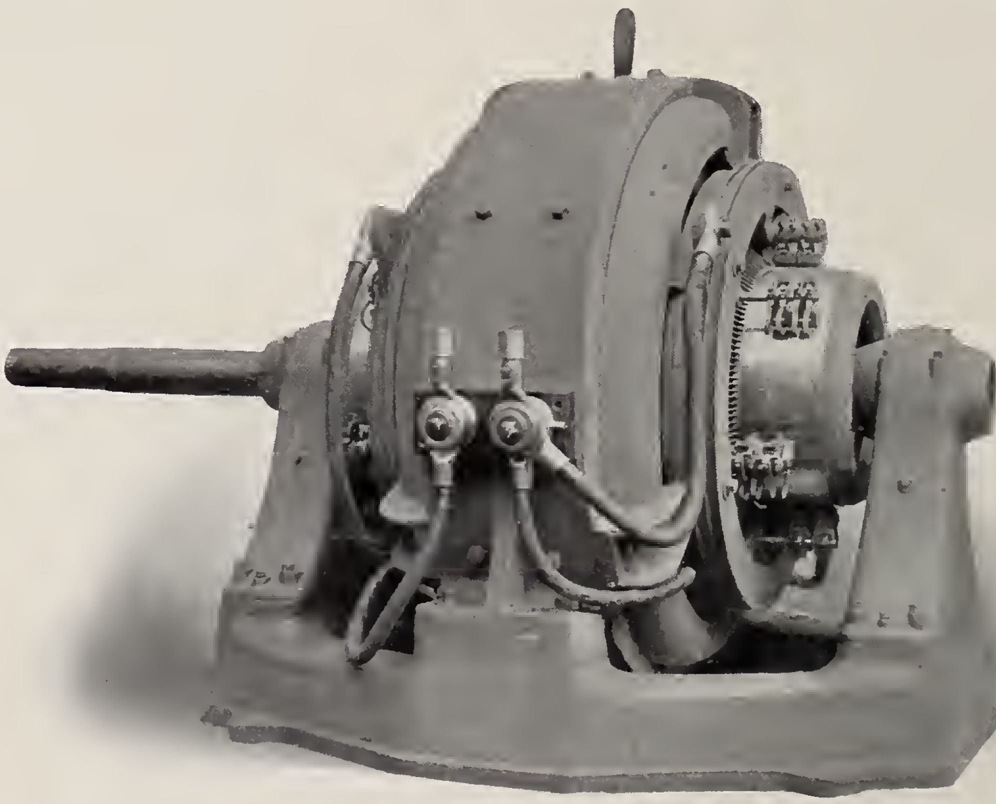


FIG. 16.—A 150-H. P. MOTOR MADE BY THE C. & C. ELECTRIC COMPANY, NEW YORK, WITH THE C. & C. SERIES-PARALLEL CONTROL

FIG. 14.—THE PRESS ROOM OF THE "EVENING TELEGRAPH," PHILADELPHIA, EQUIPPED WITH C. & C. MOTORS

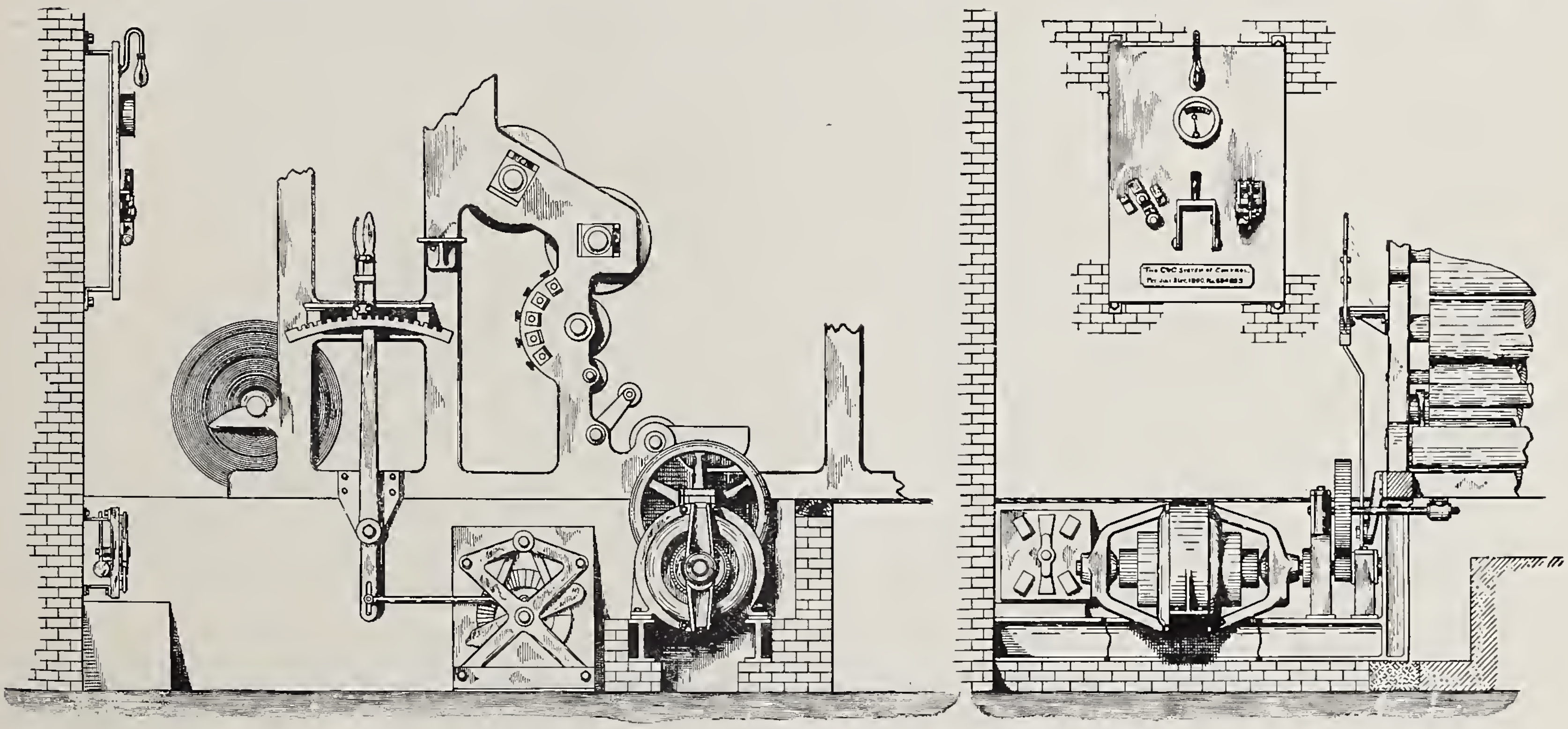


FIG. 15.—C. & C. SERIES-PARALLEL EQUIPMENT, AS APPLIED TO A NEWSPAPER PRESS

are the results of three consecutive tests starting up rapidly. The ammeter readings represent the inrush of current on the seven principal points chosen.

Just as in the operation of street car motors, the starting-handle should not be stopped at any other than economical points of operation, for it would be obviously uneconomical should the press be run while the two windings are in parallel and in series with the full external resistance. The choice of these economical points cannot be left to the pressman; therefore the running or economical points are marked by notches for his guidance.

The Jenney Electric Company, of Indianapolis, Ind., have recently designed a type of series-parallel control consisting of two separate armatures, each having two winding and two commutators and operating in the one field, side by side. I have never seen

Points on Controller.	Amperes.			Volts. Across Armature.			Kilowatts.		
	1st Test.	2nd Test.	3d Test.	1st Test.	2nd Test.	3d Test.	1st Test.	2nd Test.	3d Test.
West Motor.									
1...........	120	120	120	200	200	200	24.	24.	24.
2...........	45	45	40	234	234	234	10.53	10.53	9.36
3...........	66	65	62	124	136	138	8.18	8.84	8.56
4...........	70	65	62	150	150	140	10.5	9.75	8.68
5...........	70	60	62	160	160	152	11.2	9.6	9.42
6...........	80	75	60	180	178	170	14.4	13.3	10.2
7...........	60	64	60	195	198	200	11.7	12.67	12.
East Motor.									
1...........	110	120	80	204	202	204	22.4	24.2	16.3
2...........	40	40	40	236	238	240	9.45	9.52	9.6
3...........	82	75	78	128	130	124	10.5	9.75	9.7
4...........	78	72	80	146	148	142	11.38	10.65	11.36
5...........	82	84	98	160	162	158	13.1	13.28	15.48
6...........	120	122	110	192	180	182	23.	21.9	20.
7...........	84	84	82	200	202	200	16.8	16.97	16.4

one of these machines in operation, and have therefore no tests of them. However, all reports of their operation are very good.

The Use of Separate Motors.—This is the basis of the Kohler control which has found a wide range of application throughout this country and in Europe. It consists fundamentally of a small motor, from 5 to 10 horse power, which starts up the press very slowly through some form of reducing gear, formerly a worm gear, but more generally at the present time a spur gear, as this gives a slightly improved efficiency.

As shown in Fig. 17 this reducing mechanism is attached to the main driving shaft of the press by means of a pawl and ratchet connection. The main driving motor, which is used for operating the press, is direct-connected to this shaft. After the press has been set in motion by the small motor, the large motor is started up with a starting-resistance and its speed is gradually increased. For a while the press is being driven by both the large and small motors, but the large motor soon runs ahead of the small motor, pulling the press away from the latter, and the pawl of the pawl and ratchet connection rattles over the ratchet. In recent forms a centrifugal attachment throws the pawl away from the ratchet after the press has attained speed, thus preventing unnecessary wear of its lip. This is in brief the series of operations when starting up with the Kohler control. Fig. 18 illustrates the switchboard

FIG. 19.—A PUSH-BUTTON SWITCHBOARD USED WITH THE KOHLER CONTROL

used with this control, and Fig. 19 shows one of the push-button stations, which may be located at different points on a press.

One of the principal features of the

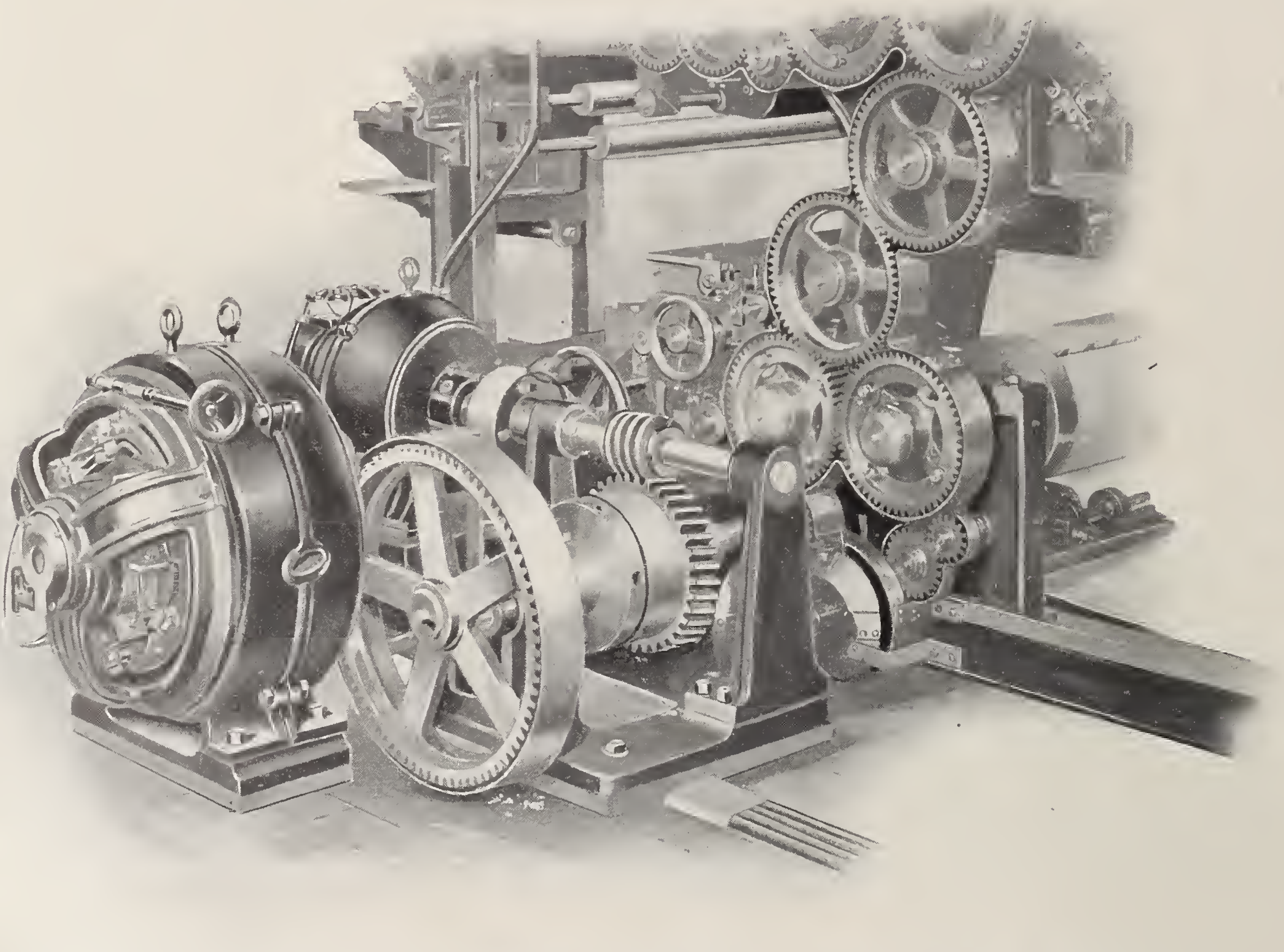


FIG. 17.—THE KOHLER CONTROL WITH SPRAGUE MOTORS, AS INSTALLED BY MESSRS. KOHLER BROTHERS, CHICAGO

Koehler control, which, by the way, is put on the market by Messrs. Kohler Bros., of Chicago, is the exclusive use of the push-button for the complete control and operation of the press motors. By pressing the starting-button the large solenoid switch shown on the switchboard in Fig. 18 drops one point, and for every successive press of this button it drops one point further, increasing the speed of the press each time. The solenoid switch, as will be seen on inspection, slides over two sets of contacts, one set terminating shortly after the second set begins. The first set controls the smaller motor, the resistance in series with which is gradually cut out between points 1 and 4, and re-inserted between points 4 and 6. At point 4 the large motor is started up. Point 6 speeds the press away from the small motor, which is then cut out entirely, leaving the large motor alone driving the press, resistance being in series with its armature.

This resistance is gradually all cut out until the motor is running directly on the full voltage of the line. It is of the compound-wound type, and to increase its speed further, its series field is first cut out, and lastly resistance is gradually inserted into the shunt field, when maximum speed is attained. There is usually a 35 per cent. range of speed obtainable with the shunt field. I have omitted the fact that the motor fields are on constantly, whether the press is in motion or not,—that is, after the main switch on the controling board has been closed. Each one of the sliding contacts on the large solenoid switch represents a different speed, and for each pressing of the starting push-button, the switch drops down one point further. There are sixteen points in the whole range.

By pressing another button, the solenoid switch may be locked so as to prevent its operation at any other speed than the one at which it is operating at the time. By pressing another button, the press may be locked so as to prevent its starting up, and it cannot be started again until this deadlock has been removed by the pressure of another button.

These push-buttons are located at any number of points around the press as desired, but I do not see the advisability of having very many of these stations. Too many of them would probably cause each pressman to take the operation of the press into his own hands, whereas one man should attend to this duty exclusively.

An excellent device is the push-button for stopping instantly, and nearly all forms of control have adopted a number of push-button stations about the press for this purpose. Instead of employing a mechanical break for stopping the motor, the motor armature is shortcircuited through a resistance. This method is also employed by many other forms of control, and has given excellent results.

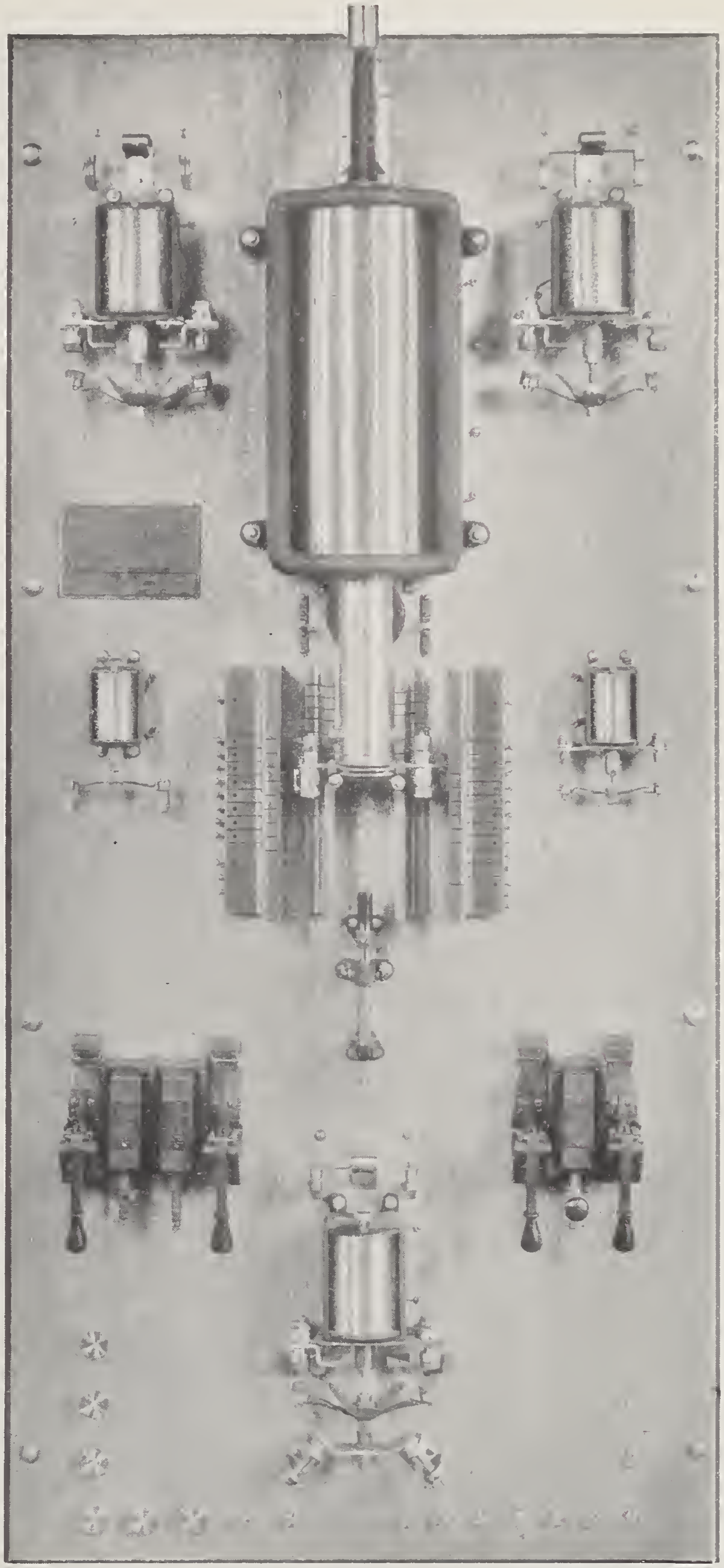


FIG. 18.—SWITCHBOARD USED WITH THE KOHLER CONTROL

Fig. 21 shows a portion of the new pressrooms of the New York "Times," in their new up-town building, where the Kohler control has been installed.

The Multi-Voltage Method.—At the present time this method has not been exploited to any extent for a newspaper press-drive, and probably will not be, due to the difficulties of furnishing multi-voltage service,—difficulties which in this particular

FIG. 20.—THE LINOTYPE DEPARTMENT OF THE NEW YORK "HERALD," HERE SHOWN, IS THE LARGEST IN THE WORLD. IT CONTAINS 56 MACHINES, GROUPED FOR ELECTRIC MOTOR DRIVING

case counterbalance the advantages of the system.

Power Requirements.—The power requirements of a newspaper press are a subject upon which the greatest differences of opinion exist, and of which little seems to be definitely known. Frequently a quadruple press is found to which a motor sufficiently large to operate an octuple press has been connected, and this may sometimes,—although appearing on the surface unwise,—I repeat, it may sometimes be wise, depending upon the special problems which are met with in each installation.

When forming conclusions upon the power requirements of presses, based upon tests of presses in actual operation which have possibly been in use for many years, the fact must not be overlooked that these presses when new require from 10 to 20 per cent. more power to drive them than after the various parts have become smooth-running from continual operation. The quality of the ink and the temperature of the air, which affects its consistency, will materially alter the power requirements of a press, probably, in extreme cases, as much as 15 per cent. The different degrees of pressure applied between various cylinders as adjusted by the pressmen, also have much to do with the smooth running of a press. The speed at which it is to operate is a factor of great importance, as the power requirements fall off materially with a reduction in speed.

One of the principal advantages of a motor-driven press is that by placing an ammeter in the electric circuit of the motor an accurate register of the working conditions of the press may be had at all times. Should the deflection of the ammeter indicate excessive power required for the operation of the press at any time, an immediate search for the defect ought to be made. When found and presumably remedied, the ammeter will indicate exactly to what extent it has been corrected. Where countershafting is employed, no means of ready detection of defects such as this is available; but where a motor is employed, the installation of an ammeter cannot be too strongly urged.

From a comparison with all data which I have been able to collect on this subject, and a study of a number of my own tests, I think the following general results may be taken as safe estimates of the power requirements of the various types of presses under different conditions:—

I realize fully that there are many exceptions to the above figures—exceptions whose reasons I have already recited, which make newspaper press engineering one of the most exacting and difficult fields for the electrical engineer. Taken in general, nevertheless, I think this table may be relied upon as conservative.

The data which apply to newspaper presses must be somewhat modified if applied to the operation of color presses like those used to print the comic Sunday supplements of the large metropolitan dailies. The color press is different from the newspaper press in that it is a hard-packing press; the pressure required of the electroplates on the paper, in order to make a good print, is much greater than with stereotype plates. The press, therefore, runs much harder and is aptly called a hard-packing press. The speed of the cylinders is reduced to little more than half that of the news press and ranges between 5000 and 7500 revolutions per hour, more usually the lower figure.

Type.	Running as	Revolutions of Cylinder Per Hour.	Max. Revolutions of Motor Per Minute.	Horse-Power Required.		
				Maximum.	Average.	Minimum.
Quadruple (news)	Quadruple	9000–12000	600	27	24	20
Sextuple "	Quadruple	9000–12000	600	28	26	23
Sextuple "	Sextuple	9000–12000	600	40	36	33
Octuple "	Quadruple	9000–12000	600	29	27	24
Octuple "	Sextuple	9000–12000	600	42	39	36
Octuple "	Octuple	9000–12000	600	52	48	44
Decuple "	Quadruple	9000–12000	600	30	28	26
Decuple "	Sextuple	9000–12000	600	43	40	37
Decuple "	Octuple	9000–12000	600	54	50	46
Decuple "	Decuple	9000–12000	600	65	60	55
Duodecuple "	Quadruple	9000–12000	600	31	29	27
Duodecuple "	Sextuple	9000–12000	600	44	42	39
Duodecuple "	Octuple	9000–12000	600	55	52	48
Duodecuple "	Decuple	9000–12000	600	67	63	58
Duodecuple "	Duodecuple	9000–12000	600	78	72	68

Double Quadruple, same as two separate quadruples. Double Sextuple, same as two separate sextuples. Double Octuple, Same as two separate octuples.

For the same rate of speed and the same number of cylinders, a color press would require fully 90 per cent. more power in its operation than a news press. But, since its speed is reduced to one-half of that of a news press, the actual power requirements of a color press of any certain number of cylinders, is usually considered the same as a news press of that number of cylinders. As an illustration of these facts the large color press of the New York "Journal" requires 27.2 H. P. when running as a full quadruple at a speed of 6000 revolutions per hour. Available data show this to be the power requirements of a quadruple news press when operating in the neighborhood of 12,000 revolutions per hour.

Again, a quadruple color press in the building of the New York "Herald," when running as a quadruple at a speed of 5500 revolutions per hour, consumes 24.3 H. P. Therefore, in general, owing to the difference in speeds, the same size of motor may be installed on a color press of a certain number of cylinders as would be installed on a news press of that same number of cylinders, even though the actual power requirements per unit of out-put are very much greater in the one case than in the other.

The leading press manufacturers are making to-day a combination color and news press which has become very popular. This color addition is usually not hard-packing, as it is intended to simply print in one or more colors certain portions of one or more pages of the paper, in which case the color addition takes about as much power per pair of rolls as the ordinary news press. Should this addition be hard-packing, however, twice as much power per pair of rolls must be provided for it as is provided for one pair of news rolls. Suppose such a press to consist of two pairs of rolls (quadruple) with a single pair of rolls (not hard-packing) in the color addition,—it would require as much power as a sextuple press, or in the neighborhood of 40 H. P. A recent test of such a press in the Denver "Post" building, installed by R. Hoe & Company, of New York, gave the results tabulated on the next page. The Bullock teaser system is used for its control.

These results further verify the previous estimates.

Economy of Operation.—Upon this point very little is known, and the reason for this is obvious, as the conditions in no two pressrooms are identical. The intelligence of the foreman may be said to be the principal factor of variation. The same presses with two different foremen might give widely different values for the cost per unit of output.

One foreman will operate his presses up to the highest speed consistent with continuity of operation,—that is, with a minimum number of breaks in the paper,—being able to do this because of his intelligent supervision of every detail of the press, whereas another foreman will operate the presses in such a way that

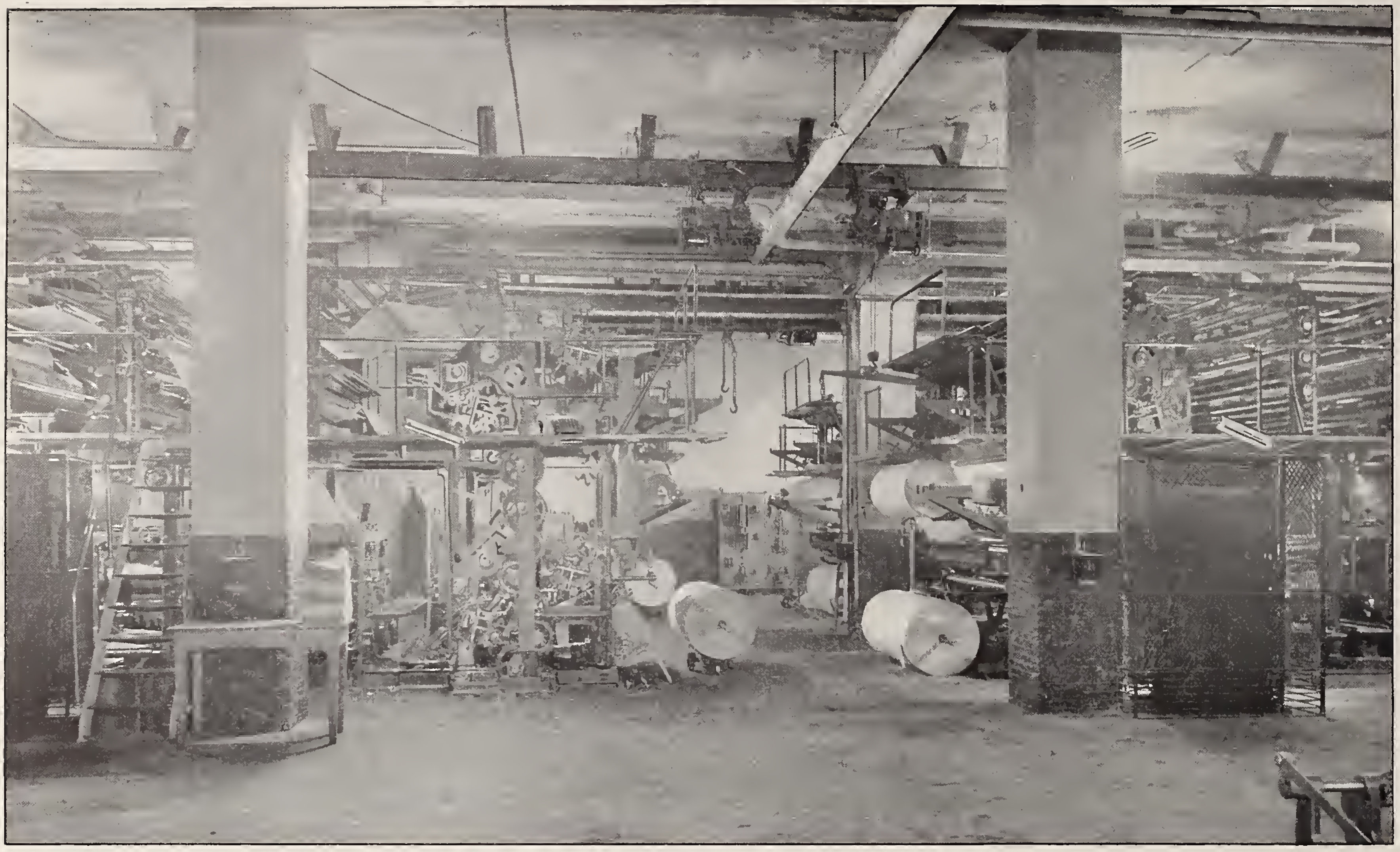


FIG. 21.—A VIEW OF THE NEW PRESS ROOM OF THE NEW YORK "TIMES." IN ADDITION TO THE MOTORS SUPPLIED BY THE MILWAUKEE ELECTRIC COMPANY, OF MILWAUKEE, WIS., DRIVING THE PRESSES, THERE ARE EIGHT SPRAGUE ELECTRIC HOISTS FOR HANDLING THE HEAVY ROLLS OF PAPER. TWO OF THESE HOISTS ARE TO BE SEEN HERE

they are either running far below or much above the speed consistent with rapidity of out-put and economy, with resultant inefficiency in either case. If presses are operated economically without an undue number of shut-downs, the cost per thousand pages of a newspaper will vary between 0.045 and 0.051 K. W.-hour, dependent upon the size of the page, the quality of the paper and the ink, and the type and make of press.

I have a test at hand where the cost of producing 28,000 twelve-page newspapers, size 18 x 21½, was 15.4 K. W.-hours, or a cost of 0.55 K. W.-hour per thousand papers. I have another test at hand where the cost of printing 35,940 twelve-page papers, 17x 23½, was 22 K. W.-hours, or 0.61 K. W.-hour per thousand papers. Many other tests show varying amounts between these two outer limits of 0.55 and 0.61 K. W.-hours.

In general, I am inclined to take the value of 0.045 K. W.-hour per thousand news pages of a size close to 18 x 22 inches as a correct basis for the estimation of the current required for the printing of newspapers. Adding to this 10 per cent. as the amount of current used in the making-ready process, and we have 0.0495 to 0.05 K. W.-hour as the actual total consumption of current per thousand pages of news matter. Upon this basis we can deduce the following table for the current consumption per thousand newspapers of various sizes:

RESULTS OF TEST OF PRESS IN THE DENVER "POST" BUILDING

3 Decks and Color.	Line Amperes.	Line Voltage.	Revolutions Per Minute.	Horse Power.
Starting, slow motion	30	470	...	19
Running " "	8	470	20 to 30	5
" fast "	40	470	168	25
" " "	45	470	200	28
" " "	50	470	210	31
Jump from slow motion to fast speed	55	470	...	33
4 Decks, Including Color.				
Starting, slow motion	45	470	...	27
Running, " "	10	...	20 to 30	6½
" fast "	45	...	175	28

Size	Cost per 1000 Papers
4-page paper (18 x 21 inches)....	0.2 K. W.-Hour
6-page paper (18 x 21 inches)....	0.3 "
8-page paper (18 x 21 inches)....	0.4 "
10-page paper (18 x 21 inches)....	0.5 "
12-page paper (18 x 21 inches)....	0.6 "
14-page paper (18 x 21 inches)....	0.7 "
16-page paper (18 x 21 inches)....	0.8 "
18-page paper (18 x 21 inches)....	0.9 "
20-page paper (18 x 21 inches)....	1.0 "

As previously stated, color presses, printing the colored supplements of a newspaper, require very much more power in their operation than ordinary news presses. In fact, from this discussion of the question it would be inferred that twice the number of kilowatt hours were required for the production of a thousand color pages as for a thousand news pages. But because of the better quality of paper employed in this work, and the fact that the presses are much more finely adjusted for it, the shut-downs due to tearing of paper are very few, and, therefore, in the continuous operation of a color press somewhat less than twice as much power is required per unit of output. A recent test by me of a large duodecuple color-press in the pressrooms of a large metropolitan daily, showed a consumption of 18 K. W.-hours for 28,980 eight-page papers, or 0.62 K. W.-hour per thousand papers. This is about a fair average of other tests which I have seen, and upon its results we can estimate that 0.0775 to 0.08 K. W.-hour is required per thousand pages (18 x 22 inches) of color matter. The following table gives the consumption of current per thousand color papers.

	Current Consumption Per 1000 Papers
4-page paper (18 x 21 inches)....	0 32 K. W.-Hour
6-page paper (18 x 21 inches)....	0.48 "
8-page paper (18 x 21 inches)....	0.64 "
10-page paper (18 x 21 inches)....	0.8 "

If then a Sunday paper contains 30 pages of news matter and comic and music supplements of 8 pages, we find from the above data that the current consumption for a thousand such papers would be 2.14 K. W.-hour.

At the low rates at which large printing concerns either buy or produce their power, namely, from four to five cents per kilowatt-hour, the actual cost of power, including all operations, in the production of a thousand ordinary newspapers is between two and two and one-half cents, —indeed a commentary on the mechanical and electrical perfection of newspaper press machinery, such perfection that the actual cost of power is the most infinitesimal item of expense of a great modern newspaper having a circulation of hundreds of thousands, amounting to less than the salary of one first-class reporter.

Wireless Telegraphy in Great Britain and Europe

According to "The Electrical Engineer," of London, an agreement has been concluded between the Italian Government and the Marconi Company for the construction of a powerful station at Coltano, intended to communicate with stations in Great Britain, Erythrea, the Netherlands, and other countries. An agreement has also been entered into between the company and the British Government for the transmission of messages to ships at sea, and the Postmaster-General has authorized the use of abbreviated or registered telegraphic addresses of firms or individuals in sending wireless messages to or from the vessels, subject to the same regulations as those governing inland telegrams.

In a steam turbine or water turbine the theoretical condition of maximum efficiency, and therefore of maximum economy, exists when the jet of working fluid moves with a velocity equal to about twice that of the vane against which it acts. Steam expanding from a pressure of 150 pounds per square inch into the atmosphere is capable of imparting to itself a velocity of 2950 feet per second; if expanded from the same initial pressure into a vacuum the resultant velocity is 4010 feet per second. The velocity of water discharged from a nozzle under a head of 350 feet—giving the same pressures as above—is only 150 feet per second. These figures, says "The Iron Age," illustrate the different conditions existing in steam turbines and water turbines.

Prospective Municipal Electric Lighting in the City of New York

As a result of the recent agitation in the city of New York in favor of municipal electric lighting, plans have been drawn for the building of a preliminary plant which is to serve for lighting of the Williamsburg Bridge across the East River and the seven temporary schools which were laid out under the bridge approach. An interesting feature of the scheme is that the city will not buy fuel for the generation of the electricity, but will use street refuse for fuel.

The plans and specifications were prepared by Henry deB. Parsons and Chief Engineer Nichols, of the Bridge Department. Work is to be commenced without delay, and it is expected that the city will begin its experiment in municipal lighting within three or four months.

The capacity of the new plant will be 400 H. P. and it will be operated under the joint supervision of the Street Cleaning and Bridge Departments. Only 250 H. P. will be required to generate the electricity needed to illuminate the bridge and schools. The surplus power will be used to run a machine shop which is to be installed under the Manhattan approach.

A commission has also been appointed by the Mayor of the city to examine into and report upon a municipal street lighting plant.

The cost of the Williamsburg Bridge installation is estimated at about $75,000. Chief Engineer Nichols is said to have calculated that the cost for lighting the lamps on the bridge will be 39 per cent. less than the prices asked by the Edison companies. But it has been admitted that in the making of this calculation no allowance had been made for depreciation, interest on the invested capital, or for taxes.

Power Plant Development in California

A NEW water-power plant which will have the highest head of any in existence is projected by the Central California Electric Company. This corporation is controlled by the same interests as the South Yuba Water Company, and is operating three water power plants, transmitting electric power to Sacramento, Grass Valley and other cities.

Preliminary surveys for the new plant are now in progress. The proposed plant will have a capacity of 25,000 H. P., and will be located on the banks of the American River at Alta Station, 60 miles from Sacramento. The water, after passing the present pump station at Alta, will be carried by a short canal to a point where a drop of 2100 feet can be obtained.

The Platt Iron Works, formerly the Stillwell-Bierce & Smith-Vaile Company, Dayton, Ohio, will design the hydraulic machinery. The turbines will resemble the Escher-Wyss pattern, which is built in Switzerland. Four direct-connected units will be installed, consisting of polyphase generators having a capacity of either 4000 or 5000 K. W. each. They will run at a speed of 750 revolutions per minute, which is a much higher speed than has been used before.

Electric Car Service Between New York and Boston

PERSONS traveling between New York and Boston may now make the trip entirely by trolley. The distance from the Grand Central Station, New York, to Park Square, Boston, is 254 miles. Fifteen changes of cars are necessary, but close connections may be made at every transfer point.

For business purposes, the trip can be made in 20 hours, at a cost of $2.85. The longest distance covered for a nickel is the 15 miles between Mount Vernon and Larchmont. The run between Worcester and Boston may be made on one car; the distance is 40 miles; the time required is 2 hours and 15 minutes, and the fare is 35 cents. This is the longest distance between the two cities that is covered by one car.

For pleasure purposes, the cost of the trip, on a fairly comfortable basis, is from $15 to $17; this, however, includes stop-overs at first-class hotels. From three to four days should be set aside for the journey, although if the traveler is off for a leisurely vacation, he will find it more pleasant to spend an even longer time on the road. The route passes through many towns of historic interest, and through country sections of varied and picturesque character.

In making the three-day trip from New York to Boston it may be divided as follows: First day, New York to New Haven; second day, New Haven to Springfield; third day, Springfield to Boston.

The four-day trip should be divided in this way:—

First day, New York to Bridgeport; second day, Bridgeport to Hartford; third day, Hartford to Ware, Mass.; fourth day, Ware to Boston.

An Economical Steam Power Plant

And What It Teaches

By GEO. H. BARRUS

ONE of the most economical steam power plants which it has been the good fortune of the writer to test is chosen as the subject of this article. In view of the high economical performance obtained, it is of interest to examine the features of the plant and ascertain the leading characteristics which produced the high results and, having done this, it is proposed to take these results as a starting point and draw such conclusions as may be warranted on the possibilities of further economy, assuming improved conditions which are within the range of attainment.

The real economy of a power plant is measured by the total expenses of operation. The expenses to be met are not only those required for fuel, but there are fixed charges for interest, depreciation, etc., and expenses for wages of attendants, for oil, supplies and repairs. It is not the purpose of this article, however, to go further than to consider the economy as relating solely to the single item of coal consumption, the only one of those mentioned which was carefully determined in the instance under consideration, and the one to which improvements of engineering design are the more commonly directed.

It is usually held that a plant, to be most economical, should be of considerable size, the larger the better. By "considerable size" is meant as large as single units can conveniently be made. We have stationary boilers which frequently run up into units of 500 boiler horse-power, or more, and we have engine units which are not uncommonly of 2500-H. P. capacity, with a tendency, in later practice, to run up into several thousand horse-power. The plant in question is one which with these comparisons would be considered rather small, the engine having a capacity of less than 1000 H. P., and the boiler units being not over 150 boiler horse-power. Under these circumstances it might be said that the plant is not, in point of size, favorable to the highest economical results. This being the case, if an error is made in assuming that the results be held as a criterion of what might be expected in plants which are arranged in larger sized units, the error is on the safe side.

The plant was used as the motive power for a cotton mill, and consequently it was run at a reasonably steady load and under practically uniform conditions of operation. The running time was divided up into continuous periods of not over $5\frac{1}{2}$ hours, and the corresponding periods of the test were consequently of comparatively short duration.

THE BOILER PLANT

The boiler plant consisted of four vertical, tubular, firebox boilers, in which the diameter of the main shell was 67 inches; that of the firebox outside, 85 inches; and of the firebox inside, 78 inches. The crown sheet was 51 inches distant from the grate, and the distance between the tube sheets and the length of the tubes was 15 feet. In each shell there were 228 tubes, measuring $2\frac{1}{2}$ inches outside diameter, and having a collective opening of 20 per cent. of the grate surface. The diameter of the grate was 78 inches, making an area of grate surface of 33.2 square feet, half of which was composed of metal and half air opening.

The water-line was carried at such a height that about 4 feet 9 inches of the upper ends of the tubes were exposed to the escaping gases, and served as steam heating surface. The water heating surface in each boiler had an area of 1489 square feet, or 44.8 times the area of the grate surface; and the steam heating surface, 665 square feet, or twenty times the area of the grate surface, making a total of 2154 square feet of heating surface for each boiler. The superheating surface was of sufficient capacity to heat the steam 12.4 degrees above the normal temperature when the boilers were running at their usual capacity. The exterior surfaces of the boiler shells were protected from radiation by means of magnesia covering.

From the boilers the products of combustion and escaping gases passed through a rectangular flue into a brick chamber containing a feed-water heater, or economizer, and thence to the brick chimney upon which dependence was placed for draught, the latter being controlled by an automatic steam pressure regulator acting upon a damper between the economizer and the chimney. The economizer contained vertical cast-iron pipes, provided with scrapers, which presented a total area of outside heating surface amounting to 2204 square feet, or slightly more than the total heating surface, both water and steam, presented by a single boiler. Two boilers were sufficient to furnish the steam required for the engine, and this was the number in use when the test was made. One of the remaining boilers was idle, and the other, running at a comparatively slow rate, was employed in furnishing steam for miscellaneous heating purposes about the mill.

Running in this way, that is, two boilers on the engine, one on the mill, and one idle, the escaping gases left the boilers and entered the economizer at a temperature of 520 degrees, and they left the economizer and entered the chimney at 322 degrees. At the same time, the feed-water entered the economizer at 101 degrees, and left it and entered the boilers at 209 degrees. The loss of temperature of the gases in passing through was 198 degrees, and the corresponding gain in the temperature of the water was 108 degrees.

The chimney was 150 feet high, with an interior flue 5 feet in diameter. Much less than the full draught of the chimney was required, the automatic damper cutting it down so that the average force of the draught in the main flue between the economizer and the boilers was only 0.16 of an inch water pressure. This was sufficient to burn the quantity of coal required, the rate of combustion being 11.7 pounds per square foot of grate per hour. The amount of boiler horse-power developed was 248.6, which is rather less than the rated capacity of the two boilers.

It is noticeable here that the coal was burned with a comparatively small force of draught. This is one of the features of the vertical type of boiler, as the natural upward tendency of the products of combustion through the vertical tubes produces a draught of its own. The draught of the chimney under the reduced temperature of the gases leaving the economizer, was about 0.6 of an inch. The relation between this force and that actually required at the boiler, which, as will be seen, is nearly 4 to 1, reveals this feature of the action of the vertical type in the clearest manner. The character of the combustion produced under these conditions is evidenced by the results of the gas analyses, which showed 13.1 per cent. carbon dioxide, 5.7 per cent. oxygen, and 0.6 per cent. carbon monoxide, all referred to volume. With this composition, the amount of air supplied per pound of combustible figures out 15.5 pounds.

The feed-water for the boilers was supplied by a plunger pump, operated by a belt from the main source of power. This fed the water through the economizer into the two boilers supplying the engine, while the auxiliary boiler was fed from another source. The water supplied to the pump was drawn from the hot well of the condenser after receiving the hot water from the engine jackets.

As a result of the evaporative work done by the two boilers for a period of 14.27 hours, 11,080 pounds of dry Cumberland coal were burned, and 115,496 pounds of water were evaporated, the steam pressure being 153.4 pounds; the temperature of the water entering the boilers, 209 degrees; and the steam superheated, 12.4 degrees. With these data, the weight of water evaporated per pound of dry coal was 10.424 pounds, and this is equivalent to 12.03 pounds evaporated from and at 212 degrees per pound of combustible, the percentage of ash in the coal being 8.5 per cent. The total heat of combustion of the coal by calorimeter test was 14,869 British thermal units per pound of combustible, and the efficiency of the boiler on this basis, that is, the percentage of the total heat utilized in evaporation, is 78.2 per cent.

The steam, on leaving the boilers, passed through a 9-inch main pipe, which extends a length of 75 feet from the throttle valve of the engine. It contained five short, right-angle turns, and a steam separator near the throttle valve. The steam pipe diagrams taken from this pipe near the cylinders showed a fluctuation of pressure at this point amounting to five pounds, and, so far as fluctuation was concerned, there was no appreciable difference produced by the resistance interposed by the separator.

THE ENGINE

The engine consisted of two horizontal cylinders arranged on the cross-compound system. The high-pressure cylinder was jacketed both on the heads and around the barrel. The low-pressure cylinder was jacketed on the heads, but not on the barrel. The diameter of the high-pressure cylinder was 18 inches; that of the low-pressure cylinder, 48 inches; and the stroke of both, 4 feet. The steam exhausted from the high-pressure cylinder passed through an 8-inch pipe containing a horizontal tubular reheater, which had 187 square feet of heating surface. The jacketed spaces of the cylinders and the tubes of the reheater were supplied with steam of full boiler pressure, and the resulting water condensed was pumped into the boilers.

It was found that, under the test conditions, the amount of water thus condensed averaged 9.5 per cent. of the total weight of steam supplied to the cylinders. The shell of the reheater was drained by a trap, and the water was thrown away. When the engine was running at its ordinary capacity 184 pounds of water were discharged per hour at this point. At the same time, there is sufficient tube surface in the reheater acted upon by boiler steam to superheat the steam passing from the reheater to the low-pressure cylinder an average of 32 degrees. The clearance of the high-pressure cylinder was 2 per cent., and that of the low-pressure cylinder 2¾ per cent. The ratio of volumes of the cylinders was unusually large, being 7.3 to 1. The valves of each cylinder consisted of one steam and one exhaust valve for each end, and these were gridiron slides. The steam valves were rendered automatic by the action of the cut-off mechanism attached to a ball governor. The cut-off of the low-pressure cylinder was adjustable by hand, in addition to being connected with the governor. The valves were not absolutely tight, especially one of the exhaust valves of the low-pressure cylinder, and the high-pressure piston leaked to some extent. The engine, on the whole, was found to be in as good condition as the average engine, but not in the best condition, as sometimes occurs.

The condenser was of the siphon type, depending on a barometric tube for the maintenance of the vacuum. It was supplied with water by gravity, and neither pump nor power was required to handle either the injection water or the overflow water.

During the progress of the test, which continued for three periods, aggregating 14.27 hours, the engine ran at a speed of eighty revolutions per minute, and developed an average of 660.1 indicated horse power. Of this, 299.8 H. P. was developed by the high-pressure cylinder, and 360.3 H. P. by the low-pressure cylinder, the mean effective pressure in the cylinders being, respectively, 62 pounds and 10.2 pounds. The pressure in the steam pipe was 150.2 pounds, the pressure in the receiver 14.9 pounds, and the vacuum in the condenser 26.6 inches. The initial pressure above atmosphere in the high-pressure cylinder was 143 pounds, and in the low-pressure cylinder 14.5 pounds. The back-pressure in the high-pressure cylinder was 16.5 pounds above the atmosphere, and in the low-pressure cylinder 13 pounds below the atmosphere. The cut-off in the high-pressure cylinder occurred at 28.5 per cent. of the stroke, and in the low-pressure cylinder at 17.6 per cent. of the stroke. The steam accounted for by the diagram at cut-off in the high-pressure cylinder was 9.21 pounds, and in the low-pressure cylinder 7.96 pounds, and these are, respectively, 75 per cent. and 65 per cent. of the actual steam consumption, the total amount used by the engine being 12.27 pounds per indicated horse power per hour.

THE GENERAL RESULT

For the entire time of the periods covered by the test, aggregating 14.27 hours, the weight of dry Cumberland coal consumed was 11,080 pounds, or 776.5 pounds per hour. The average indicated horse-power developed by the engine was 660.1; consequently, the weight of dry coal consumed per indicated horse-power per hour was 1.18 pounds. This result is an excellent one, when compared with the work of many plants which are generally considered to be doing good work if they develop a horse-power on 1.5 pounds of coal per indicated horse-power per hour.

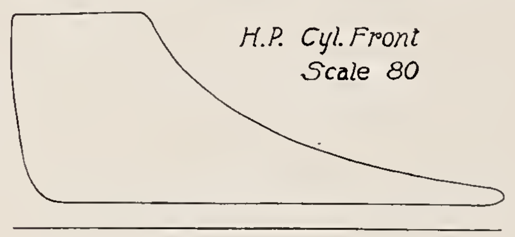
Having given the particulars in regard to the design of the plant, and the results of the test, we may now analyze the matter closely and see what were the main features which contributed to the high performance. Starting with the boilers, a fairly high efficiency was realized in the evaporative work. With a hand-fired furnace it is seldom that an efficiency much higher than 78 per cent., which was obtained in this case, can be realized; and this result points not only to an efficient design and proportioning of the boiler and heating surfaces, but also to efficient work in the firing of the coal and the operation of the boiler. Coupled with this, was a considerable gain produced by saving the heat of the waste gases by the economizer, for the heating of the water by this means to the extent of 108 degrees represents the utilization of about 10 per cent. of the total amount of heat used in the evaporation.

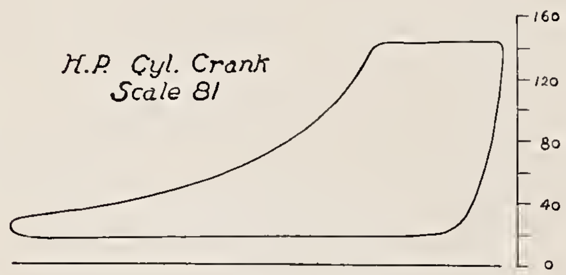
If we take into account the heat thus utilized, and compare the total amount of heat absorbed by the boiler and economizer with the heat of combustion of the coal, the efficiency of the combined generating apparatus runs up to 86.5 per cent., leaving only 13.5 per cent. for losses due to radiation, incomplete combustion, and that produced by the heat of the gases leaving the economizer and entering the chimney, which is about as low as these losses could be expected to aggregate. The coal used was not the best kind obtainable, but Cumberland coal belongs to the class of American semi-bituminous coals which possess the highest calorific qualities, and from which the best results in practical work are usually obtained. To start with, then, the high performance of this plant is due to the use of good coal in a well-proportioned and skilfully operated boiler, with all the waste due to combustion prevented, so far as it is practicable to do so in hand-fired furnaces.

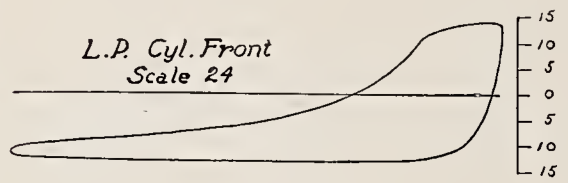
Passing to the engine, a number of noticeable features appear, which evidently contributed a share to the final result. Perhaps the most noticeable characteristic of this engine is the high ratio of volumes existing between the two cylinders. Ordinary practice in the design of compound work establishes a ratio of between 4 and 5 to 1. The ratio here goes about 50 per cent. beyond the custom. The fact that high economy in steam consumption was obtained with this ratio of volumes, is not of itself more than an indication that the large ratio was the principal cause. To prove the matter it would be necessary to compare two engines having precisely the same features of design and construction, in which the only difference between them is the single difference of volumes. It seems to be a reasonable conclusion, however, that an increase in the ratio of volume should tend to improve the economy, provided the pressure is sufficient; and it seems to be generally agreed that, as the pressure increases, the ratio of volume of the two cylinders should be in some measure increased also. The conclusion seems to be justified that, in view of the fairly high pressure which was carried, the high ratio of the cylinders was advantageous, and that this high pressure, under the circumstances, contributed much to the high economy produced.

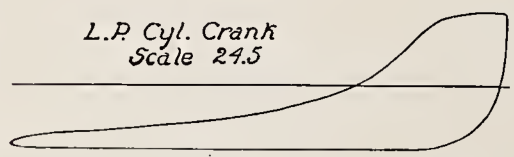
No less noticeable is the appearance of the indicator diagrams, and the excellent distribution of steam which they reveal in the working of the valve mechanism. Copies of sample diagrams, on a reduced scale, are given on this page. There is a marked absence of wire-drawing of the steam during admission to the high-pressure cylinder. There were no undue losses of area produced by faulty valve action, or choked ports and passages. Other things being the same, these characteristics can have no other influence than to improve the economy of steam consumption. It will be noticed that the cut-off of the low-pressure cylinder on these diagrams is considerably shorter than that of the high-pressure cylinder. This is one of the effects due to the large relative volume of the low-pressure cylinder.

It is interesting to note that the engine was found slightly more economical when running under these conditions than it was when the cut-off of the two cylinders was more nearly









equal. When the cut-off in the low-pressure cylinder was 32 per cent. and that in the high-pressure cylinder 28 per cent., the feed-water consumed per indicated horse-power per hour for a run of five hours was 12.29 pounds. When the cut-off in the low-pressure cylinder was reduced to 24 per cent. the consumption decreased to 12.03 pounds, and when the cut-off in the low-pressure cylinder was reduced to 17 per cent., corresponding to the work of the test, the consumption fell still further, to 11.89 pounds.

Another feature in the work of this engine is the use of slightly superheated steam, jacketed cylinders, and a reheater. These undoubtedly produce some advantage. This is shown by the results of experiments made by the writer on other engines with and without superheating, and with and without the use of steam in jackets and reheater. These points are not capable of being determined exactly without trial on the particular engine in question; but it seems to the writer that their combined advantage produced an economy which can safely be placed between 3 and 5 per cent. The shutting-off of the boiler steam from the jackets and reheater in one case of an engine of this kind, which was supplied with ordinary steam, increased the consumption of steam 2 per cent.

Although the engine appears to be highly efficient, when the actual weight of steam consumed alone is considered, it does not appear so efficient when the work of the steam in the cylinders is analyzed, and a comparison is made between the actual consumption and that revealed by the diagram. The steam accounted for by the indicator at cut-off of the high-pressure cylinder, as already stated, was 75 per cent. of the actual amount of steam consumed. For an engine which is jacketed and supplied with slightly superheated steam this proportion is rather low.

In a perfectly tight engine, which was supplied with ordinary dry steam and had no benefit from steam jackets, the writer has found 80 per cent. of the steam accounted for in the high-pressure cylinder. The difference between 75 per cent. and 80 per cent. in an engine of this class represents three-quarters of a pound steam consumption per indicated horse-power. This furnishes strong ground for the conclusion that if the engine under consideration had been perfectly tight, and in all respects in the best condition, the performance would have been considerably improved.

A still further feature in the design of this plant, which contributed not a little to the high economy obtained, was the absence of steam-driven auxiliaries for operating the condenser and feed-pumps. The whole steam used by the plant was consumed either in the cylinders of the engine, or condensed in the jackets, and there were no losses of steam of any kind, except the slight ones which invariably exist, due to leakage of joints, stuffing-boxes and piping.

CONCLUSIONS FROM THE TESTS

From a careful reading of the facts regarding these tests, it will appear that a steam plant which is not in the best condition, and which is not operated in all respects in such a manner as to secure the best obtainable results, can readily produce a horse-power on a consumption of 1.18 pounds of dry

Cumberland coal per hour, and it will suggest means by which the economy can be improved. It is not too much to expect that by these means the consumption of coal in a plant of the kind described could be reduced to not more than one pound per hour per indicated horse-power.

The first step suggested is to employ the highest grade of semi-bituminous coal. The coal used on the test was inferior, as compared with coal showing the highest calorific value. The best grades run as high as 15,000 British thermal units per pound of dry coal, as against the 13,970 which applies to the coal tested. Without going to extremes, if we use 14,750 as a practicable figure, and assume that coal of this kind was used in place of the coal employed on the test, we reduce the coal consumption 5 per cent., or 0.06 pounds per indicated horse-power per hour.

The second step for improving the performance is, naturally, the correction of the engine leakage which occurred, and other losses, which were the cause of the low percentage of steam accounted for by the diagrams, as referred to, amounting to three-quarters of a pound of steam per indicated horse-power per hour, or 6 per cent. of the total consumption. If the defects producing this loss were remedied, the coal consumption would be reduced to the further extent of 0.07 pounds per indicated horse-power per hour.

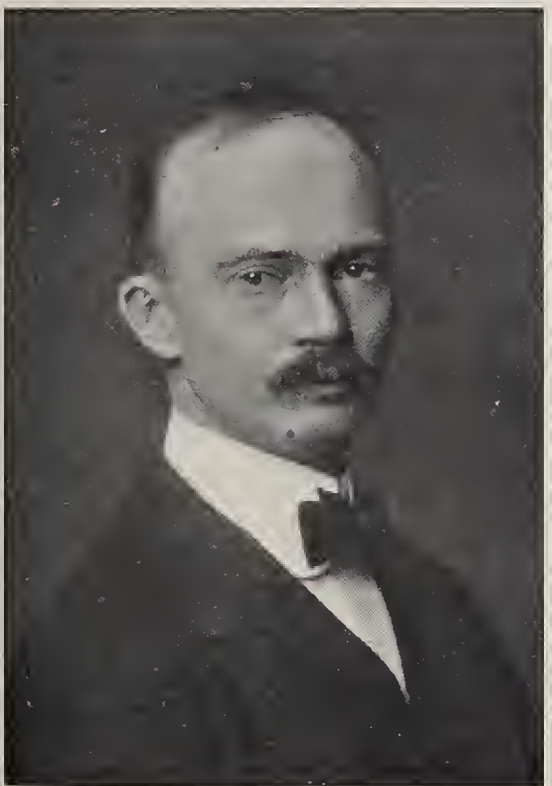
The third step for improvement that suggests itself lies in the direction of employing a higher boiler pressure. If we increase this to 200 pounds, and carry the expansion line of the high-pressure diagram up to the new steam line without changing the remaining portion of the diagram, it will be found that about ten pounds mean effective pressure can be added to the high-pressure cylinder without sensibly changing the conditions of operation of the steam in this cylinder. This will add about 8 per cent. to the power developed by the engine, and improve the economy, after allowing for the increased cylinder condensation, about 5 per cent., or 0.05 pounds of coal per indicated horse-power per hour.

Adding together these three items, we have a saving of 0.18 of a pound per indicated horse-power per hour which is practicable, and this brings the consumption of coal down to one pound per indicated horse-power per hour. We might go further and point out wherein still greater economy could be secured by the use of mechanical stokers in place of hand-firing. This is enough, however, to show that with the increase of boiler pressure, which seems to be the tendency of modern steam engineering, the time will soon come when the unit of one pound weight of coal per hour will be considered as a standard of consumption in the development of an indicated horse-power.

Electric Traction Developments

By WILLIAM B. POTTER, Engineer of the Railway Department of the General Electric Company

Extracts from a Paper Read on January 20, before the New York Railroad Club



WILLIAM B. POTTER

ELECTRICITY has been considered for traction in many different ways; but, broadly speaking, these may be divided under two main headings—Direct Current ("D. C.") and Alternating Current ("A. C.") systems. These expressions are somewhat misleading, as, strictly speaking, the term "D. C. System" should be reserved for a system using direct current only, and, therefore, should not be applied to one employing three-phase generators and transmission lines. However, since the single-phase motor has entered the traction field, it has become common practice to style a system as either D. C. or A. C., according to the type of motors used on the car.

The D. C. system, with a central station feeding numerous rotary converters through the medium of three-phase high-tension transmission lines, which in turn supply an overhead trolley network with direct current at a pressure of from 550 to 600 volts, is without doubt the most highly developed and best known system in this country.

The A. C. system may employ either single or three-phase generators and transformers. Both the generators and transformers will be three-phase where three-phase induction motors are used on the cars; and in such cases the line is equipped with two overhead trolley lines and the track rails serve as the third conductor. When single-phase motors are used on the cars, either three-phase or single-phase generators and transformers may be used, the choice being dependent on local conditions.

Three-phase systems have been extensively used in Europe, especially in Switzerland, Italy and Germany. The three-phase induction motor is particularly well adapted for service in which it is desired to control the speed of the car by means of the motors on down grades, either for the purpose of returning energy to the line, or as a measure of safety.

A great deal has been written concerning the possibilities of single-phase traction, and, as is often the case with the development of a new principle, many appear to have formed too optimistic ideas of its capabilities. While we recognize the advantage of such a system in many cases, it is a mistake to imagine that it will be a cure for all ills and revolutionize the railway world. It is well, therefore, to have a clearer idea of the advantages and disadvantages of single-phase traction, and also to analyze the reasons governing the choice of such a system. It is self-evident that the relative expenditure for equipment, operation and maintenance, should be the fundamental reason governing the selection of a system for any particular service.

The single-phase A. C. system possesses two features which recommend its use,—economy of trolley copper, due to the higher trolley voltages, and the elimination of the rotary converter.

FIG. 1.—ONE OF THE TWO OVERHEAD CONTACTS USED ON THE NEW ELECTRIC LOCOMOTIVES OF THE NEW YORK CENTRAL RAILROAD

The chief advantage gained by these features is a saving in the initial cost of equipment: factors which increase in importance in proportion to the amount of power required by each car or train, and with the length of the trolley line. On the other hand, the A. C. car equipments cost more than the D. C. equipments for a similar service and the same given rise in temperature of the motors. It is, therefore, apparent that the relative cost of an A. C. or D. C. system will be materially affected by the number of cars employed.

The saving in power resulting from the elimination of the rotaries is about off-set by the greater weight and slightly lower efficiency of the A. C. motor.

The efficiency of the A. C. control, during acceleration, will, generally speaking, be somewhat higher than that of the D. C. system with series parallel control. With the A. C. system fractional voltages can be obtained from the transformer on the car. Each step of the A. C. controller gives a running position which corresponds with the series and parallel positions in a D. C. controller.

The potential of the transmission lines from the power station may be selected, as in the case of the D. C. system, without reference to the trolley or secondary voltage. The trolley voltage must, however, be considered from a different basis than that of the D.C. system, for the reason that, in addition to the ohmic resistance of the trolley and track circuit, there is an apparent increase in resistance, due to the alternating current. This increase in apparent resistance for 25 cycle alternating current, as compared to direct current, is about 50% greater in the trolley wire, and between six and seven times greater in the rail return. The rails being steel, the increase in apparent resistance is relatively much greater than in the trolley wire. As the resistance of the track return with large steel rails is proportionately much less than that of the trolley wire, the apparent increase in resistance for the latter and the track taken together will be, roughly, from one-half to twice that for the direct current. An alternating current at 1000 volts, is, therefore, about equivalent to 600 volts direct current so far as affecting the amount of trolley copper and to secure the advantages of the A. C. system to a reasonable degree at least 3000 volts, or, for heavier service, perhaps 5000 volts must be employed.

The design of an A. C. motor as regards length of air gap and armature speed is affected by the lower average flux density. For this reason an A. C. motor is larger and heavier than a D. C. unit of the same output. The commercial A. C. motor represents a compromise in which the armature speed is somewhat higher, and the air gap slightly less than would be the case in a D. C. motor of corresponding capacity. I have mentioned these facts to indicate that the maintenance of an A. C. motor will, in all probability, be greater than that of an equivalent D. C. motor, due both to the higher armature speed and the smaller air gap.

The equipment of heavy locomotives with A. C. motors for high-speed passenger service is a possibility, but owing to the limitations imposed by the space available for the motors, it seems probable that two locomotives, each with four motors, would be required for service which could be performed by a single D. C. locomotive with four gearless motors. For locomotives in slow speed work,—such as freight or shifting, a double gear reduction will, in many cases, be required, owing to the difficulty of winding an A. C. motor of large size for slow speeds.

In view of the extensive application of the D. C. system, it is fortunate that the A. C. motor and its control may be so arranged as to be well adapted for operation on either high potential alternating or 600-volt direct current lines. This adaptability is an important factor in the net earnings as the equipments are not necessarily limited at all times to a particular route and further, where D. C. trolley lines are available, the expense of installing a special A. C. trolley is saved.

The above comparisons relating to A. C. and D. C. systems indicate certain financial and technical differences which have to be met. There is no question as to the successful operation of A. C. apparatus, and the advisability of its use when such an installation will prove financially advantageous.

The power required per ton-mile for moving trains varies so greatly with conditions of traffic that any direct comparisons between electricity and steam as a motive power can only be made by assuming a given class of service. The suburban type of traffic is generally recognized as being more especially suited to electrification, and a comparison in such service of the steam locomotive and an electrically-equipped train of equal seating capacity will be of interest.

It is admitted that the first cost of equipping a railroad electrically is higher than the initial outlay for equipping the same road with steam locomotives; but it is well-nigh impossible to make a general comparative statement as to the relative first cost. This will depend on the number of locomotives required to handle the traffic in the one case, and in the other upon the density of the traffic, and it is the latter factor upon which the size of the generating station and transmission lines are dependent.

For example, assume a suburban train of four cars hauled by a steam locomotive, and a similar train operated by electric motors under the cars:

	Tons
Weight of steam locomotive	110
4 cars, 40 tons each	160
Total weight of steam train	270

The electric equipment for these four cars to perform the same service, would weigh, approximately, 50 tons.

	Tons
Electric equipment	50
4 cars, 40 tons each	160
Total weight of electric train	210

Tests on a steam locomotive in this class of service have shown, approximately, 0.07 indicated horse-power hours per ton-mile and a coal consumption of 6.86 pounds per indicated horse-power hour, charging up the full amount of coal used during the twenty-four hours, whether running or idle. On the above basis, assuming coal at $2.50 per ton, we have the following as cost of coal per train mile:—

I. H. P. hours per ton-mile	0.07
I. H. P. hours per train-mile	18.9
Pounds coal per I. H. P. hour	6.86
Pounds coal per train-mile	130.
Cost of coal per train-mile	14.5 cents

The cost of electric power per K. W.-hour is well established by records from many power stations. The following is a typical record from a station in railway service:—

Coal ($2.85 per ton)	0.00286
Water	0.00036
Labor	0.00158
Supplies	0.00011
Maintenance	0.00009
Total	$0.00500

As the cost of coal and labor is a variable quantity we will assume $0.006 as a basis. The labor and maintenance of sub-stations may be taken as 10 per cent. additional, making a total cost per K. W.-hour of $.0066. The efficiency of transmission and sub-stations may be taken as 78 per cent. The cost of power for the electric train would, therefore, be as follows:—

Weight of train	210 tons
Watt-hours per ton-mile (Equivalent to above 0.07 I. H. P.-hours)	58
K. W. hours per train-mile at train	12.2
K. W. hours per train-mile at power station	15.6
Cost of power per K. W. hour	$ 0.0066
Cost of power per train mile	10.3 cents

The wages per day for a train crew in steam service may be taken as follows:—

Engineer	$3.50
Fireman	2.00
Conductor	3.00
2 train hands	3.50
Total	$12.00

The crew for the electric train will be the same, omitting the fireman. In steam service this crew will make a train mileage of, approximately, 100 miles per day.

In an electric service, due to its greater flexibility, it is a reasonable assumption that the crew will make a mileage of 150 miles per day.

Under this assumption the wages per train-mile will be:—

Steam	12 cents
Electric	6.7 "

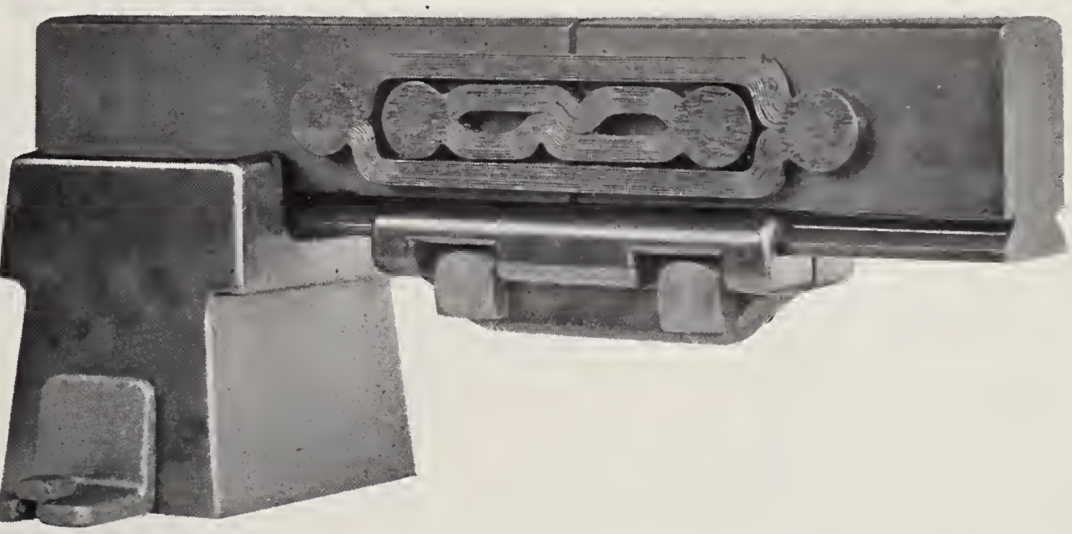


FIG. 2.—A SUGGESTED SECTION OF THIRD RAIL WHICH HAS THE MERIT OF PROVIDING LARGE CONDUCTIVITY WITH A MINIMUM OF HEIGHT

The maintenance of steam locomotives varies, but in this class of service 6.5 cents per locomotive-mile seems a fair basis from the records available. The maintenance of the electrical equipment per car-mile on the Manhattan Elevated Railway in New York City is one-quarter of a cent, and as these equipments are larger, we will assume one cent per car or four cents per train-mile.

A summary of the comparative cost per train-mile is as follows:—

	Steam	Electric
Coal or equivalent elec. power	14.5	10.3
Water	0.5	6.7
Train crew	12.	6.7
Maintenance	6.5	4.
Supplies	0.5	0.2
	34.0	21.2 cts.

Assuming a yearly mileage of 50,000 miles, which is a reasonable assumption for the electric train, the yearly difference in cost of operation, in favor of electricity, would amount to $6,400.00, representing an interest on the total investment per train which would be more than sufficient for that usually required for the car equipment and the proportionate part of the power station and transmission. Furthermore to this capitalized investment should be credited the cost of a steam locomotive equipment capable of making 50,000 miles per year.

As this is a brief consideration of a general example, it is hardly worth while to enter into refinement, but in nearly every case the use of electric power will make it possible to secure many incidental economies, both in utilization of rolling stock and cost of operation, the aggregate of which may be a large item.

The following comparison from statistics covering the steam and electric operation of the Manhattan Elevated Railway shows the increase in traffic and the lower cost of operation per car-mile, resulting from electrical equipment. The probable increase in traffic was not sufficiently recognized, prior to the electrical equipment, as to be reckoned an important factor in the earnings of the road, but its influence to this end will be better appreciated when it is remembered that during the latter period of steam service the number of passengers carried decreased each year.

Date	Steam 1896	Electric 1904
Operating ratio	58.1%	41.2%
Passengers carried	185,138,000	286,634,000
Car mileage	43,241,000	61,743,000
Receipts per car-mile	21.6	22.95 cents
Total operating expenses per car-mile	13.2	9.5 "
Total operating expenses per passenger	2.92	2.04 "

Careful calculations should be made on each individual road considering electrification, as actual results will vary with every new set of conditions. The point at issue is whether the traffic is, or is likely to be, of such a character that the saving in operation or increased receipts will show a proper return upon the required capital.

In considering the application of electric power to freight service, the subject may be considered more strictly from the standpoint of existing traffic, as the reasons which influence the growth of passenger traffic will apply only in so far as the movement of freight may be facilitated and cheapened. Electric power in a single unit, such as a locomotive, is best suited for general freight, although there may be special cases where it will be advantageous to equip several or all of the cars in a train and control from the leading car.

The method of conveying electric power to a car or train is influenced by the size of equipment and conditions under which it operates. The simple trolley and wheel in general use has been surprisingly satisfactory in service much more severe than that for which the trolley wheel was originally considered. The limitation of its capacity is rather in the life of the wheel than from any particular difficulty in collecting the current. With cars of medium size, at moderate speed, an upward pressure of 15 or 20 pounds against the trolley wire is sufficient, and the life of the wheel is frequently 10,000 miles or over. At car speeds of 50 to 60 miles an hour, an upward pressure of 35 to 40 pounds appears necessary to insure the wheel maintaining close contact with the wire over the irregularities of the suspension. This greater pressure, coupled with the larger amount of current commonly taken at such speeds, results in the rapid wearing of the trolley wheels, which is more especially noticeable on account of the large daily car mileage, common to high speed service.

Considerable attention is being given to the development of a collector for heavy service which will cost less to maintain than the present trolley wheel. The bow form of trolley, in which a sliding bar of copper or aluminium at right angles to the trolley wire replaces the trolley wheel, has been used to some extent abroad and seems to have met with considerable favor. The cars on which the bow trolley has generally been used are of comparatively slow speed and power, and such tests as have been made indicate that in the equivalent of our suburban service the maintenance cost of the bow trolley would considerably exceed that of the trolley wheel. A modification of the bow trolley in which a roller replaces the sliding bar has been used in a number of cases, with excellent results.

Where the trolley wire is maintained within a foot or two of uniform height, a reversible trolley contact with a pantagraph mechanism, carrying a roller for contact with the wire, can readily be applied. Where the variation in height of the trolley wire is considerable, on different parts of the same line, the pantagraph construction must necessarily be of considerable size. The first electrical equipment of the Brooklyn Bridge was provided with this pantagraph form of trolley, prior to the installation of the third rail. Another instance of the use of this type of trolley is on the San Francisco, Oakland & San Jose Railway. It is customary to install two pantagraph trolleys, each collecting its share of the current, and where necessary to collect a larger amount, as might be the case in locomotive work, additional trolley contacts may be installed to any extent required. A pantagraph type of trolley, provided with a shoe, instead of a roller, is well adapted for use in connection with third rail operation, where it is desired to make overhead contact through special track work or road crossings where the third rail cannot be well installed. Fig. 1 shows one of the two overhead contacts used for this purpose on the New York Central locomotive. This particular contact device is fitted with an air piston to provide a convenient means of repressing the contact shoe.

The ordinary methods of trolley wire suspension and insulation are not well adapted for high potential alternating trolley lines and what is known as a catenary suspension of the trolley wire will probably be more generally used. In the catenary suspension the supporting cable or catenary is carried over the top of high potential insulators at the point of support and the trolley wire is attached by clips and hangers, directly to the catenary without intervening insulation. The catenary thus serves as a supplemental conductor to the trolley wire and it may be of either steel or copper. As the trolley wire is supported at frequent intervals, the poles for the catenary can be spaced at longer distances than common with the ordinary type of trolley construction. While especially advantageous for high potential work, there is no reason why the catenary form of suspension should not be more generally employed for direct current work and it provides a means for supporting a larger trolley wire, if desired, than is now commonly used.

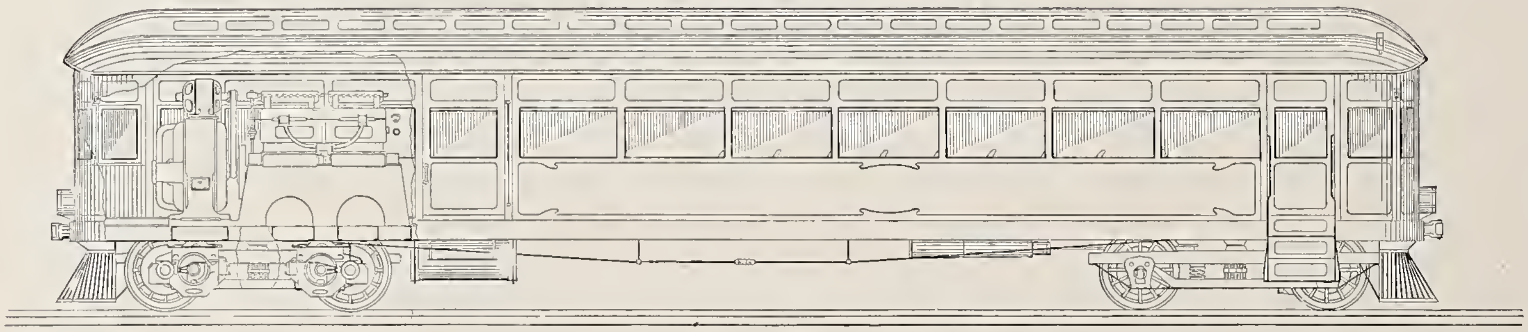


FIG. 3.—A GASOLINE-ELECTRIC COMBINATION CAR

The third rail, although used to a considerable extent in place of the trolley, has been criticised, particularly from the standpoint of danger and trouble from sleet. The unprotected rail is open to both these objections, but with a suitable protection against accidental contact and from sleet, these objections are to a great extent overcome.

The location of the third rail, with reference to the track, would seem to be a simple question, but owing to local conditions nearly every installation has been different. Between clearing the low-pressure cylinders of compound locomotives, the hoppers on the large steel coal cars and keeping within the bridge abutments and tunnels, the location is generally a case of compromise. It will be advantageous to facilitate the interchange of equipments by establishing a uniform location of the third rail and the importance of such a standard and difficulty of finally determining it will increase with every new installation.

Fig. 2 shows a suggested section of third rail, which has the merit of providing large conductivity with a minimum of height. As the amount of insulation that can be provided is in a measure dependent upon the distance between the bottom of the third rail and the tie, a minimum height is for this reason advantageous.

The subdivision of the third rail into sections which will be normally disconnected from the supply circuit and automatically connected when in the immediate vicinity of the car, has many times been proposed. Such an arrangement appears to have little or no advantage, as, apart from the complication introduced, the sectional third rail should be protected by a covering to the same degree as an ordinary third rail. Unless the sections are very short, the rail will be energized for some distance beyond the car, and persons getting on or off, or working about the car, would be likely to receive shocks, and more especially so as the rail would ordinarily be considered harmless. Another important reason for protecting the rail is that the cover will form a shield from sleet, which is much more troublesome on a sectional third rail than on the ordinary third rail.

The third rail contact shoe which has been quite generally used, depends on gravity for its contact with the rail; therefore, at high speeds with any uneveness on surface of the third rail this type of shoe shows a disposition to jump and arc excessively.

A better form of shoe is one in which the contact is held against the third rail by a spring, this principle being applied to the hinged type of third rail shoes in use on the interborough subway in the city of New York and the New York Central locomotive.

The initial expense of electrical equipment, more especially that due to the cost of power station and trolley line, has deterred many steam railroads from electrifying branch lines in sparsely populated districts. Such lines could be served more profitably by independent cars than by steam trains, as the possibility of economically operating single cars on frequent headway, by providing a better service, would have an important influence upon the development of the traffic.

To meet the requirements of this class of service, a self-propelled car, independent of any feeder system, seems particularly well suited. With this end in view numerous schemes have been suggested and tried, some employing steam and others compressed air as a motive power; and again, storage batteries and gasoline engines have been used. Without discussing the relative merits of these different methods, it may be briefly stated that the gasoline engine seems to have the advantage of possessing the greatest power for a given weight, and is also able to cover considerable distances—owing to the concentrated nature of the fuel and the high efficiency of the engine in relatively small sizes.

A number of such equipments are in operation abroad, some being provided with a mechanical transmission to the wheels similar to an automobile, and others having a generator direct connected to the engine, with the electric motors mounted on the trucks in the usual way. For cars of the weight commonly used on steam railroads in this country, and those which have bogie trucks, the gasoline-electric combination seems in many respects the better suited.

The principal difficulty that has been experienced with this type of equipment is the insufficient capacity of the engine; and this is not surprising when we appreciate that the motors of a 40-ton electric car under ordinary service conditions are frequently required to develop 500 H. P. during acceleration. The building of a successful car of this description is a problem depending entirely upon the engine; and there seems reasonable ground for the belief than an engine well adapted to this class of work can be produced.

The General Electric Company have under construction an equipment of this character which, if successful, should be well adapted to meet the requirements of the class of service under consideration. This car is provided with passenger, smoking, toilet and baggage compartments and is 65 feet over all. The engine-room is at one end, and a motorman's compartment is provided at each end of the car, to permit its being operated in both directions. The car complete will weigh, approximately, 55 tons. A general idea of such an equipment may be obtained from Fig. 3, showing an elevation of the car body. This is partially in section to show the arrangement of engine and generator.

The engine will have a full load output of 200-brake H. P. and will run at 600 revolutions. It will be direct connected to a 600-volt generator, the fields of which will be separately excited from an exciter driven by the engine. The controller for the motors will be provided with a series parallel switch, but no starting resistance, in the usual sense, will be required, as the speed of the motors will be regulated by controlling the voltage of the generator through field resistance points in the controller. The water-cooling system for the engine will be carried through radiators on the top of the car during the summer, and in the winter through the ordinary heater pipes for the purpose of warming the car. An engine of the size proposed will provide for an acceleration sufficient to maintain a schedule speed of 20 to 25 miles where stops are three to four miles apart and the car can be easily maintained at a running speed of 40 miles. There are no data on which we can accurately base the operating cost of such an equipment, but it seems probable, that including all expenses,—of the motorman, conductor, fuel and maintenance,—that the cost will be between 15 to 20 cents per car mile. This will depend somewhat on the daily mileage made by the conductor and motorman, as their wages amount to a considerable portion of the total expense. Reference has been made to this type of equipment, because considerable interest appears to exist regarding the possibilities in this direction, but what measure of success will be attained can only be determined by a thorough trial. Several different types of engines are under consideration, as is also the use of kerosene as a fuel. The object in view is to produce an equipment comparable in some respects to the all-electric car, and at the same time cheaper to operate than the steam trains, which are usually run over the lines for which an equipment of this type is intended.

Twenty-eighth Annual Convention of the National Electric Light Association

THE next annual convention of the National Electric Light Association, beginning on June 6, at Denver, is being well advertised by the committee formed for that purpose. The railroad companies are also helping through representatives on the committee, and cards are being sent out illustrating the scenic beauties of the country.

A number of pamphlets have also been issued containing complete information regarding hotels, side trips and other matters connected with the convention. Indications point to an unusually large attendance, many of the members planning to bring their families. Many visitors will also be entertained, and a large number of the leading electrical men have signified their intention of attending.

Municipal lighting seems to have proved a very decided failure in South Brooklyn, a suburb of Cleveland. According to a recently published statement, the municipal lighting plant has doubled the taxes of the village, and the people have become so discouraged that they want annexation to Cleveland, in order to get rid of the expense of supporting the plant. Middleboro, Mass., seems to be in equally bad condition.

For a new industrial college shortly to be opened in Paris a chair of automobilism is to be jointly supported by the State, the Department of the Seine and the city of Paris.

Unipolar Dynamos and Modern Central Station Design

DISCUSSED BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

AT the opening of the last monthly meeting of the American Institute of Electrical Engineers, held at New York on January 27, President J. W. Lieb, Jr., announced the sudden death of Mr. E. H. Mullin at his home in Milburn, N. J., on January 25. Mr. Mullin was a member of the Board of Directors of the Institute and one of its most active members, and will be well remembered as Chairman of the Committee on Transportation and Entertainment at the annual conventions of the Institute for many years past.

Two papers were read at this meeting, one by Mr. J. E. Noeggerath on "Acyclic (Homopolar) Dynamos;" the other by Mr. I. E. Moultrop on "Modern Central Station Design."

In his opening remarks Mr. Noeggerath called attention to the fact that hitherto the so-called homopolar or unipolar dynamos has been a failure from a commercial point of view, except for very low potentials. This is due mainly to two reasons, namely, the uncertainty as to the magnetic and electrical conditions prevailing in this type of generator, and the difficulties encountered in collecting large currents from a generator running at a high rate of speed. These conditions were dealt with in the paper in connection with the description of a 300-K. W. acyclic generator, operating at 500 volts and driven by a steam turbine.

The author classified acyclic generators in two types,—the radial type, in which the armature consists of single or double discs and the axial type, consisting of single or double cylinder; but combinations of these types are also practicable. The acyclic dynamo under consideration is of the cylinder type. It consists chiefly of a cast-steel armature and a cast-iron frame. On the smooth surface of the armature 24 conductors are mounted,—flat sheets bent on the radius of the periphery. The torque is taken up by lugs projecting axially from the armature body, and the centrifugal stress by means of steel binding wire. These conductors are connected at both ends to sets of collector rings,—twelve rings on either side of the armature, which are assembled close together and mounted on a shell. The rings are connected in series.

The field consists mainly of a cast-steel structure extending towards the shaft in three polar projections that enclose the armature in complete cylinders. Field coils are wound concentrically around the shaft. There are also two sets of brushes and a number of stationary conductors (frame conductors). Eight openings in the frame give access to three brushes, making a total of 24 contacts.

The field spools set up two primary fluxes. As the armature revolves in this uniform field, electromotive forces are generated in the armature conductors, which are constant as to magnitude and direction.

Tests on this generator show that the difference in pressure between the full load and no load is only slightly higher than the drop due to the total resistance of the armature circuit, this showing good regulation. There is a steady, but small, increase of pressure drop at the brush-contacts with increasing speed. The friction loss, declining somewhat, remains practically constant for high speed. The improved ventilation inherent to greater speed allows a higher current capacity to be used in the collector system.

The efficiency of a high-speed acyclic generator, according to the author, about equals that of a turbine-driven commutator generator, but the distribution of losses is very different. As windage and bearing friction depend on the mechanical design only, and not on the type, they can be made to have the same value for both machines. The I^2R field loss is somewhat smaller in acyclic machines principally because the length of the air-gap is limited by mechanical requirements and not by the armature reaction. The I^2R armature loss is about negligible on account of the small number of turns. In the generator under consideration, there are twelve armature conductors and twelve frame conductors in series.

The discussion on this paper was opened by Prof. F. B. Crocker, of New York. He thought it astonishing that this type of machine had been developed so far without any of us knowing anything about it. As a matter of fact, this is the original Faraday disc amplified. Faraday himself proposed to multiply voltages by connecting discs in series, and suggested discs of separate construction revolving in the same field, with their peripheries connected, which would cause the current to flow outward in one machine and inward in the other. Mr. Noeggerath has adopted the plan of splitting a cylinder longitudinally into strips, like the stave of a barrel, connecting them in series. Prof. Crocker saw no reason for using the terms "radially and axially." He thought disc and cylinder sufficient to designate the type.

Prof. W. E. Goldsborough, of Lafayette, Ind., said a machine of this type is one which many have been looking forward to as a type which would, in a great measure, revolutionize, possibly, certain departments of electrical engineering and thought the paper would not fail to be of much value to designers and educators.

Dr. A. E. Kennelly, of Cambridge, Mass., said the paper had brought out the point that this is a field in which the direct-current machine has a distinct advantage. It has always been regretted that we had not been able to get a magnetic material that would not conduct electrically; that we had to incur the expense of laminating iron in order to destroy eddy currents in the mass of revolving armatures; but in an arrangement of this kind it may be possible to obtain a revolving solid mass in which there will be no sensible eddy currents. The secret of the success of a machine of the type under discussion is the relatively enormous speed obtainable in comparison with machinery that existed before the advent of the steam turbine, and it is by reason of that enormous speed that the high electromotive force of about 30 volts per foot of wire can be obtained.

Messrs. Crellin Cartwright, of Schenectady, N. Y., F. V. Henshaw, of Ampere, N. J., and Edward P. Thompson, of New York, also participated in the discussion.

Mr. Moultrop followed with a paper on "Modern Central Station Design as Exemplified by the New Turbo-Generator Station of the Edison Electric Illuminating Company of Boston." This paper, as its somewhat lengthy caption indicates, is based upon an actual station; analogously as the paper that preceded it was based upon an actual generator, Mr. Moultrop began his paper by pointing out the requirements of a site for a large power station, namely, a low-priced water-side location reasonably near to the bulk of the business, so situated that the fuel can be brought to it with the least expense for freight and handling, and with ample ground adjacent to the station, and docks for the storage of at least six months' supply of coal, so placed that the minimum amount of coal-handling and conveying machinery is required. Also an unlimited supply of suitable cooling water must be provided for the condensers.

The location of the station under consideration meets these requirements admirably. It was planned for an ultimate capacity of 60,000 K. W., the first installation of 10,000 K. W. having just been completed. The value of the real estate being very small, no attempt was made to build additional stories to save ground area, and liberal room for and around the apparatus facilitates the operating, cheapens the cost of repairs, and makes it easy to keep the station clean. All the electrical apparatus has been grouped together and installed in a separate building adjoining the steam turbine room, turbines having been adopted as the prime movers. The electrical operators thus pursue their work under very favorable conditions and cannot be disturbed by anything going on in the turbine room, while they can oversee any of generating rooms by passing through doors in the side walls to the observation galleries.

The turbine room will be 650 feet long, 68 feet wide, 56½ feet high, and without a basement. The boiler house will be 640 feet long, and 149½ feet wide. The lighting and ventilating of these rooms is done from the roof. The switch house will be 605 feet long, by 30 feet wide, and several stories high. The boiler feed-pumps are treated as part of the turbine auxiliaries and are placed in the turbine room together with all the machinery in the station. The boiler house contains only the boilers with the necessary piping.

Before determining upon the apparatus to be employed, careful consideration was given to the respective merits of steam turbines and reciprocating engines as prime movers. The advantages of the turbine over the reciprocating engines in first cost, fewer attendants to operate, the ability to use condensed steam with safety for feed in the boilers, and the much smaller space occupied, decided the question in favor of the turbine, and outweighed the question of water consumption even if that proves to be no better than that of a good reciprocating engine.

The turbines in the first installation are of the Curtis type with a rated capacity of 5000 K. W. They are four-stage machines, with surface condensers built in their bases, and are equipped with mechanical brakes for bringing the machine to rest for an emergency stop, and in these features they are unique.

The generator is a three-phase, Y-connected, 60-cycle machine, generating at 6900 volts.

The grouping of boilers and turbines which has been adopted gives a smaller amount of piping than would be the case were the boilers placed in the usual manner in two rows, parallel to the turbine room, and makes a very short smoke flue with a minimum of reduction in the draft. A line of coal bunkers, built in monitors above the roof, supplies each row of boilers. As a large amount of coal is always stored alongside the station, the capacity of the bunkers is made small, which reduces the cost of the building materially.

The storage of coal being considered a very essential feature of a large station, an open-air storage of from 60,000 to 70,000 tons of coal is provided, without any shelter.

The water supply for the boilers is of equal importance to that of the fuel. Hence, in addition to water service mains of ample capacity for the total station, a system of storage tanks of 50,000 cubic feet of water capacity is installed on the ground, sufficient to run one turbine on the condenser for about ten days.

The apparatus is installed on the unit system. In the turbine room all the auxiliaries required for a generating unit are grouped around that unit. The boilers necessary to supply the generating unit are in one row directly behind the turbine. Practically no cross-connections are installed between the various units except that between each pair of units. The steam mains are joined by a well-sized tie so that the generating unit can be run temporarily from the boilers of its mate, should an emergency require. In this way a very simple piping system is sufficient, simplifying the manipulation of the station in emergency. Duplication of auxiliaries is eliminated, and should a generating unit be shut down by the failure of any of its essential parts, the entire unit will be shut down and another started in its place.

The auxiliaries for each turbine are steam-driven, with the exception of the wet vacuum pump, which is motor-driven, because its speed is too high to be conveniently handled by an engine. Careful consideration was given to the subject of steam-driven versus electrically-driven auxiliaries, and steam was decided upon because it gives better station economy.

A unique feature of this station is the interior finish of the walls and floors. The floor of the turbine room is tiled in dark red with black borders, arranged in the form of a simple design. The walls have a wainscott of two-colored green tile, about ten feet high, and above they are paneled with a light-colored tile and enameled brick. The boiler room has walls similarly finished, but the floor is not tiled. The result is that these rooms are ornamental in appearance and are easily kept clean, while at the same time the cost is quite moderate. Before this finish was adopted, cost estimates were made on the various possible methods of satisfactorily finishing the rooms, including the up-keep for a period of years, and tiling was found to be the cheapest, being even less expensive than painting.

The exterior of the station buildings is simple and massive. Cut granite underpinning is used, and the prominent walls are faced with a dark paving brick trimmed with terracotta. The buildings are set back from the sea walls 136 feet, the intervening space being covered with a fine lawn and planted with shrubbery, through which a paved driveway leads from the ornamental gates on the main street to the office entrance, making a well-finished and attractive environment, in keeping with the interior.

President Lieb in announcing the paper said it brought us face to face with the problem which has been before us for twenty odd years. In the design and construction of power houses one of the main factors, which is perhaps not always appreciated fully in the selection of the engine and dynamo plant, is the effect of the load factor and the extent to which the maximum load or percentage of it is used throughout the year. The factors that enter into this question are of very great importance in the design of a power plant and must be considered in arriving at the best results, not only from a mere question of operating efficiency, but also as to efficiency of investment.

Mr. H. G. Stott, of New York, in opening the discussion said he agreed with the remarks of President Lieb to the effect that, as engineers, we have neglected to think of the load factor sufficiently. The great point in the past has been to obtain the most efficient apparatus and cut down the cost of coal, water and operation, whereas in the average plant we will find that the interest and depreciation charges are at least equal, per kilowatt-hour, to the operation cost, and in some cases very much greater. He thought the steam turbine to be a move in the right direction because there our investment is reduced probably 30 per cent., compared with reciprocating engine units of the same size.

Another important point is that we ought to demand apparatus with an enormous overload capacity, not necessarily economical at that overload, but apparatus which will easily carry 75 per cent. overload for an hour or so. Such apparatus can be had and the cost need not be greatly increased, and then the fixed charges, which go on every day regardless of load, are immediately brought down very rapidly. Mr. Stott criticised the Boston station in that practically no cross-connections are installed between the various units. Cross-connections be considered very important in the case of break downs. He did not agree with the author that the ability to start an idle unit quickly was in favor of the turbine. He had seen engine units started in two minutes, and another get into synchronism in one minute and thirty-seven seconds.

Mr. Stott pointed out that there is one feature of the coal bunker or storage question that may have been overlooked, namely, the possibility of bituminous coal taking fire when exposed to the air. Bituminous coal, warmed up sufficiently, will lose 25 or 30 per cent. of its heat units.

Mr. Philip Torchio, of New York, had found in his experience that there are some drawbacks in having the electrical operating room entirely separated from the engine room, as unless the operator in charge of a station of that kind has nothing to interfere with his seeing all that goes on, he cannot keep in touch with the plant. Even small sounds mean much to the operator. Mr. Torchio thought that eventually, with the further development of the turbine, electrically-driven auxiliaries will be employed, the necessary current for the electric motors being generated by the turbine at a higher efficiency.

Mr. C. O. Mailloux, of New York, referring to the matter of auxiliaries, thought there was a danger of getting the steam auxiliaries too efficient in the use of steam, in which case we may not get enough exhaust to heat the feed-water. He praised the general appearance and arrangement of the Boston station which he had personally visited, and thought the money expended on the decorations was well spent.

Messrs. W. F. White, C. W. Rice and Mr. Bates also took part in the discussion, which was closed by Mr. Moultrop, who disagreed with Mr. Torchio on the question of separate operating room. Electrical operators have nothing to do with the running of the machinery. Their business is to maintain the pressure and distribute the current; they need not know what is going on in the turbine room. The men in the turbine room generate the current and deliver it to the electrical operating room. With regard to the economy of the steam-driven auxiliaries, he was not concerned; the steam is absolutely all consumed, and that suffices.

The meeting then adjourned.

The Edison Medal

THE Edison Medal Committee of the American Institute of Electrical Engineers, has issued the following letter, addressed to educational institutions of the United States of America and the Dominion of Canada:—

"Through the efforts of an organization known as the Edison Medal Association, a fund has been created to establish a medal to be known as the "Edison Medal," and the responsibility of annually awarding it has been entrusted to the American Institute of Electrical Engineers.

"The Edison Medal Association was founded by the friends and admirers of the great inventor, and, in the language of the deed of gift, 'was organized for the purpose of properly recounting and celebrating the achievements of a quarter of a century in the art of electric lighting, with which the name of Thomas Alva Edison is imperishably identified,' and this purpose was given effect by 'the establishment of an Edison Medal, which should, during centuries to come, serve as an honorable incentive to the youth of America to maintain by their works the high standard of accomplishment set by the illustrious man whose features shall live while human intelligence continues to inhabit the world.'

"The gift was formally made, and the responsibility of conferring the medal assumed by the Institute at its annual dinner, given at the Waldorf-Astoria Hotel in New York, on February 11 last, held not only to commemorate the event, but also to celebrate the fifty-seventh anniversary of Mr. Edison's birth.

"The fund has been deposited with the New York Security and Trust Company, and there will be available from the net income thereof sufficient funds to provide for an award of the medal for the year 1905.

"The object of this letter is to attract the attention of the authorities of such institutions of learning as may seem, to such authorities, qualified to compete for the medal under the by-laws of the Edison Medal Committee, and the request is hereby made that all such institutions send, through their proper channels, their names to the "Edison Medal Committee" of the American Institute of Electrical Engineers, 95 Liberty Street, New York City, on or before April 1, 1905, if desirous of competing this year.

"The members of the Edison Medal Committee have been selected from among the members of the Institute who are not now connected with educational training, and subsequent practical experience, to qualify them to critically analyze and fairly determine the respective merits of the theses and records of research that may be offered in competition for the medal.

"The Edison Medal Committee will promptly attend to communications from institutions of learning deeming themselves qualified, and desiring to compete, and will notify them early of their qualification to compete, or disqualification, as the case may be, in accordance with the provisions of Article VI. of the appended by-laws.

"It is hoped that prompt response to this letter will be received in order that every qualified institution shall have full opportunity to compete for the medal for this year.

"A previous letter, under date of May 13, 1904, and at a time when it was believed possible to award the medal for the year 1904, was sent by the Institute to institutitons of learning to call their attention to the creation of the medal fund, and establishment of the medal, and request them to compete. But it was not found possible to organize the Edison Medal Committee, formulate the by-laws, and in general perfect the working machinery to properly supervise the competition for, and award of, the medal for the year 1904. These working details are now, however, perfected, and the Institute is, in every way, prepared to award the medal for the year 1905, and thereafter."

Electric Cables for High-Potential Service

How Made and Tested

By WILLIAM MAVER, JR.

THERE has been a marked tendency in recent years towards the localization of the central stations of electric light and traction companies at points adjacent to the water side, or the railways, especially the former, where fuel may be delivered by suitable coal conveying apparatus from vessels to the station coal bins, and where water may be cheaply obtained for condensing, and also where generators of large and uniform units, capable of being operated at the most efficient loads, may be employed. The cost of coal hauling in American cities is estimated at about fifty cents per ton, and the importance of this item alone will be appreciated when it is considered that some of the large new power houses in the city of New York will ultimately use approximately 365,000 tons of coal per annum.

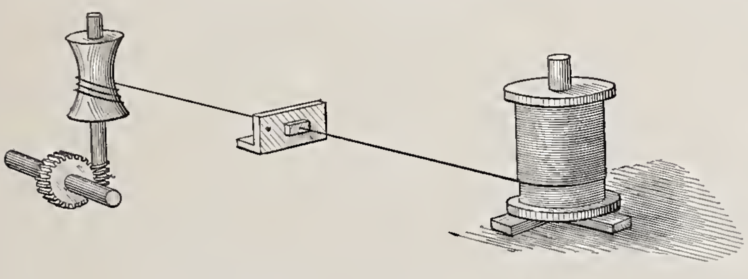


FIG. 1.—DIAGRAMMATIC ILLUSTRATION OF WIRE DRAWING

In addition to these sources of economies there are also to be considered the concentration of executive and operating forces in one building, and the releasing of valuable real estate in the busy and crowded sections of cities. In the old portion of New York City alone, south of the Harlem River, the output of eight power stations, which a few years ago were situated at different points in the city, is now generated and transmitted from two large central stations on the East River. The large electric traction companies of Manhattan now also have their power houses at one or two points on the river side, where plants capable of generating about 60,000 K. W., or about 80,000 H. P., have recently been completed.

It is, of course, well known, that the centralization of such power stations is made commercially practicable by the transmission, at a high electrical pressure, of the electrical energy generated at the power houses to the points of distribution,—it may be five, ten, or fifteen miles distant,—the pressures ranging in New York City from 6600 to about 11,000 volts. This electrical energy is successfully transmitted through cables in the underground electric conduits and subways, and on many of the circuits electrical energy to the amount of from 1000 to 2000 K. W. (say, 1340 to 2680 mechanical horse power) is thus transmitted.

When, not much more than fifteen years ago, the order was promulgated to place underground the 2400-volt light circuits of New York, the order was proclaimed by the companies concerned and by many experts and contractors to be entirely impracticable. The maximum electrical energy transmitted over such circuits did not, at that time, much exceed 100 K. W. But despite all the adverse predictions, the circuits were successfully operated in cables underground.

It is apparent that the vastly greater quantities of electrical energy now transmitted at a five-fold higher potential than was first utilized must have necessitated the employment of a cable of considerably improved construction, and it is thought that a description of some of the processes of manufacture of these cables may be of interest. Three types of underground cables are now used in the United States for this purpose, namely, rubber, varnished cambric and paper, or fibre cables. These names relate to the insulating material with which the conductors of the cables are covered.

The metal used for the conductors of underground electric cables is copper. Practically the only rival of copper for electrical purposes, outside of iron, is aluminium. But this rivalry extends to overhead wires only, where the diameter of the wire is not very material, the diameter of an aluminium wire being 1.27 times greater than that of a copper wire of equal conductivity. The weight of an aluminium wire, on the other hand, is about half that of a copper wire of equal conductivity. At the present price of aluminium, which is slightly less than twice that of copper per pound, it would, therefore, be economical and of advantage for mechanical reasons to use aluminium wire for overhead purposes, and this has been done recently in several instances. For underground purposes, however, it would seem that the greater diameter of the aluminium wire for a given conductivity must place it at a disadvantage, as compared with copper, on account

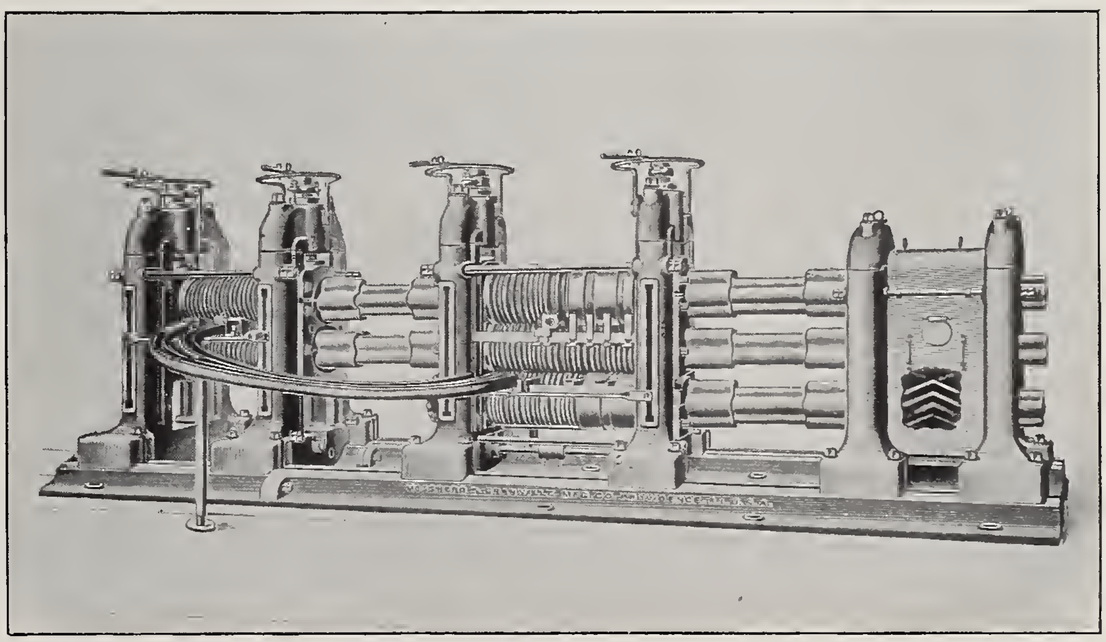


FIG. 2.—A SET OF "BREAKING-DOWN" ROLLS FOR MAKING COPPER WIRE

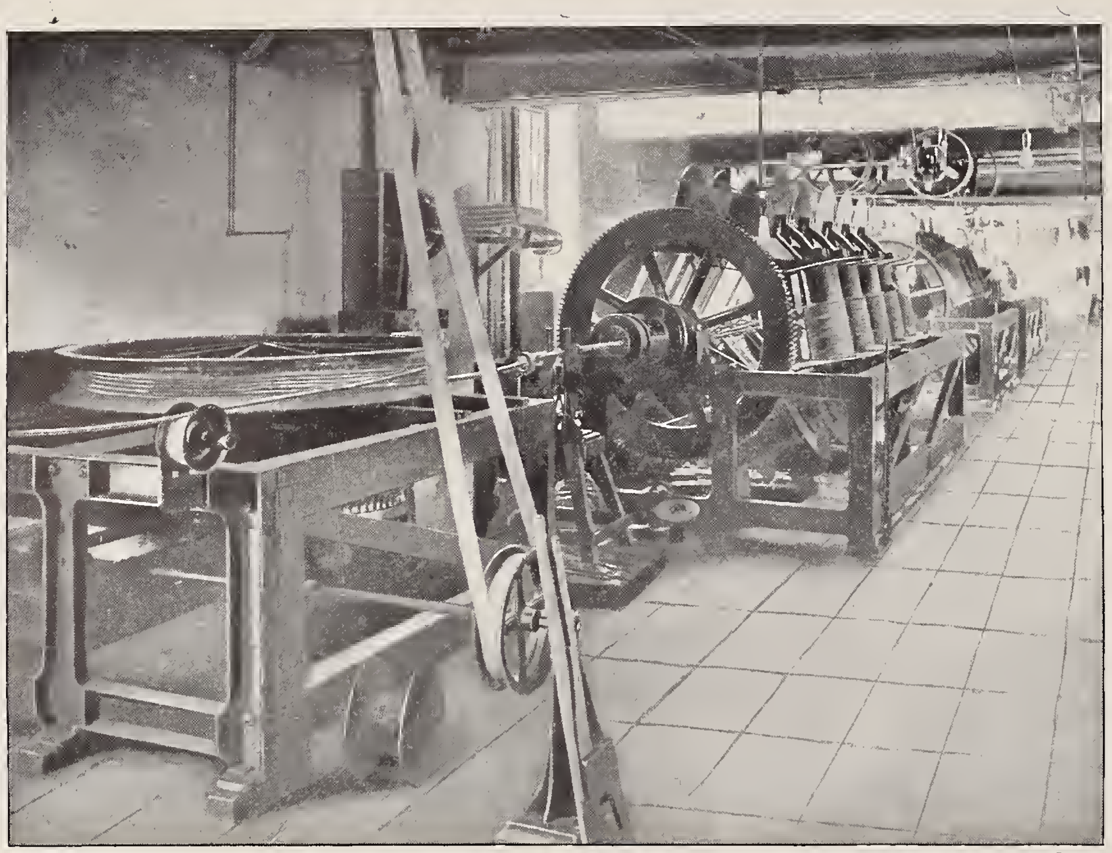


FIG. 3.—A WIRE STRANDING MACHINE

of the greater amount of insulating material and lead required to cover the aluminium wire. The increased space that cables with aluminium conductors would occupy in underground or other conduits, where space is often quite a serious consideration, is also a disadvantage. The term electric cable includes the conductor, the insulating material, and the armor, or lead covering, as well as any jute or taping that may be added.

The process of manufacture of a cable may be taken up at the wire factory, where the copper is received in billets, or ingots, weighing about 200 pounds. The billets are first rolled into rods by rolling machines or mills, shown on this page. The ingots while red hot are passed through roll after roll, the rolls gradually reducing the wire to a desired size. In the first stages the rods are passed back and forth by men on either side of the mills, but as the rod increases in length and diminishes in diameter, it is passed from one set of rolls to another by the curved guides, shown at the left of the cut. These rolls will break down fifty tons of copper per day of ten hours from the ingot to a rod or wire equal to No. 5 B. and S. gauge (No. 7 Birmingham gauge).

This process, however, does not leave the wire as uniformly round as desired; hence the rods are usually subjected to a "drawing" process, which consists in drawing the wire, while cold, by means of suitable machinery, through dies of hardened steel. It is usually necessary to repeat this drawing process several times with dies of gradually diminishing diameter, until the desired gauge of wire is finally reached. The drawing process hardens the wire and also materially increases its strength; at the same time it renders the wire less pliable. The strength of the copper wire thus hardened appears to rest very largely in a thin shell formed by the drawing process, for when the shell is nicked, even if only very slightly, the wire breaks readily at that point. Before each drawing the wire is covered with flour paste, baked on the wire in an oven. This acts as a lubricant while the wire is passing through the die.

When the wire has been drawn to the desired size, it is annealed to the required degree of softness and pliability, by heating, the extent of the annealing depending upon the use for which the wire is designed. For the conductors used for overhead telegraph and telephone purposes, it is not annealed after the final drawing, or but very slightly, and this wire is termed "hard-drawn." But for larger wires, such as No. 00 or No. 0000 B. and S. gauge (equal to 0.364 and 0.460-inch diameter, respectively), the wire is always "soft-drawn." The wire used in cables is always annealed, regardless of the size, to insure flexibility.

The wire being thus reduced to the desired diameter, the treatment which it next undergoes will depend on the nature of the insulating material with which it is to be covered. If a rubber compound is to be used, the wire will be tinned, it being supposed that this is a protection against any possible deleterious effects of the sulphur used in vulcanizing the rubber. The tinning is effected by passing the wire through a vat of molten tin. When the insulating material is fibre or paper, the wire is not tinned.

FIG. 4.—A SET OF INSULATING MACHINES

The wire is now practically ready for use in the cable. There is, however, another matter first to be considered, that is, whether the conductor of the cable is to be "solid" or stranded. When the diameter of the conductor does not exceed, say 0.204-inch diameter (No. 4 B. and S. gauge), the conductor is usually solid; that is, it consists of one wire. Above this size the conductor is stranded, chiefly to obtain greater flexibility of the cable. When all the wires to be used in a strand are of like diameter, the number of wires necessary to be used to complete a uniform strand is readily calculated. The central wire of a strand is held straight. Around this six similar wires are laid, spirally. For the next layer of the strand twelve wires are required; for the third layer eighteen wires are necessary; and for each additional layer six wires are added. If it is desired to have four layers around the central wire, sixty-one wires will compose the strand. If also it is desired that the stranded conductor shall be the equivalent of a solid wire, say, 0.500 inch in diameter, it is spoken of as a wire of 250,000 circular mils. This is the square of the diameter of the conductor in thousandths of an inch. The size of the wires of such a strand is then calculated by taking the quotient of 61 into 250,000, which gives the diameter of these wires in circular mils. The square root of this quotient gives the diameter of the wires of the strand in mils.

The work of stranding the wire is usually done in one process by a stranding machine, like that shown in Fig. 3. The wires of the strand are wound on reels, which are placed on suitable spindles, on frames around the machine, the reels for each layer of wires being in the same circle. The circle of reels for each layer is, of course, placed a suitable distance behind or before its neighboring circle, the reels for the larger layers being, naturally, behind those of the smaller.

The center wire of the strand passes from its reel, which is stationary in one place, and is held taut by a take-up drum or reel. The wires of the first layer are wound around this wire, and the wires of the second layer are wound snugly around the first layer, and so on, the reels of contiguous layers of wire being caused to revolve with their respective frames, in opposite directions, which gives the respective layers of the strand a right and left-hand lay.

Machines for such work may be designed to carry 130 reels of wire, weighing 1000 pounds each. The machine illustrated carries sixty-one reels. For the class of work here considered, however, the stranding machine need not ordinarily require more than fifty reels of wire for the strand, inasmuch as it follows from well-known electrical laws that the higher the electromotive force or voltage employed, the smaller may be the cross-section of the conductor for the transmission of a given amount of power. Thus, if the voltage of a circuit be doubled, the cross-section or weight of the conductor may be reduced one-fourth without increasing the percentage of loss in transmission.

The completed strand, as it passes from the machine, is wound on a reel or drum, and is then ready to receive its covering of insulating material.

As previously remarked, the insulating material of high-tension cables is now either a rubber compound, paper saturated with a resinous oil or varnished cambric insulation. Gutta-percha, which has been used so extensively as the insulating material for long submarine cables, is not used at all for high or low-tension cables in cities, its low melting point, about 120 degrees F., being fatal to its employment for such purposes, inasmuch as this temperature is frequently encountered in city streets. Indeed, a temporary overload of a conductor might raise the temperature to this point, in which event the conductor would settle to the lead armor or sheathing of the cable, thereby, of course, ending its usefulness.

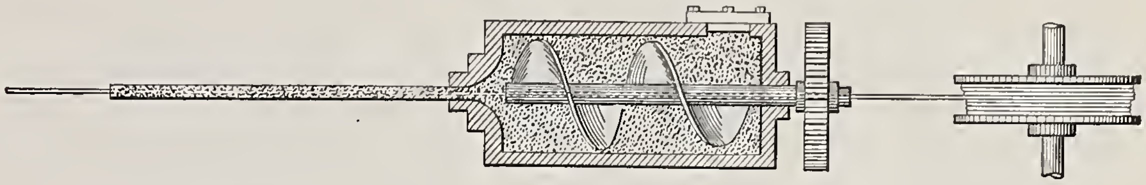


FIG. 5.—DIAGRAM ILLUSTRATING THE OPERATION OF AN INSULATING MACHINE

The rubber used in the rubber compounds employed as an insulating material is that known as pure Para rubber. It is brought to the factory in balls, which weigh from five to sixty pounds. While this is termed "pure rubber," it is quite impure in a strict sense, and during the purifying process it undergoes a shrinkage of about 20 per cent. The first step in its preparation consists in soaking it for about twelve hours in water at a temperature of about 200 or 212 degrees F. After undergoing this boiling process, the ball is passed through corrugated rolls, or mills, by which the rubber is pressed into a thin, rough sheet, about the size of a sheep's hide. As the rubber is thus passed and repassed through this mill, streams of water are caused to fall upon it, washing away the impurities which the roller exposes. After the sheets have been thoroughly washed, they are taken to a drying room, where they are usually kept for two, three, or more weeks.

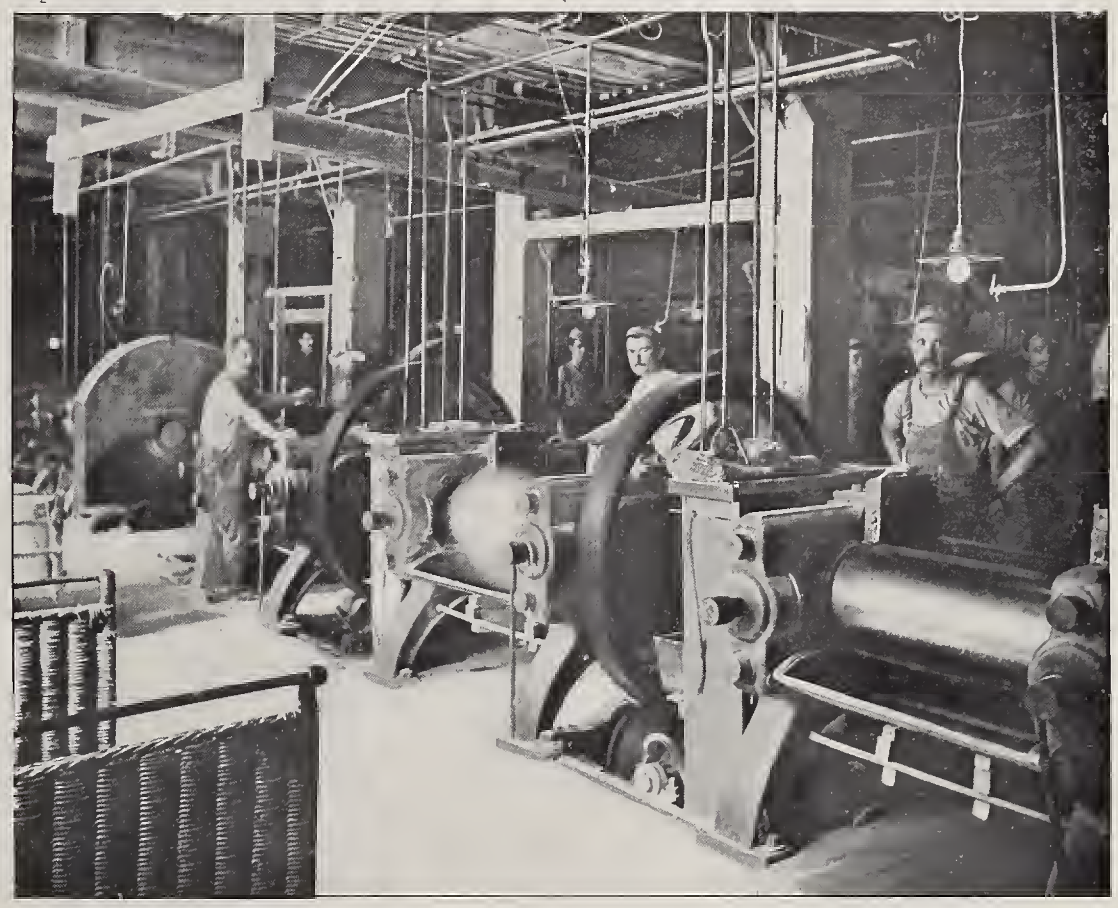


FIG. 6.—IN THE MIXING ROOM

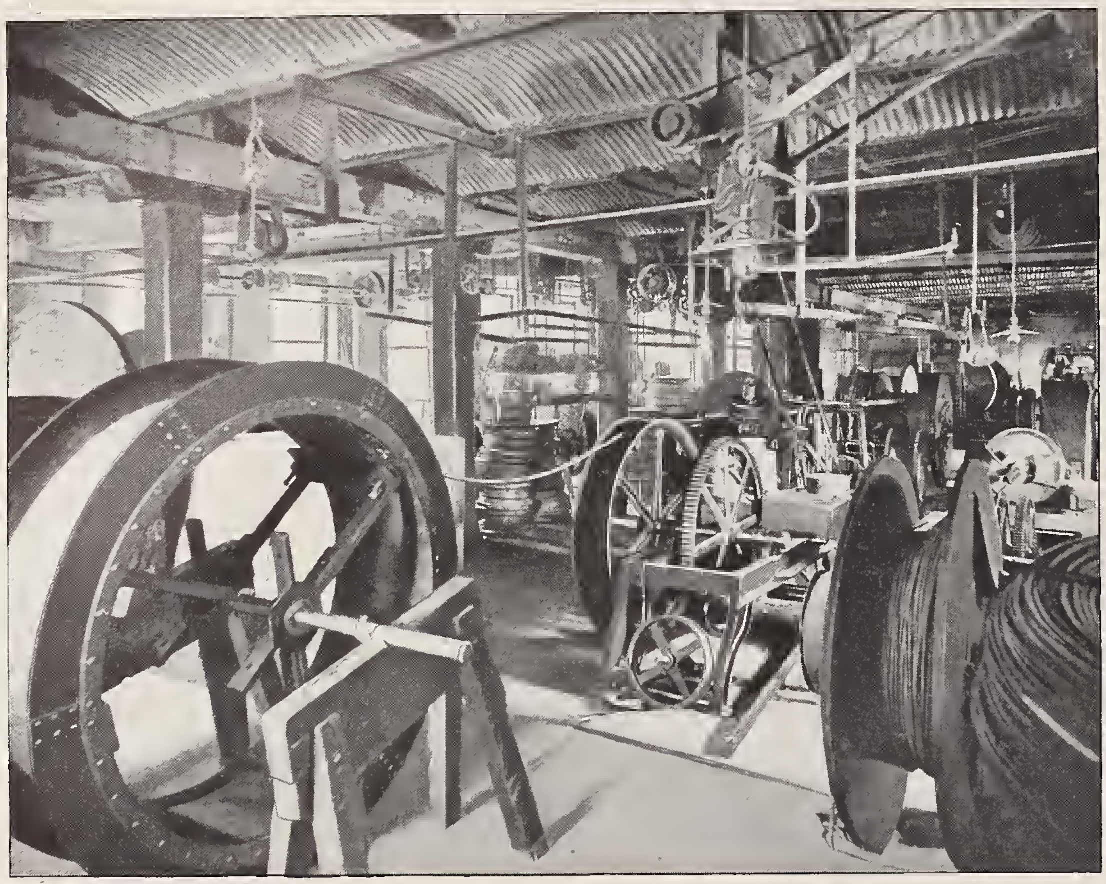


FIG. 7.—A TAPING MACHINE

The sheets are then taken to the "break-down" mills, where they are passed repeatedly through rollers which are kept at a temperature of about 200 degrees F. This reduces the sheet to a homogeneous, plastic mass of pure rubber. The rubber is then folded into thick sheets and passed into the mixing room, shown in Fig. 6. Here, as the pure rubber is passed time after time between the rolls, the attendants add the ingredients which make the completed compound, in such proportions as may be deemed advisable for any particular case, the proportion of such added ingredients, or adulterants, and pure rubber varying with every manufacturer. A sheet of the pure rubber, ready for the mixer, is shown on the nearest mill in the illustration.

The following formula will give an idea of the ingredients entering into a rubber compound used in wire insulation, but it will be understood that every manufacturer has his own preparation:—15 pounds Para rubber, 4.5 pounds litharge, 6 pounds whiting, 4.5 pounds blue lead, 7 ounces sulphur. The amount of pure rubber used in the better classes of cable varies from 35 to 50 per cent. The various ingredients are added gradually to the rubber during the process of mixing, which requires for its proper operation a high grade of shop skill. The mills are kept at a temperature of about 200 degrees F., during the process. In the mixing room of one large manufacturing company 6000 pounds of the insulating compound are prepared in a day of ten hours.

When thoroughly mixed, the rubber compound is ready for placing over the wire. This is done in two general ways,—first, by the use of insulating machines somewhat similar to the machines used in making rubber tubing. In the second method the compound is formed into a strip which is placed over the conductor. In the latter process the wire is rolled off a drum, or reel, and passes through a guide to and between a pair of grooved wheels, where the rubber strip is lapped closely around the wire, the pressure causing the edges of the strips to adhere, and at the same time the surplus rubber is removed by suitable cutting edges on the grooved wheels. This produces a seam in the insulation.

The insulating machines used in the first-named method are shown in Fig. 4. Here the prepared compound is fed by an attendant into an opening in the machine; a worm draws the compound towards the die through which the wire is passing, as shown in diagram Fig. 5, and the wire is covered with the compound to the thickness desired, this being regulated by the excess of diameter of the die over the diameter of the wire.

The compound is maintained in the desired plastic condition while in the machine by suitably arranged water jackets, the temperature of which is governed by valves which admit steam or cold water. The rate at which the wire may be covered in this way depends largely on the size of the wire and the thickness of the covering, which is termed the "wall." This method produces what is termed a "seamless" insulation. The wire, while being drawn through the die, is held by guides directly in the center of the die to insure an equal distribution or centering of the compound over the surface of the wire. When the conductor exceeds a certain size it is preferable to put on the insulating covering by the seam process, owing, among other things, to the difficulty in keeping the compound plastic in large quantities. The conductor, after issuing, covered, from the insulating machine, is drawn along a table through powdered talc, a distance of 40 or 50 feet, to a drum, upon which it is carefully coiled. The wire thus covered may then be taped prior to vulcanizing, or it may be vulcanized without taping, but in the largest sizes of cables it is customary to first tape the insulated wire.

The taping machinery is shown in Fig. 7. The taping apparatus proper is in the center of the picture. It consists of a revolving disc on the face of which a reel holding the tape is suitably supported. The insulated wire, or cable, passes through a sleeve in the center of the disc, and as it does, the reel, in the act of revolving with

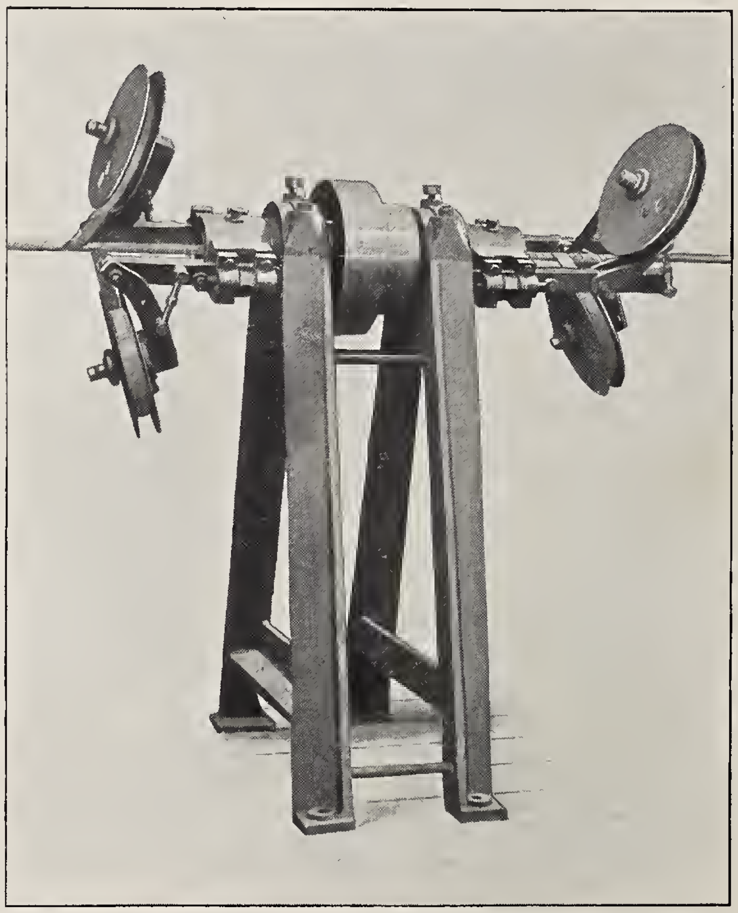


FIG. 8.—A PAPER COVERING MACHINE

the disc, wraps the tape spirally around the cable. The latter passes from the iron take-up drum, shown in the foreground, to a reel and is then ready for vulcanising. The process of vulcanizing the compound consists in placing the wire and reel in an oven, where it is subjected to a steam or dry heat at a temperature of 250 degrees F. to 300 degrees F. Steam heat is preferred by many manufacturers as giving the best results. Much care is required in the process, and the most favorable temperature and the length of time required to bring the compound to the desired degree of hardness and tenacity are matters of experiment. They vary with different compounds.

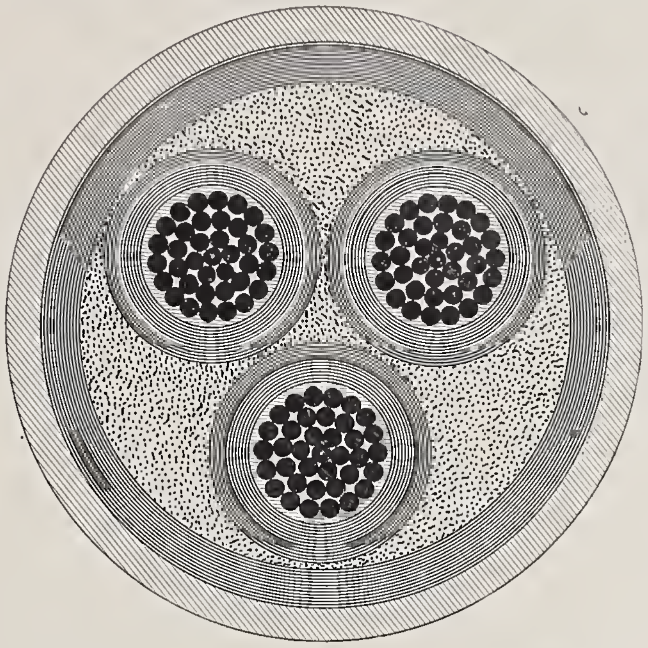


FIG. 9.—A JACKETED 7000 TO 10,000-VOLT PAPER CABLE

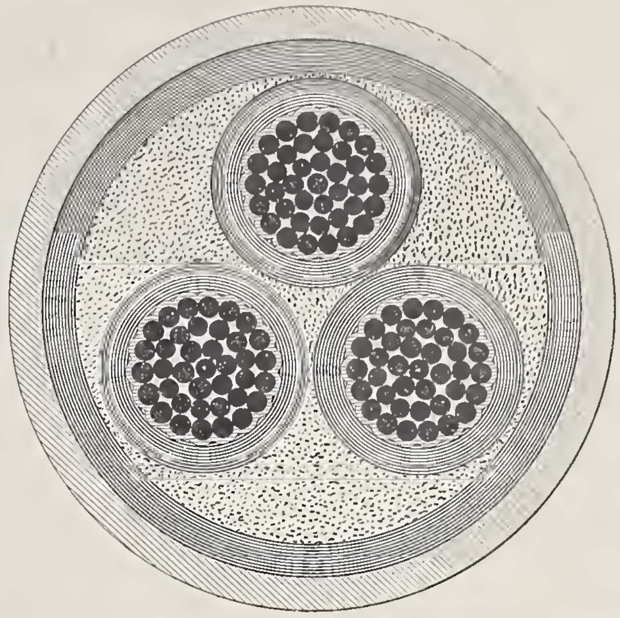


FIG. 10.—A JACKETED 7000 TO 10,000-VOLT RUBBER CABLE

At this point the manufacture of paper-covered cables may be considered. This consists essentially in winding strips of manila paper in reversed layers to any desired thickness over the conductor by a machine like that shown in Fig. 8. When the conductor is covered it is wound on a suitable reel which, with the conductor, is placed in a "bake" oven, where it is subjected for hours to a temperature sufficiently high to drive all moisture out of the paper. The oven in which this baking is done is tightly sealed, except at a vent at the top. An attendant, by holding his hand above this orifice, is able to tell when the drying has proceeded sufficiently far by the nature of the air which passes out. After thorough drying, the reel and conductor are immersed in a vat of boiling resin oil, often termed London oil, and as the baking process has rendered the paper exceedingly hygroscopic, it absorbs the oil avidiously.

Formerly the paper was placed over the wire as tightly as possible, but this plan has been abandoned for several reasons, one being that it imparted too great rigidity to the completed cable, with the result that the cable could not be bent without breaking the insulation. Further, it retarded the heat in the bake oven from reaching into the inner layers of the paper to such an extent that the outer layers were injured by too long exposure to the heat of the oven. Again, when the paper was put on under strong pressure, the compound could not readily penetrate the inner coils, and as the ability of such cables to resist high electrical pressure is largely due to the presence of the oil, the importance of this latter point is obvious. By placing the paper layers more loosely over the conductor, the layers give easily over one another when the cable is bent, and the heat and the oil more readily penetrate to the inner layers, thereby improving the insulation resistance and increasing the pressure-resisting quality of the covering. Varnished cambric insulation, which is of comparatively recent introduction in high-potential cable making, consists of strips of oiled linen cambric, which, like paper insulation, are wound spirally over the conductor in as many layers as may be desired, varnish being applied between the several layers. The material closely resembles oil silk in appearance and odor, and is very adhesive, so much so that this insulation is claimed to exclude moisture indefinitely.

The conductors thus insulated are now ready for bunching into cable form. For the high-tension cables here particularly referred to, three insulated conductors are usually employed. These are laid up in a strand, or spirally, and are taped, the interstices being filled in with jute, after which the conductors are ready for lead-covering. In other instances the conductors are bunched, and a "jacket" of paper strips or rubber compound, as the case may be, is put around the conductors thus bunched. This latter method is sometimes termed "split" insulation, because of the fact that the insulation is divided between the jacket and the insulation

FIG. 11.—JACKETED 25,000-VOLT RUBBER CABLE

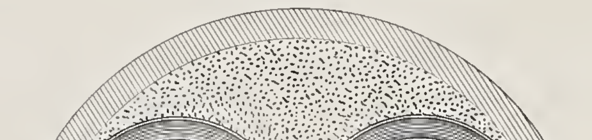


FIG. 12.—UNJACKETED 7000-VOLT RUBBER CABLE

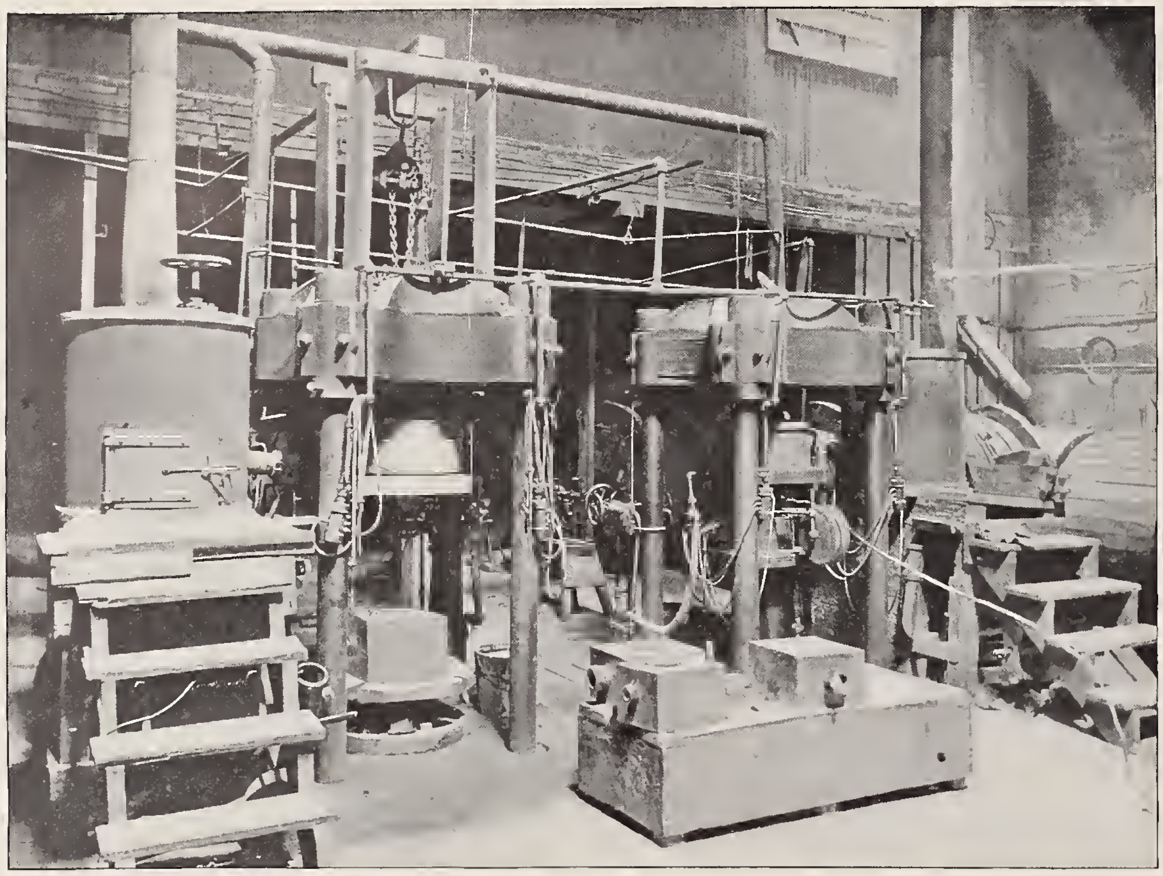


FIG. 13.—LEAD PRESSES FOR SHEATHING CABLES

over each conductor. Examples of such conductors, with and without this split insulation are shown in Figs. 9 to 12.

All cables intended for use in underground conduits in cities are now lead-covered to protect the insulating material from destruction by the acids, alkalies, etc., found in such conduits. In the case of paper or fibre cables it is absolutely necessary that they be covered with lead to protect them from moisture in the underground conduits. Rubber cables are, of course, moisture-proof, and if nothing but water were to be encountered in the conduits they would not require to be lead-covered. Rubber immersed in salt or fresh water appears to be imperishable, barring mechanical injury.

The lead-covering of the cable is an interesting process. The illustration on the page opposite shows the appearance of a vertical type of lead-covering machine, in which the lead is put on hot. The frame-work and the other parts of this machine are of massive construction to withstand the heavy pressure which is applied in putting on the lead casing. The pillars of the frame are of solid iron, about 10 inches in diameter. The working parts of the machine are a solid iron ram, about 15 inches in diameter, operated by hydraulic pressure. The ram passes down several feet into the vault in the ground, the hydraulic pressure being applied at the lower end. In the diagram on this page, *D* is the die block, *C* a hollow cylinder into which molten lead is poured; *L* is the lead ram, or plunger, of solid iron, 5 inches in diameter, rigidly bolted to the frame-work. Its lower end fits snugly into the receptacle in the cylinder *C*, as indicated by the dotted lines. As the die block must be changed to suit the size of cable to be lead-covered, the frame *W W W* is provided to permit of its easy removal. There is a curved opening in the die block, which reaches to the guide through which the cable is seen to pass. The die block rests on the top of the lower ram and the cylinder *C* rests on *D*, in which respective positions they are held by bolts.

In preparing the lead and machine for the operation of lead-covering the insulation, the operation is practically as follows: The hydraulic ram is dropped down, and carries the die block and cylinder with it, withdrawing the cylinder from the lead plunger *L*, which is stationary. The cylinder is then filled with molten lead, which is termed a "charge." As it is not desirable to place the lead in a melted state over the insulation, the charge is allowed to chill somewhat before the operation of covering is begun. The time for this varies with the size of the cable, and may be from three to four minutes. To prevent undue chilling of the lead, gas jets are placed around the cylinder. At the proper time hydraulic pressure is slowly applied to the ram. The pressure exerted on the end of this ram, which, in some cases, amounts to 500 tons, causes the cylinder to rise up against the plunger with the result that the lead is pressed down into the die, forming a tube or casing around the insulated conductor. At the same time, by suitable take-up reels, the cable is drawn through the die block. In other types of lead-covering machines the hydraulic pressure is applied from the top.

The lead is frequently alloyed with a small percentage of tin, about 2 per cent. This was done originally to protect the lead from the attack of acids, etc., but its utility in this respect is questionable. The tin, however, adds a certain amount of rigidity to the cable which is useful in facilitating the operation of drawing it into the underground ducts. The tin, at the same time, adds a difficulty to the process of lead-covering the cable, the small percentage above mentioned almost doubling the pressure that would be required to put on the lead pure. The rate at which the cable may be lead-covered, depends largely on the size of the cable, ranging from a few feet per minute in the case of large cables to several hundred feet per minute for the smaller cables.

The cable is now virtually ready for drawing into the underground ducts. Some of the manufacturers of high-potential cables, however, first subject them to a severe breaking-down or puncture test, by applying an electrical pressure from one and a half to three or four times the pressure to which the cable will be subjected in actual service. The pressure test varies with the length of time the test is to be applied. Thus, a cable designed to withstand a working pressure of 500 volts may be subjected to a pressure of 2500 volts for one hour, or to 4000 volts for a few moments. If intended to withstand a working pressure of 10,000 volts, it may be subjected to 15,000 volts for

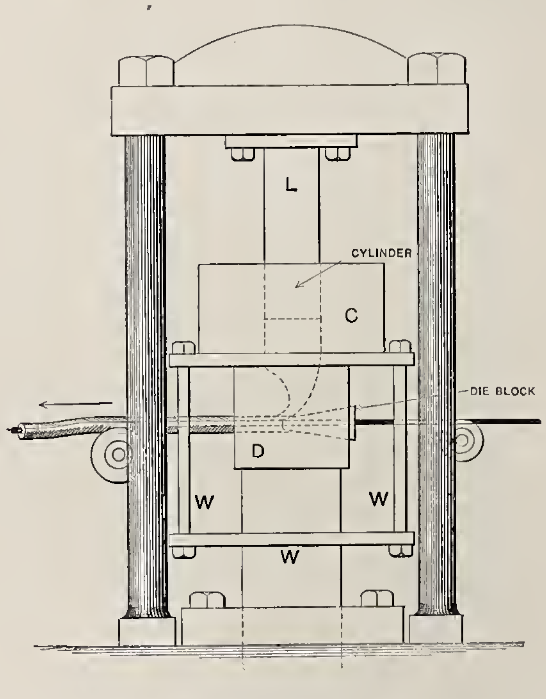


FIG. 14.—ELEVATION OF A LEAD PRESS

one hour or to an instantaneous pressure of 30,000 volts.

The high pressures for these tests are developed by means of an alternating-current generator and step-up transformers. When the apparatus is ready, the wires leading from it are connected to the conductor, and to the lead cover of the cable, respectively. In the case of rubber cables, these tests are sometimes applied before the lead cover is put on, the cable being immersed in water in a tank. The ends of the cable are, of course, kept out of the water. In this latter case, the wires run from the testing machine to the conductor of the cable and to the water in which the cable is immersed. If the cable is defective at any point, or if the pressure is too great for the inherent puncture-resisting quality of the insulating material, the current will "jump" and puncture the cable.

At such high pressures it is obviously essential that much care should be exercised in making these tests. The lead is removed, in the case of rubber cables, for a distance of several inches from the ends of the cable, as, otherwise, when a pressure of 20,000 or 25,000 volts is reached, the electricity will creep along the surface of the insulation (as it may be seen to do also on a sheet of thick glass subjected to high pressures), thereby reducing the tension of the current.

As previously remarked, the electromotive force used in the city of New York on high-potential underground cables is from 6600 to 11,000 volts. This pressure is employed by the electric traction and electric lighting companies. One traction company alone in the city of New York has over 120 miles of oil-insulated paper cable in operation at a potential of 10,500 volts, and on which during one year but two defects developed. The longest circuit on which this pressure is used measures about fifteen miles, while many other circuits range from one mile to five and six miles in length.

Rubber, paper and varnished cambric cables are employed in this service, but in recent years the rubber type of cable has not held its own in this country in high-potential work, so that to-day for the bulk of the new high-potential work, oil-saturated paper and varnished cambric cables are being used for this purpose. One apparently unavoidable feature of the operation of high-potential heavy-current circuits, in which the advantage is largely in favor of paper cable, is the undue heating of the converter following temporary overloads. This is calculated to have a more or less injurious effect upon rubber cables, but unless the temperature exceeds 176 degrees F., the effect upon oil-insulated cable is not found to be harmful. Specimens of high-potential cables used in practice are illustrated in cross section and actual size in Figs. 9 to 12. The dimensions of one of these cables may be given; for instance, a three-conductor cable, rubber, now operating at 6600 volts. Each conductor is made up of thirty-seven copper wires, giving a total cross-section of 250,000 circular mils, equal to 0.5-inch diameter. The thickness of the rubber insulating wall around each conductor is 5-32-inch. This is a rubber-jacketed, or "split" insulation, cable. The jacket is also 5-32-inch thick. This insures 10-32-inch of rubber compound between conductors, and between any conductor and the ground. Each conductor, and also the jacket, is covered with a tape, put on spirally outside of the rubber. The lead-covering of this cable is ⅛-inch thick. The outside diameter of the cable is 2.56 inches. The interstices between the conductors are filled in with jute.

For the transmission of electrical energy at high-potentials across rivers, canals, etc., rubber-covered armored cables are still employed in numerous cases.

The highest working pressure thus far employed on underground cables is 25,000 and 30,000 volts. The rubber cable used on the 25,000-volt circuit is shown in cross-section in Fig. 11. This cable consists of three conductors, each of No. 2 B. & S. gauge. The thickness of rubber insulation around each conductor is 7-32-inch, and the thickness of the jacket is 5-32-inch. The cable is lead-covered. The thickness of the insulating wall of the 30,000-volt cable is one-half inch.

A short time ago it was thought that the safe maximum pressure for underground cables should be placed at 25,000 volts, but from the experience gained by the manufacturers in recent years it is understood they are now ready to supply cables guaranteed to withstand 40,000 to 50,000 volts. Whether this is the limit remains for the future to determine.

The campaign recently inaugurated by Henry L. Doherty, the committee on membership of the National Electric Light Association, has resulted in the addition of a large number to the list of members. Judging from the interest already created, and the inquiries received regarding the new class of membership, this campaign bids fair to carry the membership list from the hundreds into the thousands.

The Beginning of a 1000-Mile Relaying Wireless Circuit on the Amazon River

REPORTS have just been received of the return of the steam yacht "Virginia" from a pleasure trip to the Amazon River, which trip was combined with business to the extent that it included the beginning of the establishment of a Fessenden wireless telegraph circuit that is designed to extend from Para to Manaos, on the Amazon River,—a distance of 1000 miles,—with relaying stations at frequent intervals along the river. The intention, in fact, is to supplant the present submarine cables that follow the course of the Amazon River between the points named, because of the unreliability of these cables, owing to injuries and breaks due to the swiftness of the current, and also, it is said, to a fondness which the alligators that infest that river have developed for submarine cable as an article of diet.

Thus far but two stations have been established, namely, at Breves, a suburb of Para, at the mouth of the Amazon, and at Pinheiro, further up the river. In all about twelve stations will be established between Para and Manaos, and it is expected that the circuit will be ready for business in about three months; but at present not any of the stations are in commercial operation.

This is no doubt the relaying wireless circuit to which Mr. Fessenden vaguely referred in a recent communication to this journal, in which he stated that his wireless system was soon to displace two cables that were earning a quarter of a million dollars per annum. The result of this experiment will be watched with great interest, and its practical success will mean much to the merchants in the territory mentioned, whose interests have suffered by reason of the unreliability of the existing cables, due to the causes stated.

A contract has been awarded the National Electrical Signaling Company, of Washington, D. C., by the United States Navy Department for the installation of Fessenden wireless telegraphic apparatus on the battleship "Alabama." The installation is guaranteed to operate satisfactorily with a similar one on the battleship "Illinois" at a distance of 250 miles.

According to R. D. Mershon, the limiting distance to which power can be economically transmitted electrically depends, finally, upon the cost of the line conductors, and upon this alone.

The Testing of Direct-Current Machinery

By E. B. RAYMOND, Electrical Engineer of the General Electric Co.

IT has become customary among manufacturers of high grade electrical apparatus, in filling orders, not to allow a machine to pass from their shops without first testing it to determine whether or not it operates according to the standard guarantees written for it.

DIRECT-CURRENT GENERATORS

The testing of a direct-current generator consists in obtaining information on the following matters:

1. The temperatures of all parts of the generator after it has been carrying full load sufficiently long for such parts to have attained a constant temperature.

The American Institute of Electrical Engineers gives as the standard temperatures for commutating machines, 50 degrees C. rise by resistance in field or armature; 55 degrees C. rise by thermometer in commutator, collectors or brushes, and 40 degrees C. rise by thermometer in bearings.

These temperatures may be departed from without immediate damage to the machine, but as a generator properly designed and built should last indefinitely, its temperature of operation should be such as not to injure the insulation in the slightest degree. Also the iron in the core of the armature, the loss in which has the commanding influence on the efficiency, must operate at a temperature that will not produce any ageing within itself. In general, a machine of abnormal temperature means one of low efficiency. Another trouble resulting from too high a temperature is the variation in resistance of the field spools and armature, for while they are heating up to their final values, it is necessary to continually adjust the rheostat in series with the shunt field if it be desired to keep the voltage constant.

The connections for the shunt field of a generator are shown in Fig. 1. The rheostat *A* and the field *B* are joined in series and connected to the brushes *D* and *E*, from the latter of which is obtained the electromotive force producing the field current. If it be desired to maintain a constant electromotive force between *D* and *E*, it becomes necessary to keep the current in *B* approximately uniform in value. If the resistance of *B* as well as that of the armature *C* increases abnormally, it must be neutralized by reducing the resistance in the rheostat *A* by a certain amount that will keep the field current at the desired value.

In a series machine, if the resistance of the series field varies considerably from cold to hot, there will be a variation in the division of current between this machine and another with which it may be running in multiple; this, of course, necessitates hand adjustment of the field rheostat for a proper division of the current

Several methods are employed in testing rooms for getting a machine to its operating temperature. One way consists in using a resistance of such a value that full load will result

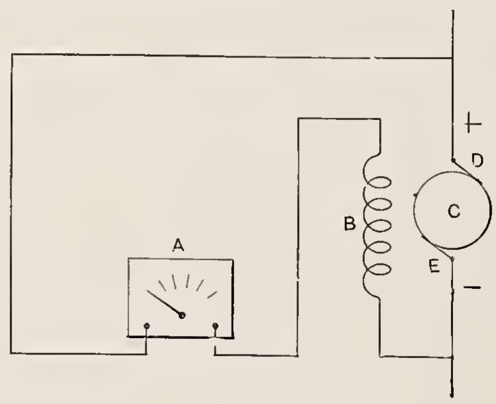


FIG. 1

when connecting it in the dynamo circuit. A box of water salted more or less constitutes a good resistance. The box may be of iron, tapering inward toward the bottom, and into this should hang an iron plate. One terminal of the circuit is connected to the box, and the other terminal to the plate. The resistance of the circuit decreases as the plate is lowered into the water, both on account of the decreasing distance between the sides of the box and plate, and also on account of the increased area of the plate exposed to the water. A box containing about 20 cubic feet of water will readily carry 150 K. W. A more economical way of accomplishing the same result is by means of the Hopkinson method, which consists in feeding back one machine upon another. Under these conditions, however, it is necessary to employ two machines. A third way is to short circuit the machine upon itself. These two latter methods will be described in the section on temperatures under overloads.

2. The temperatures of all parts of the generator after it has been carrying a specific overload for a reasonable time.

The American Institute of Electrical Engineers advises as to overloads for direct-current generators, 25 per cent. overload for two hours with an increase of temperature not exceeding 15 degrees C. above that specified for full load; the overload to be applied after the apparatus has acquired the temperatures corresponding to full load continuous operation. Since there are times in the operation of a generator that it may be required to perform unusual work for short periods, generators should possess a reserve capacity which will enable them to pass this test. Under such circumstances it is permissible to encroach somewhat upon normal conditions, and yet not inflict real injury upon the machine.

The Hopkinson method of "feeding back" one machine upon another requires connections similar to those shown in Fig. 2. Here *A* represents a source of electrical energy, *F* the field of generator No. 1, and *F′* the field of generator No. 2; *M* represents the armature of generator No. 1, and M′ the armature of generator No. 2. The armatures *M* and *M′* are mechanically connected together either by a belt or direct connection. The method of procedure is as follows: Start up the generators No. 1 and No. 2 by running them both as motors. Weaken the field of No. 1, and it will run as a motor, being fed by No. 2, which will then be running as a generator. The losses will be supplied by the source of energy *A*. The action causing the flow of current has been so often described that it will not be necessary to repeat it here. The two generators *M* and *M′* need not be of the same voltage; if *M′* gives a higher electromotive force than *M*, a water box may be inserted at *W* to use up the excessive voltage. In case it be desired to keep the two fields *F* and *F′* at the same strength, a booster giving a voltage equal to that used up in the resistance of both arms, brushes, and wire, can be inserted in circuit. The booster will circulate the current, and *A* will supply the losses as before.

Another method of loading a generator without running an actual energy load, consists in short circuiting the generator upon itself. At first thought one would imagine that under such circumstances the amount of flux through the core would be small, so that a true heating effect would not be obtained. But let us consider Fig. 3. This diagram represents a generator with brushes at *A* and *B*, and the field winding at *F*. When current flows through the ammeter *S* and the armature, the armature current itself sets up a flux in the path 1, 2, 3, 4, 5, 6, 7, and in multiple with this another flux is also set up in the path 1′, 2′, 3′, 4′, 5′, 6′, 7′, as shown by the broken line. This flux resulting from full load current is not far from normal, and the voltage between the points A′ and B′ is also not far from normal. Thus we have a condition of 0 voltage between brushes, and approximately full voltage 90 degrees away from the line of brushes. Such a condition is more than ordinarily severe as to sparking, but with proper experience one can judge of the quality of commutation this way as well as in the normal way. This method is, therefore, an extremely valuable one for loading very large generators or motors, requiring but little energy for a heat run and yet providing us with full load results. The temperature of the fields *F* must be obtained separately by running the machine with normal field current, but with no load in the armature.

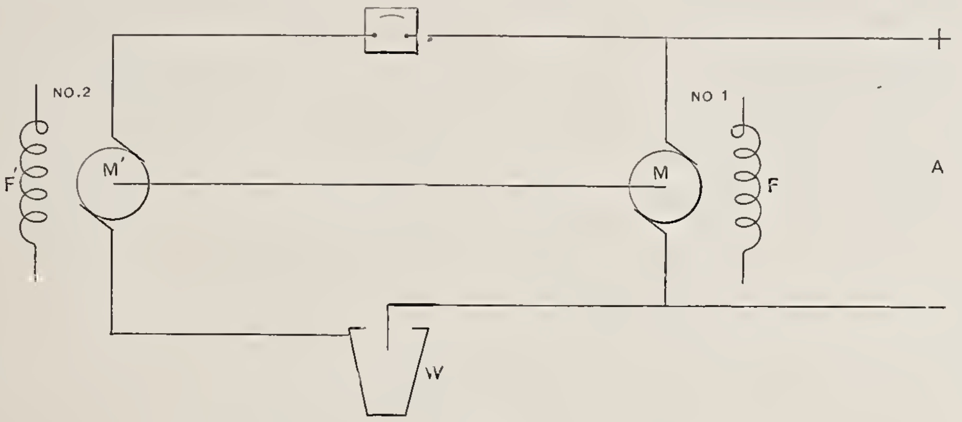


FIG. 2

3. The commutation at full load, and at various overloads; also at full voltage, and at various other voltages.

The loads to be used for judging commutation may be obtained by any one of the methods explained in the preceding section. A good machine should run sparklessly at full load, may show some slight sparking at 50 per cent. overload, and should stand double load momentarily without injury, though it must be expected under such conditions that considerable sparking will ensue.

The various degrees of sparking that may be expected at the commutator under different loads is illustrated in Figs. 4 to 8 inclusive. In Fig. 4 is shown the way a machine should run at full load, though the conditions presented in Fig. 5 would be called fair. At 50 per cent. overload, Fig. 6 illustrates the amount of sparking that might properly be expected, though that shown in Fig. 7 would be termed fair. Fig. 8 or a somewhat worse state of affairs is what might be expected at double load.

A well designed machine will carry full load current down to 0 voltage without any particular trouble as to sparking. The usual appearance of the commutator under this test is illustrated in Fig. 9.

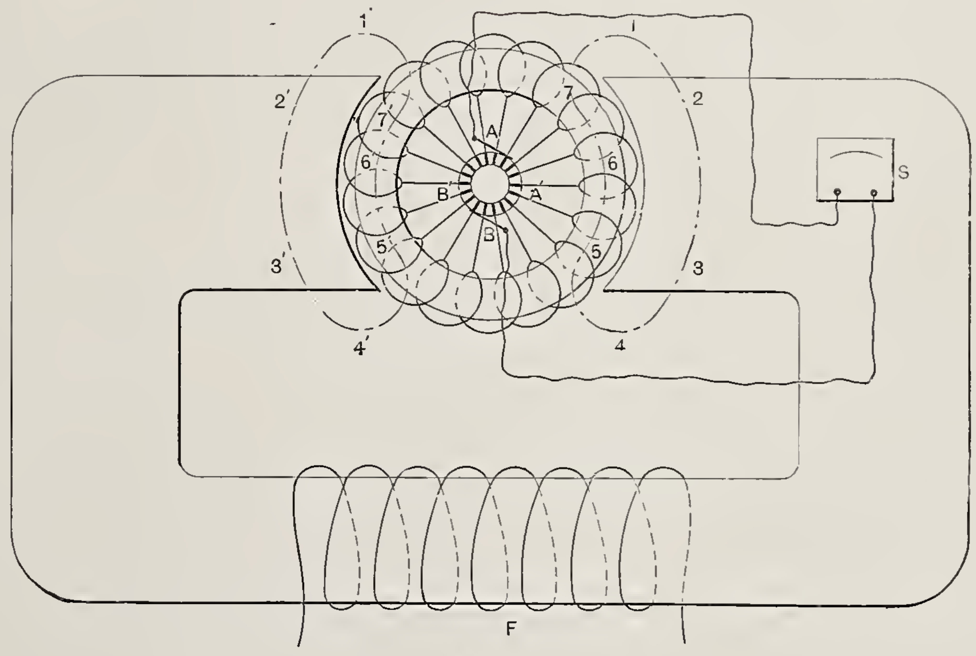


FIG. 3

4. The core loss, friction loss, and the resistance losses of field, armature, and brush contact.

An excellent method to employ for measuring the summation of these losses consists in applying to the brushes of the generator a voltage equal to the normal voltage of the generator plus the voltage drop in the armature winding and brush contact. On a motor, the applied voltage should be the normal voltage minus the voltage drop in the armature winding and brush contact. The field of the machine should be varied till normal speed is obtained. Since "running light" in this manner requires but little current, the applied electromotive force equals the back electromotive force, and this equals the generated electromotive force existing when the machine is operating as a generator at full load. The normal full load flux is thus obtained at normal speed, and hence the input gives the summation of all the losses. If the resistance losses of field, armature, and brush contact existing during the "running light" reading be subtracted from this total loss, the value of the core and friction losses will be obtained. This is the "stray power" method of Hopkinson, and is a perfectly satisfactory method for obtaining the efficiency of a dynamo. If it be desired to separate the core loss from the friction losses, it is necessary to belt to the generator of which the core loss is required, a motor of such a size that it will be about half loaded when the maximum energy of the generator loss is being registered. This is necessary in order to avoid as far as possible any armature reaction and variation of flux, and hence core loss, in the driving motor itself, the core and friction losses of which should remain as nearly constant as possible. It is also preferable to use copper brushes on the driving motor in order to avoid the variation in brush contact resistance which exists when carbon brushes are employed. The field of the driving motor should be maintained at constant strength throughout the test. A glued belt should preferably be employed to avoid the pulsation which may result from the use of a laced belt. The belt tension should be as light as possible to run without slipping, and the bearings should not heat or change in temperature during the test. As field current is supplied to the generator whose core loss is being measured, the load on the driving motor will increase. In order to maintain constant speed, the voltage applied to the driving motor must also be increased. The increase should be practically equal to the indicated voltage drop across the motor armature and brushes. If it be different, the belt is slipping, or a motor has been chosen which gives trouble owing to armature reaction, or a varying flux. If the motor be properly chosen, the brushes will require no shifting.

The input of the driving motor, less its resistance loss when running the generator under normal field, minus the input of the motor less its resistance loss when running the generator without field, gives a measure of the generator core loss at the field used.

The input of the driving motor less its resistance loss, when running with belt off and at proper speed, subtracted from the input less its resistance loss when belted to the generator without field, gives a value of the friction of the generator. In obtaining these inputs of the driving motor, sufficient time must be allowed for all acceleration or retardation to cease, otherwise an incorrect value will be obtained.

During the time in which the core loss readings are being taken, the brushes of the generator should be exactly at the neutral point; there will then be no flux, and no energy will be consumed by local currents beneath them.

The curve of core loss takes the form shown in Fig. 10. It should be noted that since hysteresis varies as the 1.6th power, the core loss at *B* should be over three times that at *A* if the volts at *B* are twice those at *A*. This furnishes a simple and rapid way to check a core loss curve which has been obtained.

The resistance of the field winding can best be measured by an ordinary Wheatstone bridge. The resistance of the armature, however, should be obtained by the "drop method," that is, by passing through it a current preferably of a value near that of the normal armature current, and recording the necessary voltage at the commutator bars to produce this current. The voltage at the bars being usually very small, is somewhat difficult te secure, but with special care, can be obtained with sufficient accuracy. These resistances should be taken both hot and cold so that the rise in temperature by resistance can be calculated by the usual formula, $R_T = R_0 (1 + \infty t)$. When this formula is used for copper, $\infty = 0.0042$.

The rise in temperature of a winding thus calculated is usually 50 per cent. more than when obtained on a thermometer, since the latter only registers the outside temperature, while the former takes into account the temperature of the entire winding. On an armature this difference is about 25 per cent., but on a field spool it may be as high as 80 per cent.

The brush contact resistance for carbon brushes will be found to be .028 ohm per square inch at ordinary speeds. This, however, is an average value. It varies with the density of current flowing, ranging from about 0.040 per square inch at a density of 15 amperes per square inch to 0.022 per square inch at a density of 60 amperes per square inch. At a given density, say 30 amperes per square inch, the brush contact resistance varies from 0.028 ohm at $1\frac{3}{4}$ pounds pressure per square inch to 0.035 ohm at $\frac{3}{4}$-pound pressure per square inch. With copper brushes, the value of contact resistance is about 1-10 of this, and the density of operation can go to 150 amperes per square inch. The brush contact resistance should be considered as a part of the armature resistance, and should enter into all the efficiency and armature drop calculations.

In calculating the loss resulting from friction of the brushes, a coefficient of friction of 0.3 may be used, and the usual operating of mechanical pressure may be taken between $1\frac{1}{2}$ and $1\frac{3}{4}$ pounds per square inch.

5. The efficiency at various loads.

A method has previously been outlined of obtaining the core loss, the friction loss, the resistance of field and armature, and the brush contact resistance. The efficiency of a generator therefore equals the output in watts, divided by the summation of the output in watts, the core loss, the field resistance loss, the armature resistance loss, the brush contact resistance loss, and the total friction loss.

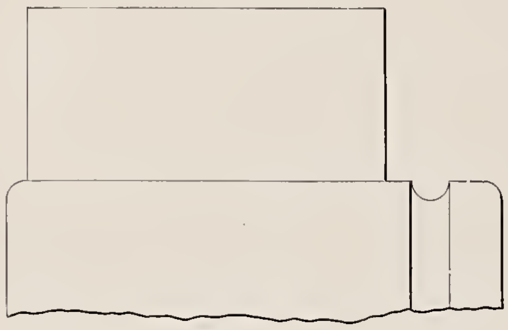


Fig. 4

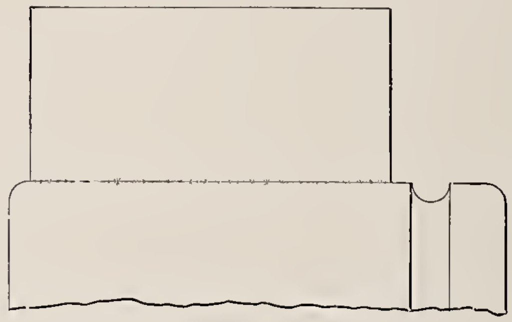


Fig. 5

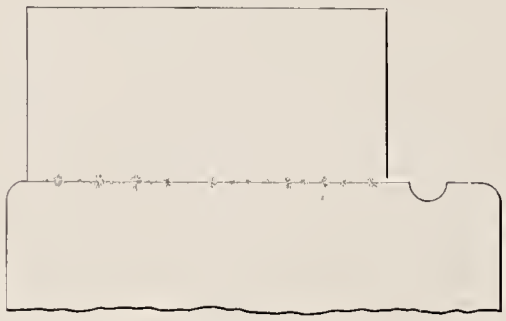


Fig. 6

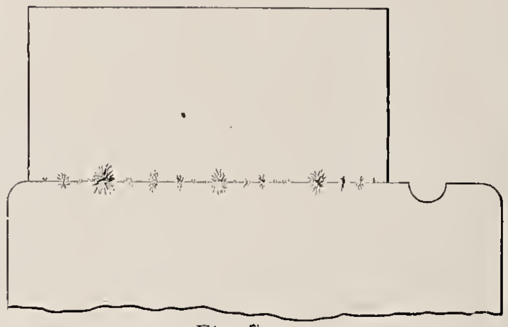


Fig. 7

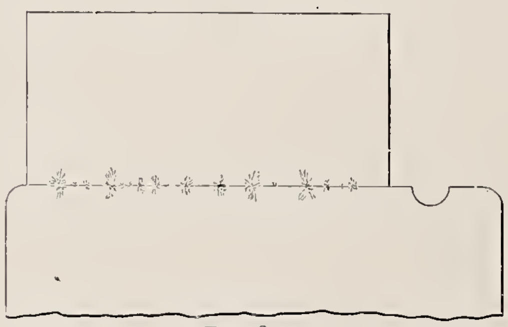


Fig. 8

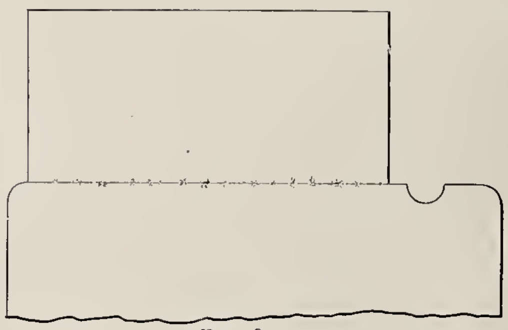


Fig. 9

6. A certainty that the commutator is properly "settled."

A commutator consists of many segments of copper separated from each other by insulation (usually mica about .030-inch thick) as well as from the shell and clamps holding them. For satisfactory operation, it is necessary that the mica separating the segments from each other does not extend above the wearing surface, and that no individual bar alters its position with respect to the other bars by the slightest amount. To accomplish this, the clamps must exert a force in each bar. If roughness appears when the machine is in operation, the clamps should be tightened until each bar is subjected to the proper force to hold it in position. When this is done, the commutator surface should be smoothed and polished, after which it should run indefinitely without further trouble. The "settling" of a commutator may take considerable time, but no reputable manufacturer should ship a generator without the determination of a stable state of its commutator.

7. The insulation resistance and dielectric strength.

The American Institute of Electrical Engineers recommends for insulation resistance a value on the complete apparatus, such that the rated voltage will not send more than $\frac{1}{1,000,000}$ of the full load current through it. When the value found in this way exceeds 1 megohm, the insulation resistance is sufficient. The insulation resistance of a machine varies considerably with the weather and degree of dampness of the surroundings. It can quickly be lowered by dampness and raised by baking in a dry chamber.

A convenient way to measure insulation resistance is to insert a voltmeter of known resistance R in series between the winding whose resistance is to be measured, and the ground or a part of the machine from which the winding is supposed to be insulated. If X equals the insulation resistance desired, R equals the voltmeter resistance, V equals the voltage of circuit (say 500) used to measure the insulation, and D equals the deflection on scale of voltmeter, then since according to Ohm's law the deflection is proportioned to the resistance,

$$\frac{R}{X}=\frac{D}{500-D} \text{ or } X=R\left(\frac{500}{D}-1\right)$$

Of more importance than the insulation resistance is the dielectric strength. For this, the American Institute of Electrical Engineers recommends for apparatus rated between 400 and 800 volts, 2000 volts "high potential" applied one minute, the application to be between circuits normally running insulated, and between these circuits and ground. This test should be made on the generator while it is at its normal operating temperature, and with a sine curve of electromotive force and normal operating frequency. Most manufacturers use a higher voltage than that recommended by the Institute. On railway apparatus, for example, it is common to test all parts with 5000 volts.

8. Certain mechanical matters to be investigated.

(a) Proper mechanical balance of revolving element.

The armature should run free from any vibration. If vibration occurs, the armature must be put in a lathe, if one large enough is available, and the armature shaft straightened. The armature should then be placed on balance ways and its balance checked,

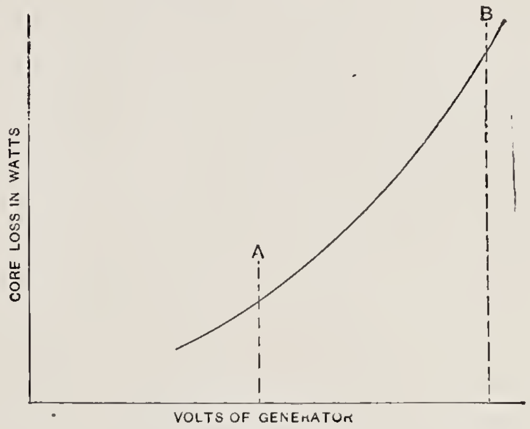


FIG. 10

and then replaced in the bearings to see if it rotates without noise. The best results cannot be obtained if the armature be unbalanced.

(b) True running of parts.

This is merely a matter of appearance, but a piece not running true indicates carelessness on the part of the manufacturer.

(c) Freedom from undue noise.

Noise may result from chattering of the brushes, or from a magnetic hum. If the former, two methods exist to stop the trouble. First may be mentioned lubrication; this ordinarily means the attention of an attendant, or the use of a lubricated brush of proper hardness and freedom from gumming. The second method consists in placing the brushes so that they form the proper angle with the commutator. This angle is an important feature in brush holder design, and if improperly chosen may cause considerable noise. Where a magnetic hum appears to be the trouble, there is probably a too sudden entrance of the armature teeth under the poles. In this case a champfering of the polar horns may remedy the trouble. At all events the point should be checked before shipment.

(d) Proper turning of the oil rings.

The oil rings for lubricating the bearings should certainly start to turn at one-quarter normal speed, and they should carry up and deliver to the oil rings a proper amount of oil.

(e) Freedom of bearings from leakage of oil.

Many excellent machines become unsightly and gather dirt which injures the insulation, on account of the fact that their bearings throw or leak oil. Bearings should be designed to give dry results, and all generators should be investigated with this fact in mind.

(f) Proper end play.

By proper end play is meant a free floating movement of the armature from side to side with a tendency for it to return to a central point half way between the limits of the thrust collars on the shaft. The magnetic pull will sometimes force the armature against the thrust collar so hard as to cause undue heating; this matter should therefore be given attention.

(g) Uniformity of air gap.

A measurement should be made to see that the armature is mechanically centered in the frame. This may be done with a metal wedge which, when pushed into the gap, shows the amount of clearance by the distance it enters therein before binding.

(h) The general appearance of the machine.

The general mechanical condition of all parts should be investigated, and any defects corrected. Inspections are easily made by a properly trained tester, but they are both important and necessary for high class work.

9. The ability of the generator to build up when connected according to the print issued by the manufacturing company.

In certain cases considerable trouble may result if a generator does not build up when connected according to its print. This is especially true when many generators are connected in multiple with series fields. In order for the generator to build up, a certain terminal of the shunt field winding must be connected to a certain brush. This requirement exists regardless of the initial magnetism of the generator.

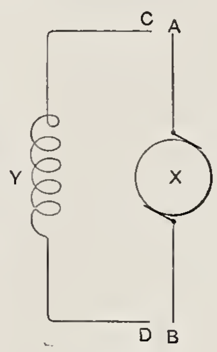


FIG. 11

In Fig. 11, C and D represent the terminals of the shunt field winding Y, and A and B the leads from the armature X.

In order for this generator to build up, C must be connected to A and D to B irrespective of the polarity of the residual magnetism. For the opposite rotation of the armature, C must be connected to B and D to A. It is thus seen to be important that the operation of the generator be checked with the print, and corrected if found to differ therefrom. The trouble may result from an improper assembling of the field spools or from a wrong progression of the armature winding, or from an incorrect print.

10. In a compound machine, the shape of the compounding curve.

The compounding curve shows the

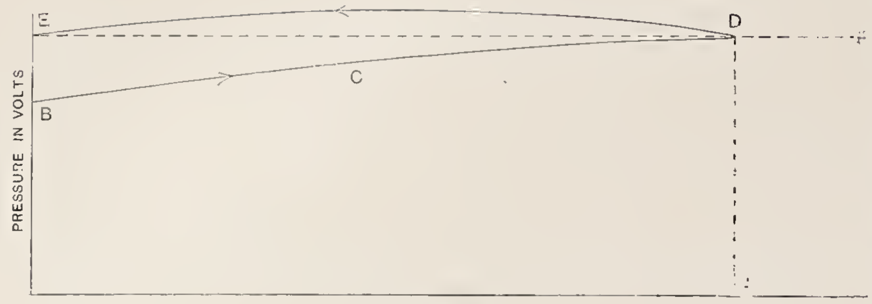


FIG. 12

relation between the load or current and the volts at the terminals of the machine. The variation from the desired compounding at any point is generally known as the "hump" of the curve. The United States government allows a maximum variation of 2 per cent. when starting at the desired voltage and returning to the same voltage. This must also include any variation that may occur in engine speed. On a commercial generator one should expect a maximum variation of not over 3 per cent. Such a compounding curve would therefore resemble the one shown in Fig. 12 for a 125-volt generator.

This curve starts at *B*, runs to *D* at full load as indicated by the arrow, and then returns to *E* at no load. The departure of this curve from the line *EF* which represents a constant pressure of 125 volts, should not be over 3 or 4 per cent.

A curve derived from the one in Fig. 12 should be recorded for future design as well as for data on individual operation. Such a curve is shown in Fig. 13.

The point *A* on this curve gives the ampere-turns for no load, and the point *B* those for full load.

The brushes on a carbon brush machine should be stationary; they should be set forward at no load, an angular distance around the commutator.

This distance should be such as not to give appreciable sparking at no load, and no sparking at full load. This is known as the "brush shift" of the machine. It should be as small as possible, yet consistent with the best operation for the armature-turns embraced by the double angle. In fact, the compounding ampere-turns are composed of these back ampere-turns on the armature and of the extra ampere-turns due to leakage, together with the actual increase of flux necessary for all the resistance drops, and the variation of flux density in the pole faces due to armature distortion.

11. In a shunt machine, the shape of the curve which shows the drop in voltage as the load is increased under a constant magnetomotive force.

Such a curve resembles that shown in Fig. 14. The line *AB* represents the voltage which, in this case, equals 125. At one-quarter load the voltage has fallen to *G*. Increasing it again to 125 volts or *C*, and adding another quarter load, it drops to *H*. Raising it to *D* and adding another quarter load brings it to *I*, and so on. A properly designed machine will drop as shown, but will not unbuild with quarter load variations. The variation at *G, H, I,* and *K* grows larger as full load is approached; *FK*, for example, being greater than *CG*.

12. The shape of the saturation curve.

The saturation curve takes the form shown in Fig. 15. As the ampere-turns increase, the volts increase. At the point *C*, however, the increase of volts diminishes appreciably. A generator should be operated just above the point *C* to obtain stability and freedom from "unbuilding." No unbuilding can result above *C*, since the volts are then no longer proportional to the ampere-turns, and perfect balance can be secured. When the volts are proportional to the ampere-turns, the voltage will wander up and down, usually unbuilding the machine, or rushing up the voltage to a "flashing over" point. For this curve, the brushes should be placed at the geometrical neutral point, and it should be seen that the presence of the brushes upon the commutator do not create a magnetomotive force due to local currents beneath them. On concentrated designs, this brush effect may be considerable.

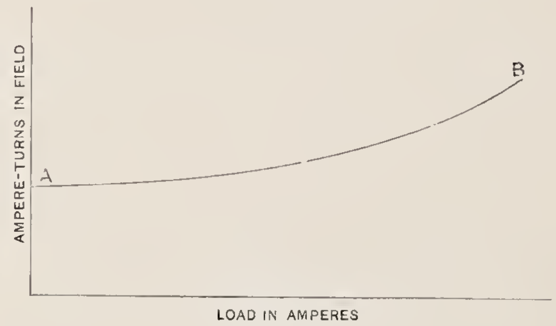


FIG. 13

13. The drop of potential through the series winding, including its shunt, if there be one.

This drop of potential should be the same at normal current on all sizes of generators that may ever be run in multiple; otherwise, an equal distribution of load will not result under these conditions. This value should therefore be read, recorded, and checked.

14. The potential curve of the commutator.

On multiple-wound armatures, the voltage between any one brush and the next brush in order to it in both directions, should be obtained. A variation of not over 4 per cent. should be allowed; otherwise, cross currents will exist which will lower the efficiency and injure the ability of commutation. This test cannot be applied to series-wound armatures, or to those that are cross-connected; in such cases, reliance must be placed upon the mechanical centering of the armature.

15. The voltage at no load with field rheostat entirely cut out.

This reading should be taken with the field winding at normal operating temperature, and at a brush shift that will permit it without flashing; it shows the maximum power of the field to produce voltage. In hot climates, the resistance of the shunt field is higher, and the margin in the field rheostat is cut down materially over what it would be on a cold day in a cold climate.

16. The normal voltage drop in field rheostat at no load.

This is as important a reading as the one in Section 15. The brushes should be in their normal operating position, and the field should be at its normal operating temperature. The drop in the field rheostat should be sufficient to allow for variation of climate and of load. The minimum drop should be about 12½ per cent., and the maximum drop about 40 per cent.

17. The voltage drops across field spools.

The resistance of the shunt and series windings on the different spools of a generator should be the same. A variation of 10 per cent., however, is allowable under usual conditions, without affecting the potential curve or the individual spool temperatures.

DIRECT-CURRENT MOTORS

Direct-current motors, in general, require tests similar to those for a direct-current generator. Thus, the various temperatures of a motor under full load should be obtained as described in Section 1, under the head of

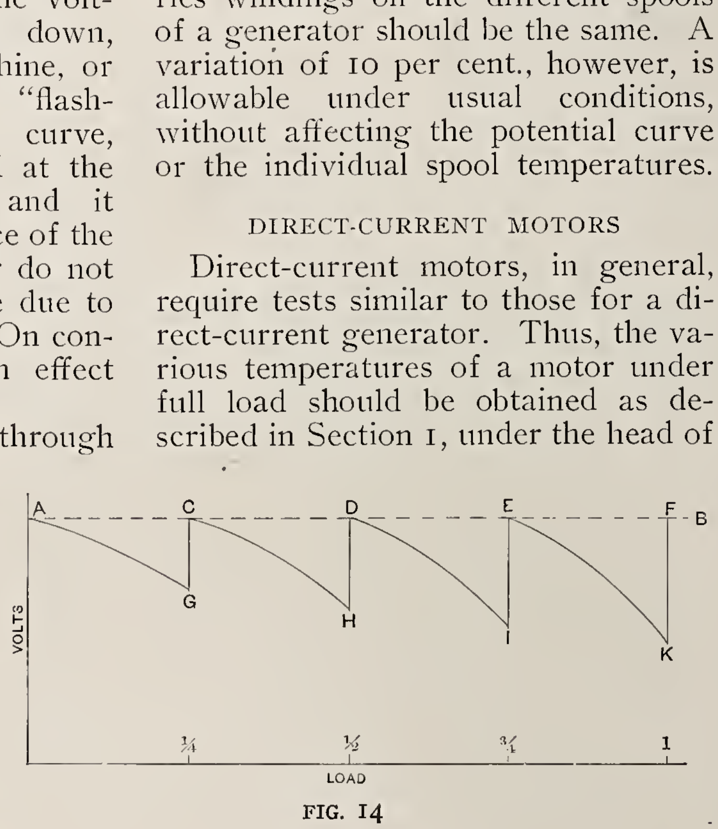


FIG. 14

Direct-Current Generators. The Hopkinson method may be used in loading the motor, or a water box may be employed in connection with a generator belted to the motor and acting as a load. In a motor, the variation of resistance in the field winding produces variation of speed. The temperature of the field winding must therefore be maintained sufficiently low, that the

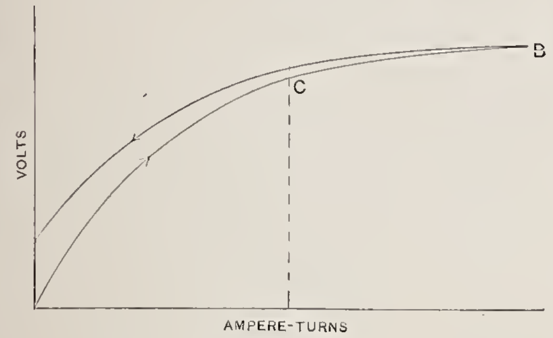


FIG. 15

variation of speed resulting from the resistance variation be less than 6 per cent. The American Institute of Electrical Engineers allows 50 degrees C. rise in temperature of the field winding by increase of resistance.

The various temperatures of a motor under overload should be obtained as described in Section 2, under the head of Direct-Current Generators.

The commutation of a motor at full load, and at various overloads; also at full voltage and at various other voltages, should be obtained as described in Section 3, under the head of Direct-Current Generators.

The core loss, friction losses, and the resistance losses of field, armature, and brush contact should be obtained as described in Section 4, under the head of Direct-Current Generators.

The efficiency of a motor equals the input in watts, minus the sum of the core loss, field resistance loss, armature resistance loss, brush contact resistance loss, and total friction loss, divided by the input in watts.

Information as to the settling of a commutator in a motor should be obtained as described in Section 6, under the head of Direct-Current Generators.

Information as to the insulation resistance and dielectric strength of a motor should be obtained as described in Section 7, under the head of Direct-Current Generators.

Information as to the mechanical matters to be investigated in motors should be obtained as described in Section 8, under the head of Direct-Current Generators.

A motor does not have to build up as mentioned in Section 9, under the head of Direct-Current Generators, but a certain connection of the field spools gives one direction of rotation, and a reversed connection gives the opposite direction of rotation. The direction of rotation of a motor should therefore be checked with the print, relatively to the connection of the field spools.

Corresponding to the compounding curve described in Section 10, under the head of Direct-Current Generators, is the regulation curve in the case of motors. The regulation curve shows the change in speed of a motor from no load to full load, and also from a cold condition to a hot one. The curve is taken by gradually loading the motor when hot and when cold, and noting the corresponding speeds; these results, when plotted, give the two curves shown in Fig. 16.

The curve *DA* represents the variation of speed with load when all parts of the motor are at running temperatures. The curve *CB* represents the variation of speed with load when all parts of the motor are cold. The point *A* at full load should not be over 6 per cent. above the point *B* at full load; the point *A* should not be more than 5 per cent. below the point *D* at no load; and the point *B* should not be more than 5 per cent. below the point *C* at no load. In some motors, the point *A* may actually be higher than *D* owing to very large armature reactions. Such motors are sometimes dangerous for the reason that the effect of the armature may entirely overcome that of the field, and cause an unsafe speed if much overload is placed upon the motor.

Sections 11, 12 and 13 under the head of Direct-Current Generators do not apply to motors.

The potential curve of the commutator in a motor should be obtained as described in Section 14, under the head of Direct-Current Generators.

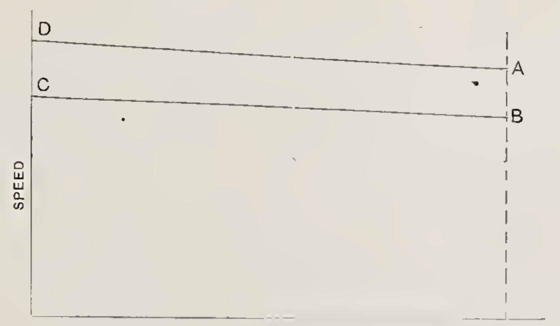


FIG. 16

Sections 15 and 16, under the head of Direct-Current Generators do not apply to motors.

The voltage drops across the field spools of a motor should be obtained as described in Section 17, under the head of Direct-Current Generators.

Although the details in handling the instruments for these measurements have not been mentioned, it is evident from what has already been stated, that proper calibrating facilities must be provided, and that care in the placing and handling of the instruments is necessary in order to secure the best results.

In conclusion, it may be stated that the tests described in this article can be applied to any generator or motor within a reasonable length of time, and that an absolute guarantee of operation can be obtained for a moderate expenditure of money. As a high-class insurance of future satisfaction to a customer, such testing is of inestimable value.

Modern Steam Engine Refinement

It is a matter of wonder for an old-time steam engineer to go over a modern generating engine and observe its many accessories. Taking the most advanced, he will find lubricating devices for all joints with motion, the oil all collected by drains to one point, filtered and cleaned, and then returned by a pump to the oil cups to be again circulated automatically. The fixed bearings of high-speed engines will be water-jacketed to prevent heating, and there will be a world of indicating devices for speed, pressure, vacuum, temperature and time. The condensing water will pass through filters to extract the oil that is entrained from the cylinders, and separators are provided to catch the water in the steam. Most of these things have come from the sea where economy and completeness have outrun land practice in a wonderful degree.

In the steam-generating elements there are the same additions and elaboration, all tending to economy, but demanding a new class of engineers with a knowledge and training that older practice did not afford,—more knowledge and less work, because all things are automatic, even to firing. Results, too, are of a nature not imaginable twenty years ago, especially in respect to control of speed. One may stand along side of a 1000-H. P. engine when the resistance changes as one to ten, and neither hear nor see, nor even feel, a sign of such a change. It is a master achievement in mechanic art and a result of co-operative effort on the part of hundreds, or even thousands, of the most skilled men of the age.

A series of lectures on electrical subjects is now being given on Monday evening of each week before the electrical class of the Brooklyn Rapid Transit Employees' Benefit Association. Trips will also be made over the company's lines, power houses, shops and like places being visited.

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Leading Articles

An Important Electrolysis Decision

A DECISION of much interest to electric railway companies and municipalities, and to private companies operating water works, gas companies, and bridge departments in every town in which there is an electric street railway, was recently handed down by Judge Sullivan, of the Circuit Court, in the city of Dayton, Ohio, in a suit instituted by that city about three years ago to restrain the local street railway company from operating a system that was causing damage by electrolysis to the city's water mains.

The suit was most stubbornly fought. It was carried from the Common Pleas Court, Judge Brown sitting, to the Circuit Court, and the record handed to the Circuit Court consisted of 3000 typewritten pages. The court's summary was as follows:—

"The law authorizes the action of the city.

"The case presented does not authorize the court to require defendant to change to another system.

"The faulty construction of the defendant's road and negligent operation of the same result in a continual damage to the water pipes of the city for which it has no adequate remedy at law.

"The fact that other electric railways operated in the city by the same system are in part responsible for the injury to the city's water pipes constitutes no defense for the defendant.

"The defendant will be enjoined from operating its road in the condition shown by the evidence, and from negligently operating the same.

"Jurisdiction of the case will be retained, to give the defendant an opportunity to show what, if any, improvement it has made since the cause was submitted to this court, in the way of bringing up the construction of its road and in operating the same.

"The question of costs of the appeal is reserved."

This decision is quite similar to that of the lower court, particularly in its main features, which are,—

"That because other electric railways are operating in the city, that fact constitutes no defense for the defendant, and

"That the case presented does not authorize the court to require defendant to change to another system."

In both decisions the court enjoins the defendant from operating its road in such negligent manner as to cause damage to water mains.

One important point in this decision, as well as in the earlier one, stands out prominently and will, doubtless, have a wide influence, namely, the establishing of liability on the part of the railway company for damage by electrolysis to water mains by their currents. This is practically admitted by the railway company in the following clause of its defense:—

"Its legal obligation to use reasonable care to prevent the electricity escaping from its rails to the water pipes of the city is admitted, but it avers it has exercised such care and diligence."

The concluding clauses of the decision emphasize this feature, and while this suit was not brought for the purpose of collecting damages for the destruction of mains and service pipes, it none the less squarely fixes the responsibility for any damage caused by electrolysis.

By reason of the frequent cases of damage by electrolysis in all parts of the country, railway companies have, in many instances, begun to recognize it as a matter for which they are responsible, and where they have been shown to be liable, they have paid for such damage without compelling the city to bring suit. This would seem the more sensible plan so far as actual damage is concerned, which may be discovered now and then. But this is not all; the question of continued damage by reason of the "ground return" is still an open one. So far as the decision is concerned, therefore, in this respect it is of little value as a guarantee to owners of underground structures, for it must be understood that the returning trolley current is uncontrollable in its flow and will cause damage more or less in many unknown and inaccessible places, such as joints in a piping system, in bridge foundations, or other structures in the ground.

If, however, the question of liability be settled, it would seem to be in the line of business prudence and foresight for railway companies to try to adopt a system that would give them a better control of currents than the present one.

In the case of the New York and Brooklyn Bridge, for example, it has been stated on apparently good authority that, owing to "over strain and electrolysis," the greater portion of that structure will have to be rebuilt. If a commission of specialists were appointed to determine what percentage of deterioration this bridge had sustained from electrolysis, their report, in view of what is already known from tests made by A. A. Knudson and others, might readily enough fix a heavy responsibility upon the railway company operating the "single trolley."

What might be shown to be true here, applies, though perhaps in a lesser sense, to underground mains and foundations of buildings.

Trees as Antennae in Wireless Telegraphy

ELSEWHERE in this issue we print a pretty full abstract from the report of Major George Squier, of the United States Signal Corps, on his interesting and novel experiments and tests with trees as antennæ in wireless telegraphy, and on the absorption of electromagnetic waves by growing vegetation. Major Squier's attention, as he states, was first attracted to these matters by the simple fact, found by one of his colleagues in the signal corps, that "grounds," ample for the purposes of field military telegraph and telephone signaling purposes, were readily obtainable by driving a nail into a living tree. When it is reflected that from the earliest days of telegraphy it has been known that the contact of wires with the leaves and boughs of trees would practically "ground" the wires, as even the earliest text-books on the subject have indicated, it would seem that this method of "grounding" a circuit in emergencies might have been anticipated. And in fact it has been, as the account which we give on page 140 of the use of trees as a "ground," by Mr. F. A. Stumm, will indicate, but certainly not on an extensive scale. Indeed, the text-books on the subject have so constantly urged the importance of a metallic ground for telegraphy and telephony, that a comparatively high-resistance ground, such as a tree affords, would not naturally have been regarded as good practice, and of course would not be for regular work.

Apart from the instance alluded to by Major Squier, the nearest approach to the Goodale experiment which we recall was one in which Mr. Henry van Hoevenberg, about the year 1882, drove nails into two beech trees and connected them by a wire in the circuit of which he inserted a telephone receiver. On listening, he heard a murmur as of the sea. Relating the experience to his friend, Mr. Wm. Hadden, the latter remarked that as the experiment was made with beech trees the results were not extraordinary, which "bon mot" by its repetition preserved the experiment from oblivion. These murmurs were possibly due to the variations of the electromotive forces which Major Squier describes in his report.

In perusing the account of Major Squier's experiments, one is led to inquire whether perhaps the results obtained with the telephone as a receiver in a shunt circuit of the trees adjacent to the power transmission line are not a repetition, on a magnified scale, of those in which the microphone is affected by the wireless transmitter at Fort Mason, in which case both would be due to electrostatic effects. It is also an interesting question whether the effects in the experiment made with a wire parallel with the ground and with the leaf system of the tree might not have been due to electrostatic lines of force between the leaf system and the ground. The experiments are all very interesting and will, no doubt, open up a new field of investigation, whatever may be their ultimate outcome from a practical standpoint.

It is interesting to note in connection with Major Squier's use of trees as a support for the antenna, that Captain Marryat, the well-known novelist, in his juvenile story "Masterman Ready," written in 1841, describes a very close anticipation of this arrangement. The castaways, it may be remembered, had narrowly escaped death by lightning, and some coils of copper wire having fortunately been saved from the wreck, a lightning conductor was proposed for their future security, the erection of which Marryat describes as follows:—

"Ready put his ladder against one of the trees, and taking with him the hammer and a bag of large spike nails, drove one of the nails into the trunk of the tree till it was deep enough to bear his weight; he then drove in another nail above it, and so he continued to do, standing upon one of them while he drove in another above till he had reached the top of the tree close to the boughs. He then took up a saw and small axe, and in about ten minutes he had cut off the head of the cocoanut tree, which then remained but a tall bare pole.

"Ready came down again and cut down a small pole to fix with a thick piece of pointed wire at the top of it on the head of the cocoanut tree. He then went up, lashed the small pole to the head of the tree, and made the end of the copper wire fast to the pointed wire. The lower end of the wire was then buried in the ground at the bottom of the tree on which the lightning conductor had been fixed. 'That's a good job done,' said Ready. 'Yes,' replied Mr. Seagrave, 'and we must put up another near the outhouse, or we may lose our stores.' "

Future Sources of Energy

LONG before the coal fields of the world are exhausted, there is little doubt the workers on the borderland of engineering will have discovered some plan of tapping the inconceivably great stores of energy around us. The very earth we live on is whirling around like a huge fly-wheel, and if we could only find some way of utilizing its momentum we could draw upon it for ages for all the power we want without appreciably affecting the speed of its revolution or the length of our day. It is, indeed, naturally drawn upon now in various things intimately associated with the work of the harbor and dock engineer.

The flow of the tide in enormous volume, up and down a river, is accompanied by a vast expenditure of power in overcoming the frictional resistance of the river bed, in the grinding of shingle into sand, and in the transport of sandbanks from one part of the river to another. Even the flow of the water through the sluices of locks involves a loss of energy, as does the working of a tide mill, which latter is one way of utilizing, as the others are of destroying, some of the earth's momentum. No true engineer will believe that with so many sources of energy around us the progress of mankind and the work of the engineer will cease with the exhaustion of the coal fields.

The city of St. John, N. B., may decide to purchase the plant which provides electric lights for the west side of the city and run it as a civic enterprise. According to Consul W. R. Holloway, at Halifax, the following statement shows the present expense: —Cost of lighting north end of city from an electric light station owned by the city, $75 a light; cost of lighting east end of city by lights rented from the city railway company, $85 a light; cost of lighting west end by company which it is now proposed to buy out, $105 a light.

A Combined Town Water Supply and Electric Light and Power Plant

At Zwoelfmalgreien, Tyrol

By A. STEENS

A MUNICIPAL lighting plant built in conjunction with the city water supply and directly dependent on the latter for its power is a combination of which we do not hear every day. A rather unique installation of this type has been placed in commission at Zwoelfmalgreien, Tyrol. The mountain stream Eggenthalerbach, not far from this village, promised an ample supply of all the water required. The problem was to make this water available for domestic uses at a cost which would not be prohibitive. The difficulty was finally overcome by slightly enlarging the aqueduct, and employing the excess of watei to supply power to an electric plant. In this way a large share of the expense was borne by a profitable investment, and at the same time the long-formed project of electric street lighting could be realized. The electric installation was put down by the Oerlikon Construction Company.

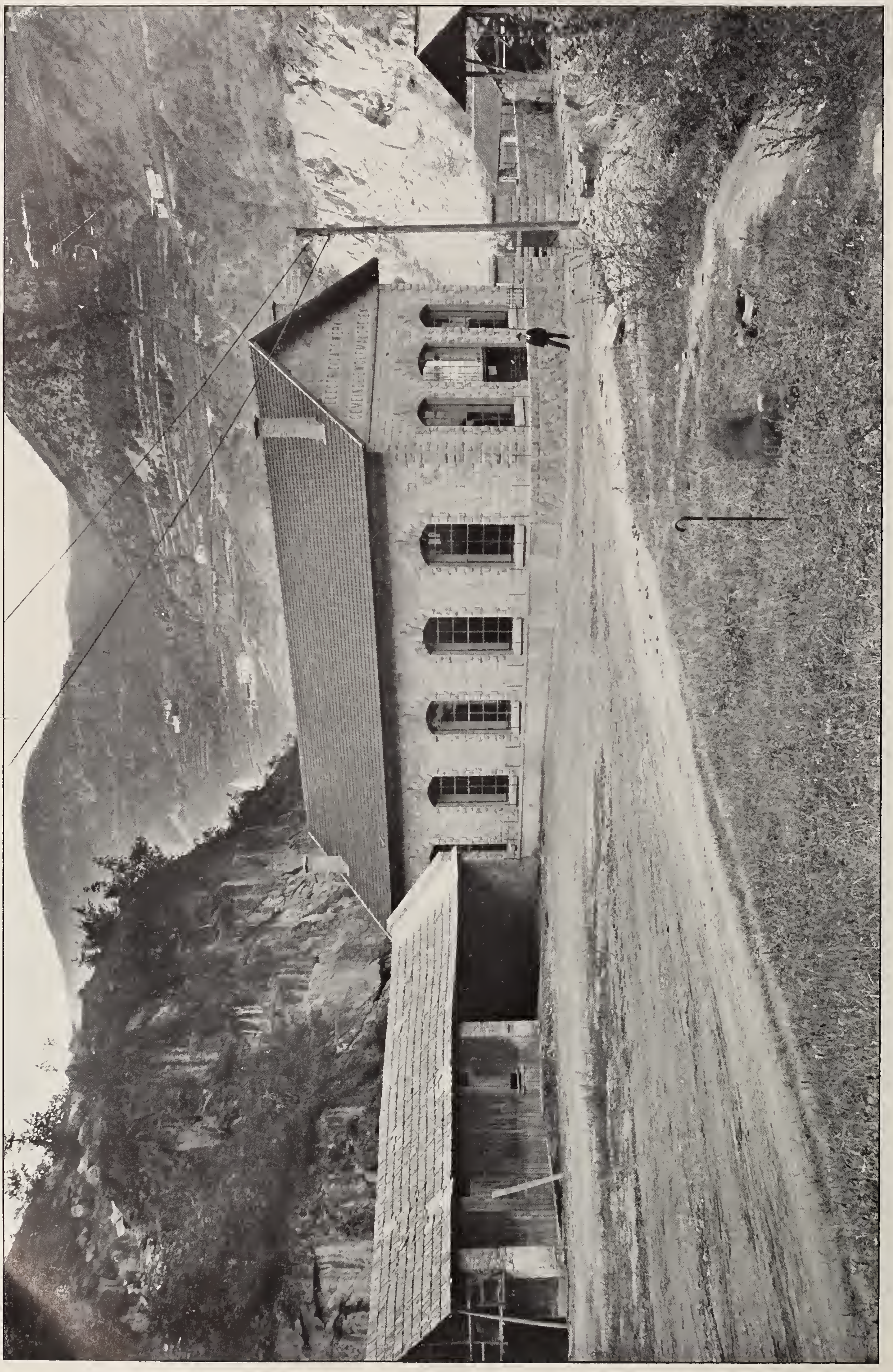
The power house lies at an altitude of 984 feet above sea level, on the left bank of the Eggenthalerbach at a place called Florkeller. This is the beginning of the valley Eggen, and is situated about 2300 feet upstream along the Eggenthalerbach from the confluence of this stream with the Eisack. The railroad station Bozen is about $2\frac{1}{2}$ miles distant, and Kardaun is not very far off. The main building has a floor space of 4031 square feet, of which the dynamo room occupies 2960 square feet. An annex contains the apparatus room (273.5 square feet) on the first floor, while the second floor is set apart for the attendants. In the basement on the river side is located a repair shop with 318 square feet of floor space, from which direct access may be had to the dynamo room by means of a staircase. A second staircase leads from this hall to the attendants' room, which is separated from the former by a glass partition, so that a constant supervision of the machinery is possible.

The building has a concrete floor and masonry walls. The roof trusses are steel, and carry a ceiling of wire lath and plaster. The floor of the dynamo room is covered with cement tiles. The switchboard stands on a cement platform raised about 16 inches above the floor. This platform is covered for safety with linoleum, and over this is spread a rubber runner to make the insulation perfectly secure. The apparatus room also is carpeted with rubber matting.

A traveling crane of $8\frac{1}{4}$ tons capacity serves the dynamo room. Provision has been made for the accommodation of five hydraulically driven

A VIEW OF THE OVERHEAD TRANSMISSION LINES

ONE OF THE SHEET-IRON TRANSFORMER TOWERS USED FOR THE OVERHEAD WIRES



THE POWER HOUSE AT FLORKELLER

generators, three of which are now in place. Once the installation is complete, four of these machines will be run continuously, the fifth one being kept in reserve.

Running along the south wall of the building on the outside is a trench containing the conduit for the incoming water. Its dimensions are 6½ feet wide by 5½ feet deep. This trench is lined with concrete.

The power house is 2.1 miles from the dam across the Eggenthalerbach. This dam is built of stone; it is 197 feet long and 14.7 feet high. The minimum flow of water is 35.3 cubic feet per second. The intake proper has five gates, each protected with a grating made of 2-inch gas pipe. The bottom of the raceway is concave, and its sides are masonry.

The flume, which is about 11,000 feet long, runs off at right angles from the raceway. Floating debris is prevented from entering the flume by a grating with 9-16-inch spaces. It is somewhat shallower than the raceway, so that heavy material carried along by the flow of the water, as rolling stones and sand, may remain in the latter as much as possible. A gate 3¼ feet wide by 8¼ feet deep at the far end of the raceway provides the necessary facilities for removing such extraneous matter from time to time. The flume may be shut off at two points by means of gates, while the water in it may be let out through eight other gates along its sides. Almost the entire length of this conduit is cut through solid rock. Only at a few places were masonry walls required.

The water used for the hydraulic machinery flows along the bottom, and fills a space about 4 feet deep. This stream is covered along its entire length by a plank flooring carried on supports let into the side walls. The height of the conduit above this flooring is 5¼ feet, and in this upper section is laid the town water-supply pipe line. This is 9 inches in diameter, and rests on the same supports which support the planking. The grade of the flume is uniformly 1.5 per cent., producing a velocity of flow of from 3¼ to 5 feet per second. At its lower end the conduit empties into a tank built entirely of concrete, which forms a connecting link between the flume and the penstock. Owing to the decreased velocity of the water at this point, any impurities which may have passed the gratings at the entrance of the flume settle here and may be removed through a grate conveniently placed in one of the side walls.

The upper end of the steel penstock is built into the wall of the tank opposite the mouth of the flume. Its total length is 1366 feet, and its diameter about 3 feet. It is carried on cast-iron shoes bolted to blocks of concrete; on these shoes it can slide freely, not being fastened down. It is anchored, however, at each one of the four bends along its length. Three expansion joints take care of temperature variations. The lower end of the penstock lies in a trench 108 feet long, running along the side of the power house. The actual fall from the upper end of the penstock to the lower is 689 feet, giving an effective head of 682 feet.

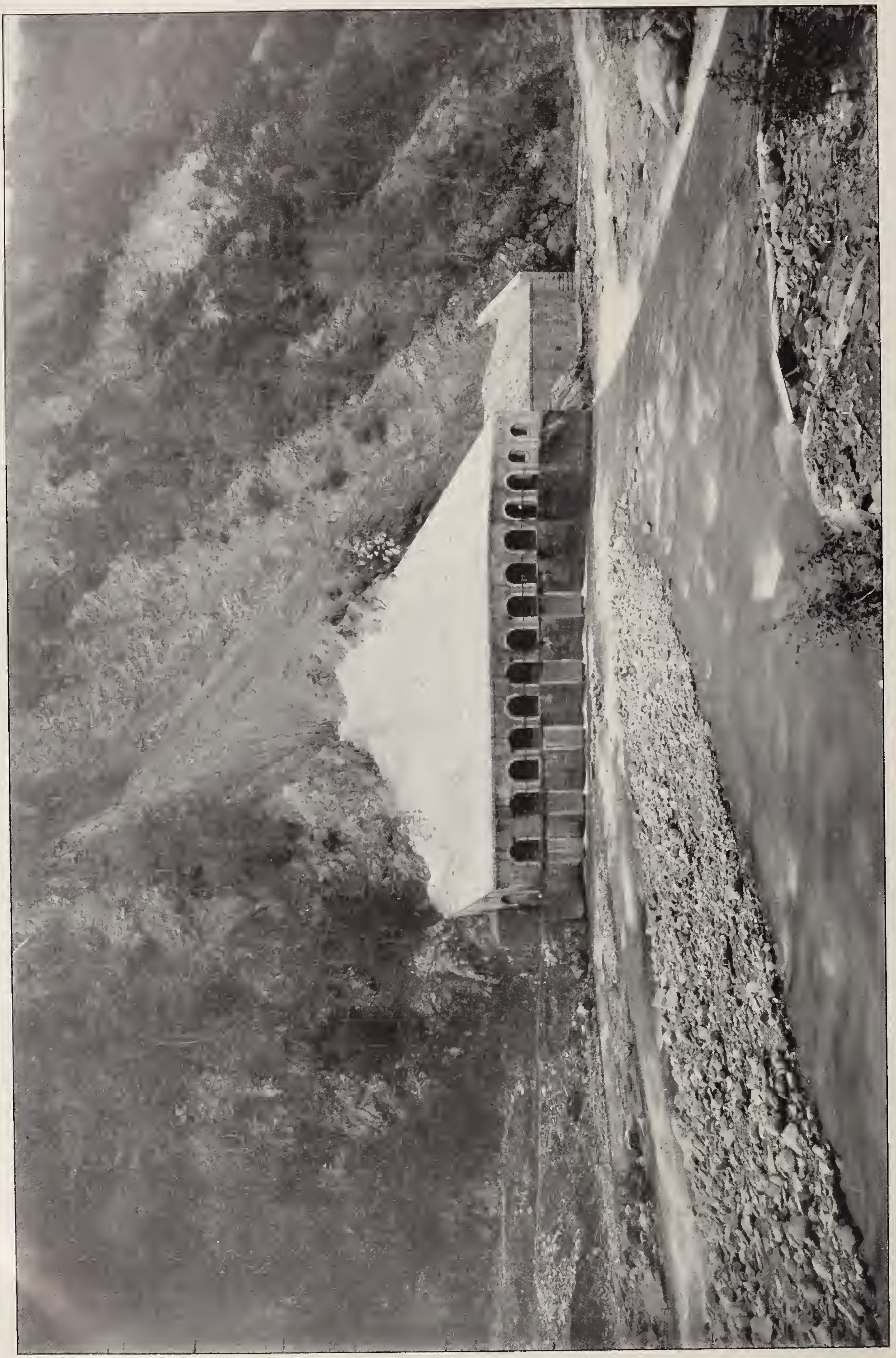
From the lower end of the penstock, or distributing chamber as it may be called, in the trench previously mentioned, five conical tubes carry the water to the wheels. Each tube is provided with a gate, and an air chamber is located in front of the first one of them. Four safety valves on the distributing member take care of any possible excessive pressures. At the far end of this pipe is placed a discharge gate.

Each of the water wheels of the Pelton type develops 493 H. P. The water passes through a regulating gate to the wheel chamber, and impinges on the buckets through phosphor-bronze nozzles. These may be closed one by one by separate gates, operated by means of hand wheels, conveniently placed on the switchboard. The buckets are made of white metal, and may be easily removed and replaced. The regulating gate in front of the wheel chamber, whose function it is to automatically adjust the flow to the load, is moved by hydraulic mechanism controlled by a sensitive ball-governor. The governor is supplied with oil dash-pots to prevent too sudden changes in speed. The speed regulation is further aided by a 4-foot 9-inch diameter flywheel weighing about 7000 pounds, and by the previously mentioned safety valves on the distributing chamber which afford relief as soon as the pressure goes beyond the normal. The air chamber near one end of the distributing chamber prevents water-hammer.

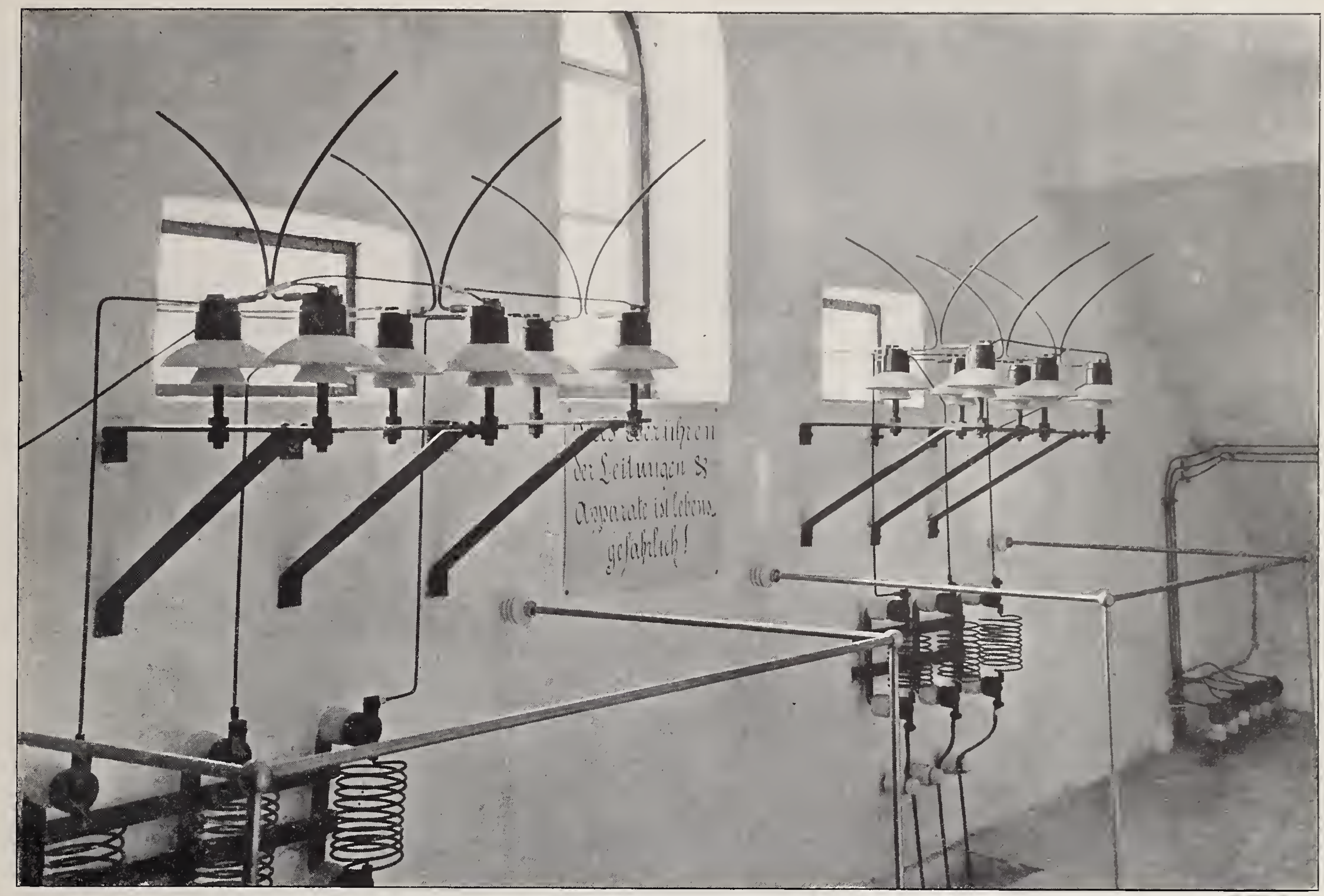
Tachometers, mounted directly on the shaft of the generators, allow a constant checking of the speed. According to the guarantee, a sudden change in the load of 50 per cent. must not cause a speed variation exceeding 3 per cent., and a change in the load of 100 per cent. must not vary the speed more than 6 per cent. Tests made on the generators after installation showed that suddenly throwing off a load of 375 H. P. did not affect the velocity of the water wheel more than 2½ per cent.

THE INTERIOR OF THE POWER HOUSE SHOWN ON OPPOSITE PAGE

The 493-H. P. dynamos were built by the Oerlikon Construction Company, and generate three-phase alternating current of 3600 volts and 50 cycles frequency. The transformers are placed in cylindrical sheet-iron towers, built on concrete foundations. There are two sizes, 19 feet 8¼-inches, and 13 feet 1½ inches high, respectively, and ranging from 5 feet 3 inches to 4 feet 8 inches in diameter. The former is used where the secondary circuit is composed of over-



THE DAM AND INTAKE AT EGGENTHALERBACH, OVER TWO MILES FROM THE POWER HOUSE



TRANSMISSION LINE EXITS FROM THE STATION

head wires, and the latter where this circuit is carried through underground conduits. Three doors give access to the interior; of these, one opens on the transformer compartment; the second on the high-tension, and the third on the low-tension compartment. Separate conductors carry the power and the lighting currents. Only the latter are stepped-down in the towers; the cables for the former are led in merely so that in case of accident to the high-potential lighting wires, current may be supplied to the primary transformer coils from the other network. Where two transformers are placed in one tower, one is on top of the other.

Seven of the 19-foot and two of the 13-foot towers are located in Zwoelfmalgreien, and three of the smaller size in Gries. An extra transformer station is placed in a masonry vault at the Hotel Stigel, at Zwoelfmalgreien. Only one of these stations receives its current through overhead conductors. The low-tension lighting system has a potential of 150. All motors larger than 2 H. P. are placed across the primary power circuit, the voltage being stepped-down by individual transformers.. Twelve transformers for the illuminating system are at present in use, representing a total of 137 K. W.

Where the current consumption is large, or where aesthetic considerations outweighed the greater cost, the secondary circuit is laid underground. So far 10,295 feet of cable have been put down. Each cable is made up of three conductors. A large part of the low-potential system is made up of overhead wires which are carried on double petticoated porcelain insulators mounted on poles about 35 feet high. On the same poles the wires carrying current for lighting the streets, are strung. The poles are topped off with a pointed sheet-iron cap, all the points being inter-connected by an iron wire. At every fourth or fifth pole this wire is connected with a galvanized-iron plate buried in the ground.

Arc lamps for lighting the streets are either mounted on posts, or are carried on a steel wire stretched across the street. The posts are of cast iron, with a wrought-iron arm, and are about 20 feet high. Each light consumes 15 amperes and is rated at 800 candle power. Three or four of them are placed in series on one circuit. All incandescent lights used for public illumination are of 32 candle power. They are attached, as convenience may dictate, to the line-poles themselves, to houses, or to separate lamp-posts. The brackets are of wrought iron, about 30 inches long, and carry conical reflectors besides the lamps, which are enclosed, for protection, in sealed globes. They are placed 13 feet above the street level. So far 23 arc lights and 60 incandescent lamps have been placed in the streets of Zwoelfmalgreien; at Gries the respective numbers are 2 and 35. For private purposes about 2000 incandescent lights ranging from 5 to 25 candle power have been installed since the electric current was made available.

Each of the two high-tension transmission systems, that for power and that for lighting, is carried partly overhead and partly underground. The overhead conductors, of which there are three for each system, run along the left bank of the Eggenthalerbach as far as Gasnerhof. The first transformer is located there. At this point they cross the stream, and, following its right bank, span 148 feet (45 meters) over the Eisack at the confluence of the two rivers; 295 feet further on, the overhead line ends in a square masonry tower 22 feet high, where the connection with the underground conductors is made. In the upper part of the tower is a frame carrying lightning arresters and a single-pole fuse for each wire; down below, the junctions are made between the overhead conductors and their underground prolongations.

The entire overhead line is only 2625 feet long. On this stretch 3747 pounds of copper are carried on 26 larchwood poles; these poles are 49 feet high, and from 7 to 10 inches thick at the small end. The lower end is buried in the ground about 5½ feet. Each pole carries at its top a lightning rod connected to a 15-inch by 17-inch grounding plate by means of a copper wire about a quarter of an inch in diameter. All these lightning rods are inter-connected by a galvanized-iron wire, so that a possible accident to one of the grounding wires would not seriously impair the usefulness of the rod.

The underground cables contain three wires each. These are paper-insulated and served with tarred jute and two layers of steel ribbon, the whole being encased in lead. The power and the lightning cables lie side by side on sand. They are covered with plates of porphyry and buried about 27 inches in the ground.

The overhead conductors enter the power house through two openings in the wall directly under the roof, the wires being there enclosed in glass tubes. Immediately inside the building are lightning arresters connected to earth by quarter-inch bare copper wires.

From there the conductors are led to the bus-bars. These are placed in the apparatus room mentioned at the beginning of the article. They are connected to the generators by means of conductors running partly in conduits in the floor of the dynamo room, and covered with sheet iron, and partly through the basement. Current from the exciters is taken to the bus-bars in the apparatus room along a similar path. The principal conductors are carried on double petticoated porcelain insulators mounted on iron pins; the exciter wires are strung on small cylindrical insulators.

The apparatus room is separated from the dynamo room by a partition consisting of five panels of white marble on an iron frame-work. The marble panels do not quite reach the floor; the remaining space is occupied by a piece of perforated sheet iron, whereby perfect ventilation is secured for the apparatus room. That side of the partition separating the hall from the dynamo room, which is in the latter, serves as a switchboard.

Meeting of Allis-Chalmers Officials

A MEETING of the executive officers, heads of departments and salesmen of the Allis-Chalmers Company was held recently at Milwaukee. This was not only the first meeting of the kind called together by the new management, but was the first of this kind within the organization. Eighty-six men were present, and they came from as far east as Boston, as far west as Seattle and San Francisco, as far north as Minneapolis, and far south as Dallas, Texas. The meeting lasted several days and terminated with a banquet given at the Plankinton House by the president, Mr. B. H. Warren. The group opposite shows sixty-six of the members of the organization who were present at the meeting. Another similar meeting will be held in the early spring and will be composed of the men whose duties prevented them from attending the first series.

1. James Tribe.
2. G. C. Forgeot.
3. A. Niedermeyer.
4. W. J. Sando, Manager, Pumping Engine Dept.
5. W. H. Whiteside, General Manager of Sales.
6. W. J. Chalmers, Vice-President and Treasurer.
7. B. H. Warren, President.
8. A. M. Mattiee, Chief Engineer.
9. Arthur Warren, Manager of Publicity.
10. B. A. Behrend, Chief Engineer of Eleetrieal Dept.
11. C. C. Tyler, General Superintendent.
12. W. M. S. Miller.
13. Ervin Dryer.
14. F. F. Coleman.
15. James Ashworth.
16. H. A. Allen.
17. W. W. Niehols, Vice-President and Seeretary.
18. J. F. Harrison, Manager, Flour Mill Mach. Dept.
19. Almon Emrie, Superintendent, Milwaukee Works.
20. W. G. Starkweather.
21. J. R. Jeffrey.
22. C. J. Printz.
23. H. S. Mitchell.
24. I. L. Skeith.
25. G. C. Henry.
26. Robert Mulford.
27. J. C. Buekbee.
28. H. Woodland, Assistant Treasurer.
29. Clemens Herschel, Manager, Hydraulie Turbine Dept.
30. C. A. Burns.
31. H. L. Wells.
32. Franklin Wharton.
33. H. V. Croll.
34. G. L. Tifft.
35. J. D. Millar.
36. W. C. Trout.
37. M. C. Miller.
38. W. A. Wood.
39. H. Sehifflin.
40. J. A. Milne, Comptroller.
41. H. S. Pell.
42. G. S. DeWein.
43. H. J. Holden.
44. M. J. Furlong.
45. George T. Thomas.
46. W. E. Dodds, Superintendent of Construction.
47. Riehard Hoppin.
48. H. C. Helvey.
49. Albert Hoppin.
50. A. J. Gates, Superintendent, Chicago Works No. 1.
51. George L. Fisher.
52. W. N. Tanner.
53. Riehard Barnard.
54. F. W. Greenleaf.
55. H. S. Mallalieu.
56. H. I. Keen.
57. J. O. Watkins.
58. J. R. Glendinning.
59. G. F. Collins.
60. R. D. Tomlinson.
61. C. A. Derby.
62. G. A. Berg.
63. J. C. M. Lueas.
64. W. O. Everett.
65. H. A. Hammil.
66. D. T. Jones.

EXECUTIVE OFFICERS AND OTHERS IN ATTENDANCE AT THE RECENT MILWAUKEE MEETING OF THE ALLIS-CHALMERS COMPANY

The telephone service of the executive departments of the government at Washington costs $50,000 a year, not including the capitol and congressional library, the government printing office, the capitol stables and other governmental branches in that part of the city, which probably pay altogether $25,000 more, making a total expenditure annually in that city alone of not less than $75,000.

Electric Train Lighting

THE Pennsylvania Railway Company is rapidly extending the use of electricity in the lighting of their passenger trains. Many of the limited trains running over this road for a number of years past, have been lighted by electricity obtained from a dynamo in the baggage car, and the results have been so satisfactory that storage batteries are now to be installed on practically all of the passenger trains and charged with current from electric plants at the terminal stations. One of these plants has recently been completed at Pittsburg, near the passenger yards of the company. This is a large power plant, and in addition to providing electricity for charging the storage batteries used in lighting the cars, it will also furnish steam for heating the cars in the yards, and compressed air for testing the brakes.

A GROUP OF ALLIS-CHALMERS OFFICIALS AT THE RECENT MILWAUKEE MEETING. FOR KEY SEE OPPOSITE PAGE

Trees as Antennae for Wireless Telegraphy

The Absorption of Electromagnetic Waves by Living Vegetable Organisms

Major George O. Squier, of the Signal Corps of the United States Army, has recently forwarded to Major-General Arthur MacArthur a very interesting report containing an account of a number of experiments carried on by him with a view of ascertaining to what extent trees may be available as antennæ in wireless telegraphy. These experiments were conducted primarily for military purposes, but they led on to others, which are also described in the same report from which the valuable details that follow are abstracted.

Major Squier is already well known in electrical circles by reason of his work with Lieutenant Crehore in automatic telegraphy, and by his paper on "An American-Pacific Cable," read before the American Institute of Electrical Engineers several years ago.

Major Squier states that his attention was first directed to the utilization of trees as antennæ by learning of an experiment made by Lieutenant William M. Goodale, of the United States Signal Corps, at the military manœuvers of the Department of Columbia at American Lake, Washington, in July, 1904.

In this experiment it was found that a better ground could be obtained for the telephone and telegraph lines used in the field exercises of the army by driving a nail into a tree than by the usual method of driving an iron spike into the earth, or by burying a plate. These results were confirmed by Major Squier at the joint military manœuvers of the Department of California at Camp Atascadero, California, in August, 1904, under conditions which were still more likely to test the serviceability of this method of grounding, namely, in a country where, owing to the dry nature of the soil to considerable depths, it was almost impossible to obtain a ground in the ordinary way.

Major Squier found that, for telephonic currents, the conductivity of a healthy growing tree is such that the nail contact may be carried up the tree to a height of 30 feet or more and the telephone be used from that elevation. Further, his experiments showed that communication can be maintained from one tree top to another with the trunks of both trees in the circuit; also, that if the operator holds the ground wire in his hand and completes the circuit to earth by merely touching a live twig or leaf, the transmission of speech is good. This, therefore, permits the military scout to use the vantage point of a tree elevation for observing the enemy while being screened from view by its foliage, and at the same time enables him to transmit by telephone to the distant station the information thus obtained.

From a consideration of the established facts that the transmission of electromagnetic waves over land is much more difficult than over water, due, it is assumed, to the absorption of the waves by intervening hills, buildings and conductors, and that the importance of good earth connections and the general condition of the earth around the foot of the antennæ as to moisture, temperature and composition, has been fully demonstrated, Major Squier was induced to undertake these experiments to ascertain how far the conditions just mentioned can be fulfilled by high trees covered with green leaves.

The first of these experiments was made at the U. S. Signal Corps wireless station at Fort Mason, San Francisco, Cal. The transmitting apparatus at this station consists of a small 4-inch spark induction coil, and a vertical wire suspended from a 75-foot pole on a bluff 80 feet above the sea. This transmitting apparatus was used to send out pulsations corresponding to some letter of the alphabet, such as S. The length of the transmitted wave was about 300 feet. The receiving apparatus was placed at a distance of about 320 yards from the transmitter, a tree being employed as the receiving antenna.

The arrangement of the receiving apparatus for the first test is shown in Fig. 1. A spike *P* was driven into the tree trunk *A* an inch or two above the earth line *E*. The detector *M* is microphonic in type, and is shown in series with the wire between the upper nail or spike *N* and the lower one at *P*. This detector, which was admittedly crude for the purpose, consisted of a small ebonite tube partly filled with the ordinary spherical granules used in telephone transmitters, and in which two steel needles are introduced until their points nearly meet in the middle of the tube. This is an autocoherer, requiring only an occasional tap to keep it sensitive. A head telephone *T* was used in the ordinary way in the shunt circuit with several small dry cells *B*. This circuit could be closed and opened by the switch *S*. The apparatus was mounted on a small board about 10 x 12 inches. The contact at *P* was held stationary while the upper contact *N* was moved vertically up and down the tree.

Major Squier found that when the contacts *P* and *N* were closer than 3 feet, no sounds were heard in the telephone. With a greater distance than 3 feet, signals began to be heard, and the volume of sound increased with the distance between the contacts up to the point where the first branches of the tree began to diverge; beyond this point there was no perceptible increase in sound.

To insure that the observed results were due to electric oscillations in the tree itself and not to the short wire *NM* acting as an antenna, the wires *NM* and *MP* were lead-covered, and the lead covering connected to the ground. As a further precaution in this direction, the receiving instruments were screened from the incoming electric waves by metallic net screens which were held close to the tree on the side toward the transmitting station and to a point considerably above the contact *N*. When the upper contact *N* was held an inch or two away from the tree, but still at the same height above the earth, no sounds were observed in the telephone; but sounds were at once restored when connection was again made with the tree.

Another experiment was made in which electromagnetic effects were received from the ground immediately surrounding the tree. The electrical connections were as shown in Fig. 2. The terminal *P* remained at the same point as before, but the terminal *G* was placed at various radial horizontal distances up to and somewhat beyond a quarter wave length, or 75 feet. It was found that a marked difference was noticeable in the effects, by changing the point *G* relatively to the base of the tree, even as little as a foot or two, provided, however, it was in a zone beyond 6 or 8 feet from *P*. When the wire at *P* was entirely removed from the nail at the base of the tree

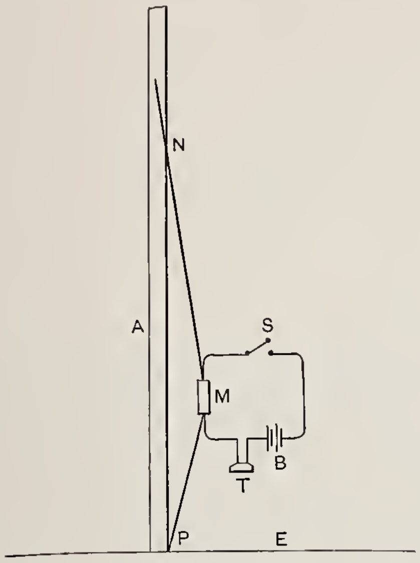


FIG. 1

and inserted in the ground immediately adjacent to it, but not touching the tree, the signals were heard. Here, then, electromagnetic effects were received without any actual contact with any form of antenna, but directly from the earth itself surrounding the foot of the antenna, and under its electrical influence.

The arrangement of the circuits shown in Fig. 3 is a combination of the arrangements illustrated in Figs. 1 and 2. This plan gives slightly stronger results than were obtained with the arrangement shown in Fig. 1 or in Fig. 2.

Other experiments gave the following results:—Inserting impedance in *MN*, Fig. 1 or Fig. 3, always cut down the intensity of the signals, whereas impedance in *MP*, Fig. 1 or Fig. 2, had practically no effect. The reducing effect of 100 ohms in *MN*, Fig. 1 or Fig. 3, was, however, decidedly noticeable. A small air-core coil of a few turns of small wire on this branch of the circuit cut down the effects perceptibly, while 7000 or 8000 ohms thus introduced cut off all signals. Short-circuiting from a point at the base of the tree to either side of the microphone *M*, Fig. 3, had no effect on the signals.

Several trees of a large grove were connected in parallel by joining their upper terminals to one terminal of the detector *M*, and the other terminal of *M* to earth. As the microphone is a device operated by the difference of potential, it was not expected that this arrangement would produce much change in the signals; this, in fact, was the case, the only variation noticeable being probably due to a difference in the size and character of the trees when one or more of them were connected in the circuit in parallel.

Another experiment consisted in inserting a circle of contacts at *N* and *P*, Fig. 1, which were short-circuited by separate wires. These short-circuits had no effect upon the signals received in the detector circuit, even when brought very close to the contacts of the detector circuit. This experiment shows that the electromagnetic effects utilized in the single circuit are but a very small part of the total effect absorbed by the whole tree system. This, in turn, indicates that the use of a detector operated by current would produce stronger effects than the potentially operated detector, and that by surrounding the tree at the selected upper point by a conducting ring or collar containing many metallic contacts with the tree itself, the proportion of the energy of the electromagnetic waves absorbed by the tree system as a whole could be multiplied and concentrated at the detector almost at will.

If, in Fig. 1, a wire be attached to the contact *N* and the other terminal of this wire be touched in succession to other contacts along the tree nearer and nearer to the lower contact *P* of the detector *M*, a perceptible decrease in the intensity of the signals is observed as *P* is approached. When this wire is touched to the tree within a few inches of the point *P*, the signals in the telephone *T* almost entirely disappear.

The field receiving apparatus which was used in some of these experiments over short distances, is shown in Fig. 4.

An arrangement of transmitting antenna, which, however, has been used only over very short distances thus far, is shown in Fig. 5. Here the ground connection is made through the root system of the tree *A*, and the vertical wire is merely suspended,

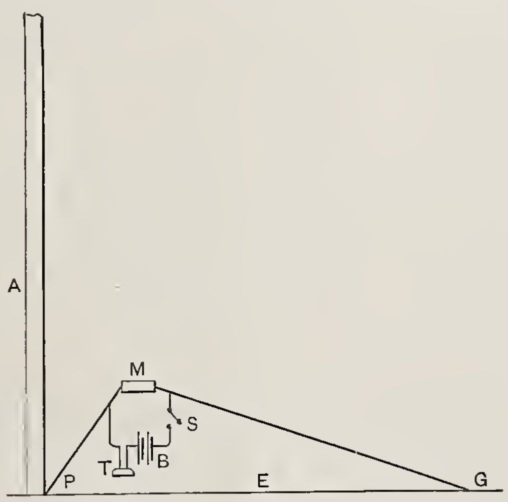


FIG. 2

using the tree itself as a supporting mast. In the figure, *I'* and *I* are inductances, *C* and *C* are condensers, *S* is the spark gap, *I'C* an induction coil, and *E* the earth line.

Since the capacity of a vertical wire is increased by the presence near it of a parallel conductor, the efficiency of the arrangement can be changed by varying the distance of the vertical wire from the trunk of the tree. Attempts were made to note if there was any screening effect from neighboring trees in line with the receiving station; in other words, if electromagnetic shadows were cast. With the wave lengths used and the distance involved (presumably about 320 yards), the results seemed equally good from even smaller trees immediately behind a bank of larger ones in line with the transmitting station. Short-circuiting the trunks of trees by running wires directly from contacts at a point where the main branches diverged to a terminal at the base of each tree, had no appreciable influence upon the signals being received from neighboring trees. A direct current sent through the tree by a battery of 100 volts, when thrown on and off, and reversed, showed no perceptible

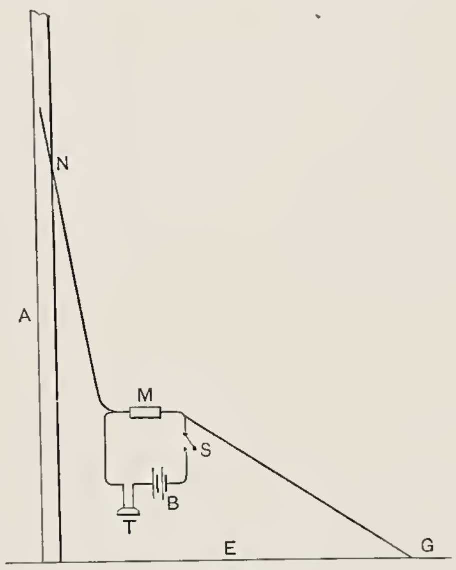


FIG. 3

effects upon the signals being received through the microphone. There was no perceptible difference in the character of the signals received when different wave lengths were employed, whether from the Fort Mason station, Alcatraz Island station, or the naval station at Yerba Buena Island, in San Francisco Harbor. The maximum distance of these stations from one another is approximately 3¼ miles.

Measurements of a eucalyptus tree about 15 inches in diameter, showed it to have a resistance of about 5500 ohms between two nails 15 feet apart. In trees possessing a well-defined heartwood, the effect of girdling is pronounced, since in such a tree the only living portion is a comparatively thin outer layer, the central portion of the heartwood being practically dead and free from sap.

It appears possible that the manifold and varied forms and shapes given by nature to the leaf surfaces of vegetation adapt them for absorbing electromagnetic radiation; while the general configuration of the root system of trees, consisting of large radial root trunks, proceeding out from a common root stem and supplemented by innumerable branches and microscopic hair roots and rootlets filled with conducting fluids, is not ill-suited for the conduction of electromagnetic waves into the earth. Again, the strength required in towers and masts for supporting vertical wires is amply provided by the antennæ here suggested, since a great tree, with its natural buttresses and its root system often extending deep into the earth, is well designed to resist the elements.

For determining to what extent electromagnetic waves of low frequency were absorbed by vegetation, Major Squier conducted the following experiment:—Near Lorin station, along the route of the long-distance transmission line of the California Gas & Electric Corporation, of San Francisco, the vegetation was examined for inductive effects. The transmission line is of the three-phase type and supplies power at 56,000 volts, with a frequency of 60 cycles per second. Upon connecting a telephone between two nails driven in any growing tree along the route of this line, and at a reasonable distance from it, the telephone responded with great clearness to the note corresponding to the frequency of 60 cycles. For this experiment no microphone need be used, and no other source of electromotive force than that induced in the tree itself. Since the trunk or stem of a tree is perpendicular to the surface of the earth, and normal to the direction of a transmitting line wire, the effects of electromagnetic induction should be a maximum between points of the tree on a line parallel to the wire, and a minimum between points on a vertical line. Since, however, the large leaf surface at the top of the tree presents in reality an extensive conducting area, it may be regarded as having a resultant surface which acts as a capacity plate parallel to the earth and connected therewith by a vertical cylindrical conductor represented by the stem or trunk of the tree.

When a telephone was connected to a tree 18 inches in diameter, between points in its circumference at the same level above the surface of the earth, and parallel to the wire, no effects were produced in the instrument, but the effects obtained in a vertical line along the trunk of the tree increased in general with the distance between the electrodes. It appears, therefore, that although the stem of the tree is normal to the power line, the general leaf surface spreads out horizontally and receives electrostatic charges from the alternating current in the line, thereby producing in the trunk of the tree a corresponding alternating current which can be detected in the telephone. Several kinds of trees of various sizes and forms were examined along this power transmission line, and all were found to be singing with a lond voice the fundamental note characteristic of the frequency of the line current. Indeed, the strip of vegetation along this line has been singing in this manner continuously, day and night, for several years, it needing only the electromagnetic ear to make the sound apparent.

The transmission line at the point examined is supported by wooden poles about 45 feet in height, on porcelain insulators especially designed for the high voltages employed. The insulation is so effective that an examination of one of the supporting poles of the line failed to give any indication in the telephone. In fact, the dead vegetable matter, when thoroughly dry and free from sap, formed an efficient insulator for electrical oscillations.

In the course of the experiments and tests mentioned, Major Squier found difficulty in obtaining accurate results in measuring the resistance of trees by means of a Wheatstone bridge, due, as he assumed, to the unbalancing of the bridge by the electromotive forces of the tree itself. To determine to what extent these electromotive forces existed a millivolt-meter was placed in circuit between two nails driven 25 feet apart into a growing tree. The resistance of the tree between these terminals was ascertained to be about 6150 ohms.

The tests were made half hourly for 24 hours, and indicated electromotive forces in the tree of from .00002 to .00004 of a volt. The upper contact was positive to the lower contact. These results were not at all uniform, as from 9 P. M. until 6:30 A. M. the electromotive force was too small to affect the instrument; the principal changes occurred between 6:30 P. M. and 9 P. M., with another rise between 1:30 P. M. and 4 P. M. In other tests, the readings between electrodes a short distance apart indicated as much as 8 millivolts, and at times the terminal at the base was positive instead of negative.

In a section of the report devoted to floral spectra, some details are given of the effects of electrical discharges upon house plants when the latter are used as the electrodes of ordinary powerful induction coils. Two growing plants were connected with the secondary terminals of such an induction coil by sticking the bared ends of the wire into the earth in the pots, one terminal in each pot, close together.

FIG. 4.—DETAILS OF FIELD WIRELESS TELEGRAPH RECEIVER, FORT NASON, CALIFORNIA

Placing the jars in a darkened room and then separating them while the coil was excited, caused the brush discharge effect to outline the edges of the various leaves and present a beautiful appearance; all the points and edges of the leaves were traced in streamlets of purple and lavender discharges. As the jars were moved nearer together, the usual disruptive spark followed, and at a distance so nearly equal to the regular sparking distance between metal electrodes that the living leaves of the plants may be said to behave electri-

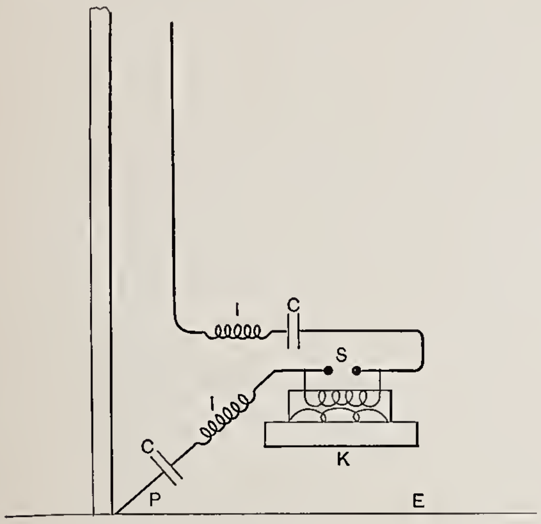


FIG. 5

cally, for these highly oscillating currents, as though they were sheets of metal having the shapes and dimensions of the leaves themselves. Upon closing the primary circuit of the coil, a decided movement of the leaves and stems of each electrode was observed. When the discharge was a powerful one and the plant surface small, the leaves between which the disruptive discharge took place seemed to dry up and die within a day or two, whereas other stems of the same electrode, on the side away from the disruptive discharge, seemingly remained unaffected.

In closing his report, Major Squier dwells upon the possibility that, if as indicated by the experiments which he has detailed, the earth's surface is already generously provided with efficient antennæ, a large class of information, such as meteorological reports, crop reports and general news items of interest to all, may in time be sent from central points and be received at many places within the radius of influence of the signal station, and this, too, by means of the simplest forms of apparatus. Finally, the author asks, in view of the fact that the physical method of studying science is proving to be the true one, has not the time arrived for a more systematic study of physical botany in the light of the new electric theory of matter?

The largest water turbine ever built is that now being installed by the I. P. Morris Company, of Philadelphia, in the power house of the Shawinigan Water & Power Company, on the St. Maurice River, in Canada. It is of 10,500 H. P., and is 30 feet from base to top. The intake is 10 feet in diameter.

Long Spans for Electric Wires

WITH the periodically recurring discussions of tower construction and long wire spans for electric transmission lines, it may be interesting to recall the fact that it was frequently necessary in the early days of telegraphy, and before the advent of submarine cables, to employ long spans of wire to cross rivers and bays. For example, there were several spans of wire over 2000 feet long across the Elba and other rivers in Continental Europe, and prior to 1847 the Hudson River, in the United States, was spanned by a number of wires from Fort Lee to Washington Heights, which was then 10 miles out of New York City, but is now several miles within the city limits. At that point the river is 2700 feet wide, and it was the custom to lower the wires into the water to permit ships to pass, for which purpose men were stationed at the crossing. The Mississippi River also was spanned in this way in several places, and at one point where the river was 3720 feet wide, the wires, No. 16 hard-drawn iron, were supported on masts 307 feet in height.

Among much more recent instances of the employment of long spans of wire for electrical purposes across bodies of water; where, for example, the nature of the bottom or the prevalence of rapids currents and ice make it impracticable to maintain cables, or where, in other cases, the electric pressure on the circuit is greater than can safely be carried in a cable in the present state of the art, are a telephone cable 3200 feet in length, with ten pairs of conductors, suspended from poles 270 feet high, across the Susquehanna River, in Pennsylvania; and the span across Carquinez Straits, in California, where the four heavy conductors of a power transmission line carrying current at a pressure of 60,000 volts are strung from iron towers 225 feet in height and 4427 feet apart.

A curious development of cinematography is to be undertaken by a London firm. According to the "Scientific American," the North German Lloyd Steamship Company have made arrangements for a complete bioscope record of every phase of life, both recreation and work, upon a transatlantic liner. The vessel "Kaiser Wilhelm II." has been selected for the purpose. One of the most difficult phases of the work will be the photographing of the operations in the engine room and stokeholds, owing to the indifferent lighting facilities. For the illumination purposes, however, special electric arc lamps of high candle-power will be installed for the occasion, while a special lens, the largest and most powerful that has ever been designated for cinematograph work, will be employed.

Annual Banquet of the American Institute of Electrical Engineers

THE annual banquet of the American Institute of Electrical Engineers was held on the evening of February 8, at the Waldorf-Astoria Hotel, New York.

In view of the recent opening of the Subway, thus adding underground traction in New York to the domain of electricity; the adoption of electric locomotives for their great Manhattan terminal divisions by the New York Central and Pennsylvania Railroads; the equipment of the Long Island Railroad with electricity, and other kindred events, the Banquet Committee had decided to devote this dinner to signalizing the triumph of Electric Traction.

A number of pioneers and leaders were present; an original menu had been designed; and some novel features were introduced,—biograph views of happenings in the works of the Westinghouse Company, of the running of electric trains on the viaduct portion of the New York interborough rapid transit system, and of the electric locomotive trials on the line of the New York Central Railroad near Schenectady. The reproductions were excellent and were correspondingly appreciated.

The speakers of the evening were John W. Lieb, Jr., who, as president of the Institute made the opening remarks; Frank J. Sprague, whose topic was "The Art and the Men;" Leo Daft, who discoursed on "These Twenty Years;" H. H. Vreeland, who explained the mysteries of "The Broomstick Train;" L. B. Stillwell, who told of "Traction Above Ground and Under;" and Brigadier-General A. W. Greely, chief signal officer of the United States Army, who dealt with "Other Uses of Electricity."

T. C. Martin officiated as toastmaster in his usual happy manner.

In Indiana there are about 800 miles of interurban electric railways, operating 100 cars regularly. Twenty-four power stations furnish current to these, the combined capacity being slightly more than 20,000 K. W. Twelve generate direct current, and twelve alternating current. Returns from 85 per cent. of the total show an average of 5,845,450 K. W.-hours per month at a cost of 0.755 cent. The average load factor is about 40 per cent.

Annual Convention of the Crocker-Wheeler Company Officers and Managers

THE annual convention of the officers and branch managers of the Crocker-Wheeler Company took place at the main office and works at Ampere, N. J., on January 26, 27 and 28. Managers and representatives from all parts of the country were in attendance, and during the various sessions many lively discussions took place. The feeling of good-fellowship for which the company has been remarkable, was clearly demonstrated at these meetings, where the selling force had an opportunity to come into personal contact with the administrating and engineering departments of the business.

Alternating-current design and construction was, of course, the leading topic of discussion. The company has only recently entered the alternating-current field, and this was the first opportunity for many of the branch managers to talk over alternating-current problems with the members of the engineering department.

Chief Engineer Gano S. Dunn gave a lecture on this subject, and Edward Heitmann and H. Pikler, of the engineering department, also talked to the assemblage. Messrs. Dunn and Heitmann informally told the selling men of their experiences in San Francisco, where the company recently closed an order with the California Gas & Electric Corporation for three 4000-K. W. alternating - current generators,—the largest gas-engine-driven generators in the world, previously noted in these pages.

The field-weakening motor, which has just been put on the market by the Crocker-Wheeler Company, also came in for thorough discussion, especially on the part of the branch office managers whose territory lies in that part of the country where machine-tool builders are most numerous. This new motor is particularly well adapted to the requirements of machine tools.

Prof. F. B. Crocker, head of the electrical engineering department at Columbia University, New York, attended the sessions of the convention and contributed his academic knowledge to the various discussions.

A banquet was given by the company to the branch managers and department heads on the evening of January 27, at the Café Martin, in New York. Dr. Schuyler Skaats Wheeler, president of the company, presided.

Every man present responded briefly to the call of the toastmaster, Secretary Arthur L. Doremus, and all expressed the belief that heavy business is in store during the coming year.

The speech of the evening, however, was the brief one by August Hartmann, shop superintendent, who has been with the company for 17 years, and who worked at the bench for Dr. Wheeler before the company was formed. He said:—

"When I look around and see all you gentlemen here, it makes me think of the time when there was Dr. Wheeler and only myself. [Protracted applause.] All I can say to you branch managers is,—you send in all the orders you can; we'll take care of them." [Cheers.]

1. Henry J. Sage.
2. W. L. Brownell (Treas.)
3. H. L. Patteson.
4. A. L. Doremus (Sec'y).
5. Dr. Schuyler Skaats Wheeler (President).
6. Gano S. Dunn (Vice-President).
7. Julian Roe.
8. J. R. Wilson.
9. Rodman Gilder.
10. H. C. Baker.
11. H. C. Petty.
12. S. Russell, Jr.
13. Harold Lomas.
14. F. B. Degress.
15. Leonard S. Horner.
16. Louis M. Ward.
17. Wm. F. Sullivan.
18. E. Heitman.
19. R. B. Treat.
20. W. A. Doble.
21. H. A. Brown.
22. R. N. C. Barnes.
23. H. S. Pikler.
24. C. W. Gearhart.
25. H. M. Gassman.

CROCKER-WHEELER COMPANY OFFICERS AND MANAGERS

Preservative Treatment of Telegraph and Telephone Poles

IN co-operation with the American Telephone & Telegraph Company, and more recently with the Postal Telegraph-Cable Company, the Bureau of Forestry, during the past two years, has been making an experimental study of preservative treatment to increase the life of telegraph and telephone poles.

That part of a pole which is most subject to decay extends about 6 or 8 inches above and below the surface of the ground. Decay begins at the ground line and extends both ways, being limited by the extent of conditions favoring it. Thus, a few inches below ground, the necessary oxygen and heat are lacking, and above ground moisture is lacking. The begining of decay depends, in most part, on the climate and the soil, being most rapid where the former is hot and moist.

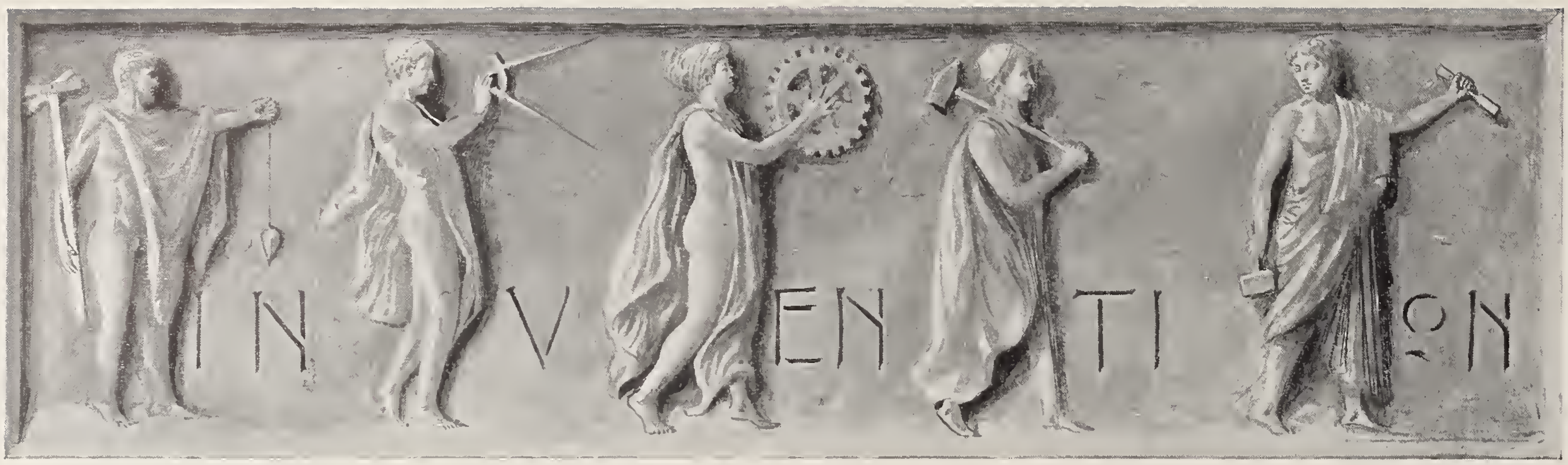
To make a pole last as long as possible under these conditions, a careful selection of available woods was necessary and of these chestnut and white cedar have been found superior to others. The life of the former, however, is only from 12 to 15 years, and of the latter, 10 to 12 years. Recourse to preservative treatments was then had, and it is the object of the Bureau of Forestry to determine the best of these.

Experiments have already produced materially successful results. The wood is impregnated with antiseptics which prevent the growth of the fungi causing decay. Methods of impregnating the whole pole have formerly been tried, the poles being placed in long cylinders and subjected first to steam pressure, and afterward to creosote under pressure, but in the present experiments only 8 feet of the pole is to be treated. The creosote method is to be used, and dead oil of coal tar will be forced through the butt of the pole.

In thus preventing decay, the necessity of having a pole of large diameter, to allow for decay, will be avoided and smaller trees may be used where larger ones are now necessary. Cross-arms are also coming in for their share of attention in this work.

The Postmaster-General of Great Britain has made provisional arrangements with the Marconi Company for the prepayment at telegraph offices of telegrams for the transmission from wireless telegraph stations on the coast to ships at sea. The charges are 13 cents a word, and $1.72 as a minimum for a telegram.

CROCKER-WHEELER COMPANY OFFICERS AND MANAGERS PHOTOGRAPHED AT THE COMPANY'S RECENT ANNUAL CONVENTION. SEE KEY ON OPPOSITE PAGE



Electrical and Mechanical Progress

Electrification on the Grand Trunk Railway

IT is reported that the Grand Trunk Railway is to electrify that portion of its line through the tunnel between Sarnia, Ont., and Port Huron, Mich. The plans provide for the third-rail system in the tunnel and overhead wires on the approaches, and for a power plant on the St. Clair River directly over the tunnel.

It is stated that the proposed change will necessitate an expenditure of between $300,000 and $400,000. This move is made, probably due to the fact that several lives were recently lost in the tunnel owing to suffocation by coal gas from the locomotive of a stalled train.

A New Generating Set

A NEW generating set, built by the B. F. Sturtevant Company, of Boston, Mass., is shown in the annexed illustration.

The general design of the engine embodies several improvements. The reciprocating parts are counterbalanced with discs loaded with lead and the crankshaft is forged in one piece with the discs shrunk on it. A special arrangement of the Rites governor is designed to give a regulation within 1 to 1½ per cent. from full load to no load, and by a modification of the Marshall valve gear an adjustment of the cut-off from zero to 70 per cent. is attained. The main bearings, crankpins, valve stem and slides are well babbitted with the Sturtevant white metal.

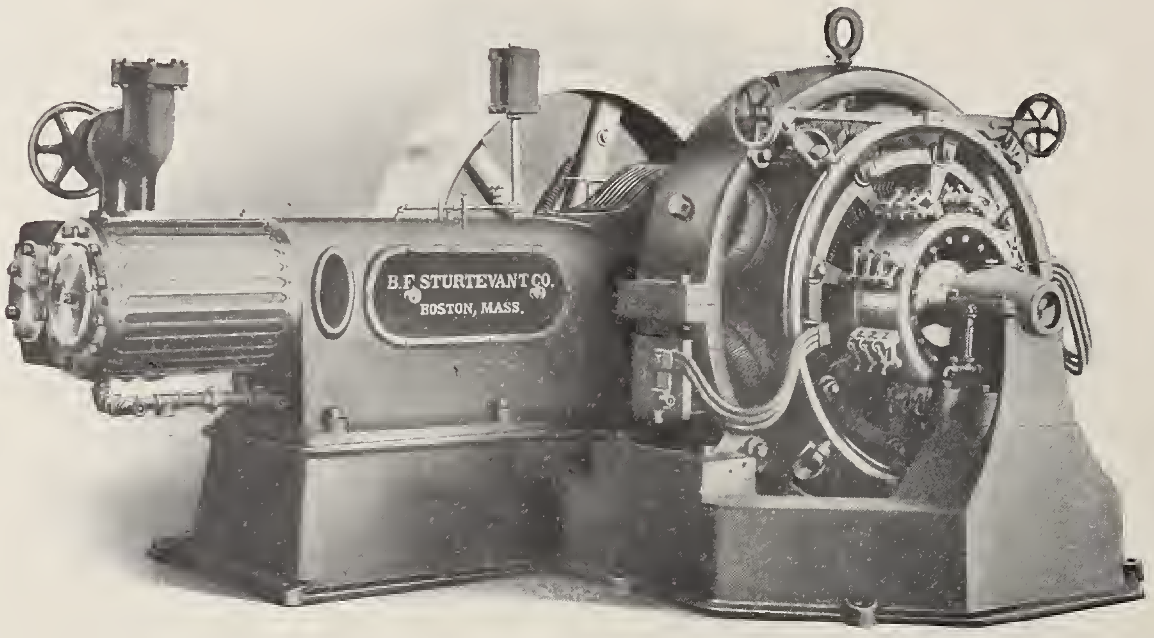
A recent improvement is a watershed partition to prevent water from the piston rod stuffing box reaching the interior of the engine frame, and the oil on the reciprocating parts being thrown out into the engine room. The main body of the engine is enclosed on both sides by removable plates, and the crank webs are enclosed by a cast-iron hood having two holes with removable covers, one for cleaning the crankpin box while the engine is in motion and the other for removing the box without taking off the large hood. Between the watershed partition and the front end of the cylinder is a handhole for reaching the stuffing-box bolts.

Two oiling systems are provided, the gravity or tank system and that by a pump. With the gravity or tank system, shown in the illustration, an oil tank supplies the pipe leading to the parts to be oiled. At each point where the oil is delivered is a little gauge, glass and valve for regulating the flow. A valve just below the tank regulates the entire oiling system.

With the forced lubricating system, a pump is located in the base of the engine and is operated by the crankshaft. Oil is delivered from this pump to the main bearings, and from these through holes in the crankshaft and web to the crankpin. From this point the oil is conducted up through a hole in the connecting rod to the crosshead pin. A separate set of pipes conveys the oil from the crosshead guides to the valve stem guides. The pressure of oil in the bearings under this system will vary from 12 to 13 pounds per square inch.

The generator is of the eight-pole type and is capable of carrying momentary over-loads of 50 per cent. and an over-load of 25 per cent. for a period of two hours without undue heating.

The field frame is the best grade of cast iron, split horizontally. The pole



A NEW GENERATING SET BUILT BY THE B. F. STURTEVANT CO., BOSTON, MASS.

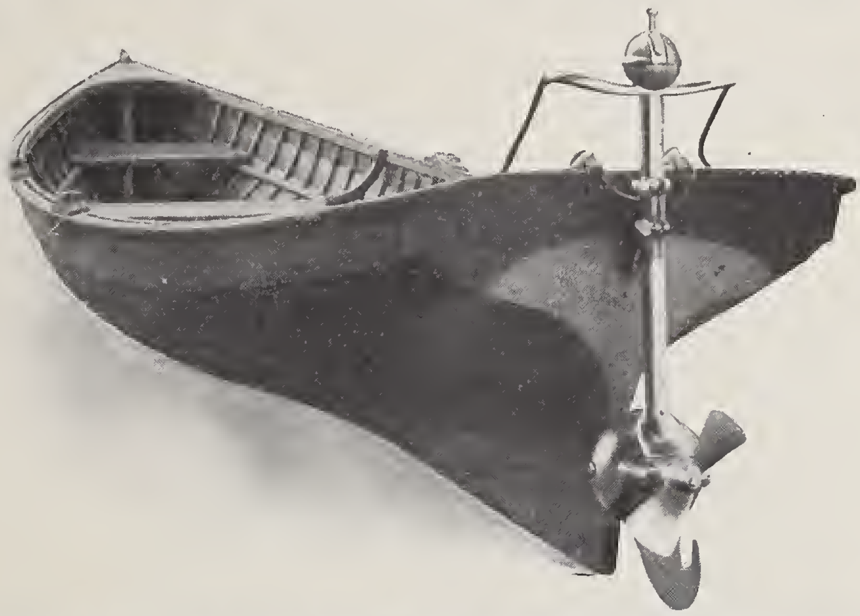
pieces are of wrought iron with cast-iron shoes or horns, and are secured to the magnet frame by through bolts. Any of the pole pieces may thus be removed to repair the field coils. The latter are wound in two sections, with an air space between the shunt and series coils. The shunt winding is of double cotton-covered magnet wire, thoroughly insulated and so treated as to be practically waterproof. The series winding is of solid copper bars, insulated in the same manner as the shunt coil.

The armature is of the ironclad, form wound, ventilated drum type, having a core built up of charcoal iron plates, which, after being thoroughly japanned, are mounted on a cast-iron spider and securely held in position by end flanges. No bolts pass through the armature laminations. The armature spider has an extension upon which the commutator is mounted.

The armature conductors are solid copper bars, without joints, except at the commutator end. When these bars are formed they are insulated by material not perceptibly affected by heat or ordinary atmospheric moisture.

In the construction of the commutator, only drop-forged or drawn segments are used, these being secured in a cast-iron shell of spider form and clamped in place with a steel ring. No cast segments are used. The segments are insulated with the best quality of mica, of a degree of hardness to allow the mica and segments to wear uniformly. The end insulation consists of micanite rings, and the whole commutator is assembled while hot, under great pressure. Carbon brushes only are used, the commutator being so proportioned and the brushes of such size as to allow at least 1 square inch of brush area to every 30 amperes carried. These brushes are carried in holders, each mounted on a self-contained brush rigging so arranged that the entire set of brushes may be rotated completly around the commutator.

Hand wheels are furnished for adjusting the brushes in position, these hand wheels being so located that the brushes may be adjusted from either side of the generator.



A SUBMERGED MOTOR FOR PROPELLER SERVICE, MADE BY THE SUBMERGED ELECTRIC MOTOR COMPANY, MENOMONIE, WIS.

Electric Motors Working Under Water

AFTER the South African war, when the water had been pumped out of the mines in that country, a number of the dynamo machines that had been used in the mines and which had been submerged for over a year were brought to the surface. It was at first thought that these generators were injured beyond repair; but, much to the surprise of all concerned, after the machines had been thoroughly dried out by heat it was found that they were as efficient as before the flooding of the mines. Perhaps this result would not have been so astonishing if it had been known to the persons interested that for some years a small motor used in electric launches has been operated successfully under and in the water. In this instance the propeller is mounted directly on the shaft of the motor, which is enclosed in a spherical steel or brass case. There is no stuffing box to prevent the entrance of water into the case. On the contrary, small holes are made in the case to admit the water around the bearings and the armature. The result is that the friction of the ordinary stuffing box is dispensed with, and, furthermore, the water lubricates and cools the motor, so that a higher efficiency and greater durability are obtained. When the motor is employed in salt water, the electrical conductivity of which is much higher than that of fresh water, the motor is contained in a nearly water-tight case, the shaft passing through a bushed bearing. To prevent any leakage of salt water into the case, the latter is filled with fresh water through a suitable opening, and is renewed as often as necessary, say every three or four days. The propeller and motor, together with a rudder, are supported by an upright post bracketed to the boat that takes the place of the usual rudder post. Consequently, the propeller also assists in the steering. The annexed illustration explains the arrangement. Whether these experiences contain the germ of a suggestion for the operation of more powerful, especially high-tension, dynamos in insulating liquids remains to be seen; but for the purpose to which the idea has thus far been utilized it has been found very satisfactory in practice.

Transformer Outfits for Thawing Pipes

THE manifest superiority of electricity as a thermal agent in thawing frozen pipes, and the field for this service that awaits development has attracted considerable attention on the part of central station managers, many of whom have improvised outfits for this purpose. A general demand has arisen for thawing outfits that shall have a range in capacity to cover all ordinary requirements, and that shall be portable, easy to connect and moderate in price, and to meet this demand the Westinghouse Electric & Manufacturing Company has designed two transformers, one of which is shown opposite.

The larger of the two outfits weighs complete, with transformer, switchboard and base, 750 pounds. It occupies a floor space 2 feet 4 inches by 1 foot 10 inches, and is 1 foot 7 inches in height. A link in the top of the transformer case affords a means of lifting the outfit, and, if desired, truck wheels may be attached to the wooden base.

The transformer may be operated satisfactorily on circuits varying from 1800 to 2500 volts. The low tension is arranged to deliver approximately 500 amperes for several hours at an electromotive force from 15 to 50 volts. By a simple change in connections, the windings may be arranged to deliver about 1000 amperes at voltages from 8 to 16 for thawing large mains whose resistance is generally low. It is suitable for thawing anything from a ½-inch pipe to a 1-foot main.

The transformer is generously designed, and will deliver large overloads for short periods of time. The windings are air-cooled. The insulation is not injured by rain, snow or ordinary abrasion.

A light, but substantial, switchboard is mounted upon the high-tension end of the transformer. The switches are of the enclosed plug type, such as are used upon high-tension arc light circuits, and permit a variation of the low-tension voltage, and consequently the current supplied to the pipes. The switches are so arranged that it is impossible to make a wrong connection.

The smaller transformer outfit is particularly adapted for thawing service piping about dwelling houses. It is light, of such proportions as to make it easy to handle, and is mounted in a wooden box provided with a handle and shoulder strap. It has a capacity of 200 amperes at potentials up to 25 volts for one hour. It is arranged for operation on a normal 2000-volt circuit, but can be supplied for any other primary voltage to as low as 200 volts. The voltage regulation and current control are obtained through plug switches in the high-tension circuit.

When desired, these outfits are furnished with a current measuring device, so that the operator may know the amount of current that is being used.

The Stanley Rotated Jewel Bearing Wattmeter

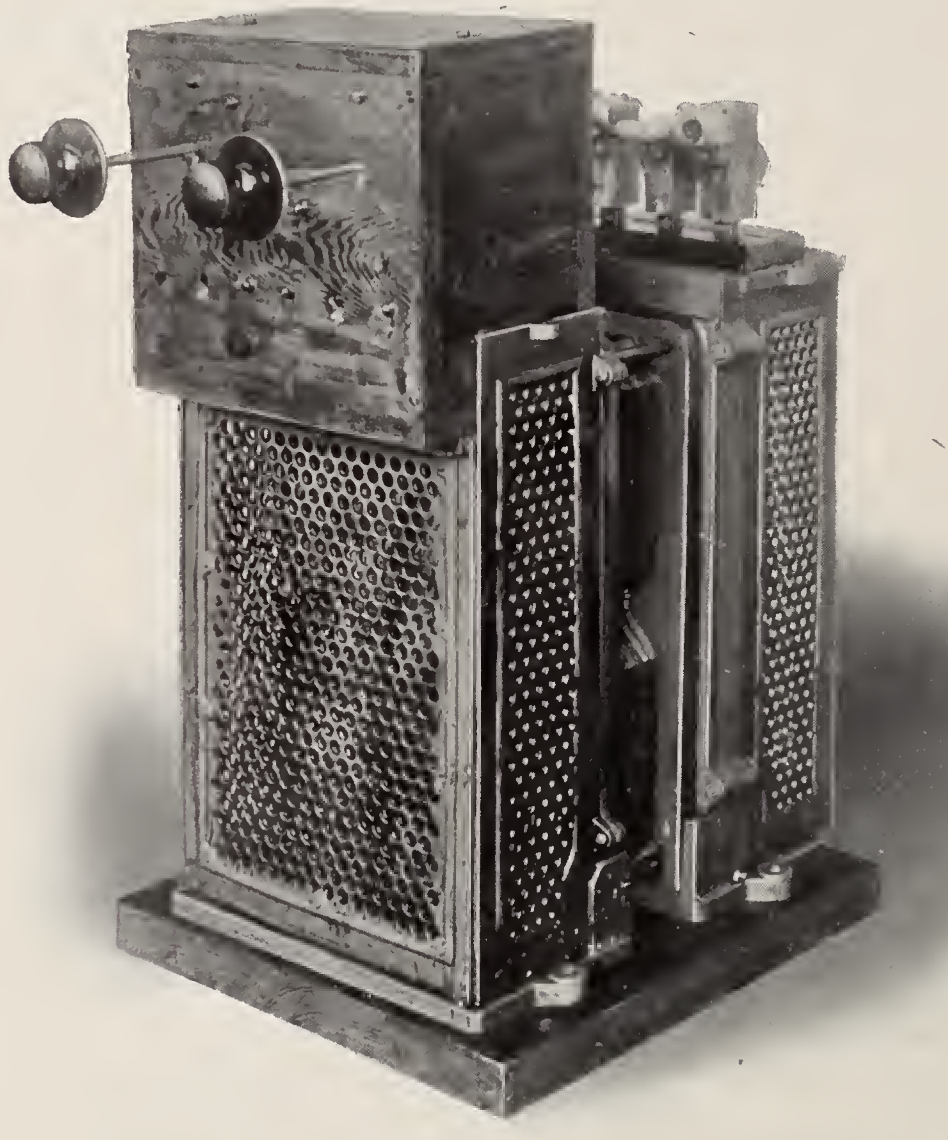
A NEW recording wattmeter for alternating current circuits, which contains many very novel and remarkable features has been placed upon the market by the Stanley Instrument Company, Great Barrington, Mass. The principal characteristic of the meter is that the jewel bearing upon which the disc shaft pivot rests and turns is itself turned or rotated by the train gearing, so that a new jewel surface is constantly and automatically placed under the disc shaft pivot whenever the disc moves.

The meter derives its name of rotated bearing wattmeter from this distinctive device, the details of which are illustrated on the next page. The jewel carrier shaft is connected with the train gearing by a bevel gear; whenever the train moves the jewel-bearing shaft must also move. The turning of the jewel bearing is a positive action operated by the system of gears constituting the train registering mechanism. At every movement, no matter how slight, of the train gearing, a new spot of highly polished jewel surface is automatically brought under the disc shaft pivot. Consequently during each and every portion of a revolution of the pivot a new jewel bearing is automatically supplied.

The gear in the train registering mechanism which rotates the jewel-bearing shaft is so arranged that the disc shaft pivot can be in contact with the same spot or point of the jewel surface only once during approximately 1,800,000 revolutions of the disc shaft pivot,—the equivalent of 1000 K. W.-hours. For example, in a 10-ampere, 110-volt meter the disc will make 1,800,000 revolutions while the jewel bearing makes one revolution; and the train will register 1000 K. W.-hours.

At the rate of ten cents per K. W.-hour, the dial registration would indicate an earning of $100. During such earning the meter will have been automatically and positively supplied with new polished jewel surface bearings to the equivalent of approximately 1,800,000 new jewels. In all other jewel-bearing meters the disc shaft pivot is constantly in contact with the same spot or point, or spots or points, of the jewel surface.

It is well known that the inaccuracy of stationary jewel bearing meters increases very rapidly after the polished surface of the jewel bearing has become abraded by the constant friction of the end of the disc shaft pivot upon the same spot or spots of the jewel surface. It is well known also that once the polished surface has been damaged, the increase of friction goes on with extreme rapidity; the material of the jewel assisting in the more rapid cutting of its surface; jewel workers employ, for instance, jewel dust to do the work of cutting jewels.

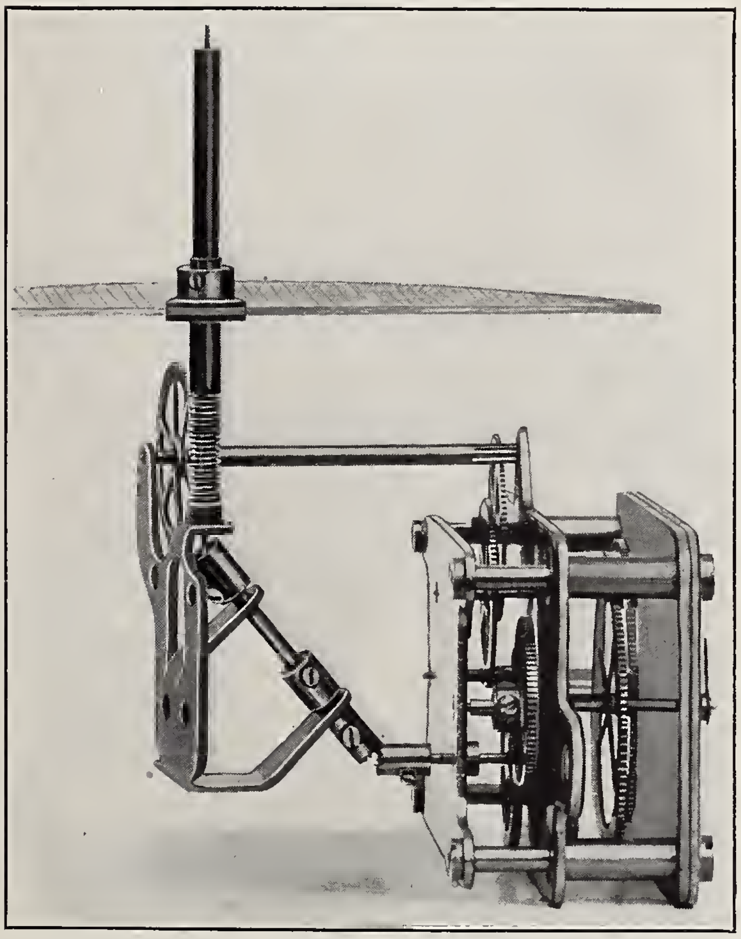


A 2500-50-VOLT TRANSFORMER FOR USE IN THAWING OUT FROZEN WATER PIPES BY ELECTRICITY. MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., PITTSBURG

Under the continuous contact of rotation and hammering of the meter pivot upon the same spot, the life of a polished jewel surface is very limited and is variable, dependent upon the hardness of the jewel and the fineness of its polish as well as on the design and construction of the meter; some meters lose accuracy because of jewel friction much more quickly than others; but it is a matter of some period, more or less extended, when the surface of a jewel in any stationary bearing meter must become roughened by the constant wear of the pivot end both from rotation and hammering.

In the rotated bearing meter the effect on the jewel by change of point of contact with the disc shaft pivot end is to improve the jewel surface constantly because the movement of the pivot along the surface continues the polishing of the jewel,—a directly opposite effect to that produced on the stationary jewel by the constant hammer and drilling contact on the same spot of the pivot end. At the end of many revolutions of the jewel bearing in the rotated bearing wattmeter, the surface is more highly polished than at the beginning of its use.

In the Stanley rotated bearing wattmeter the jewel is so shaped that the disc shaft is maintained in exact perpendicular alignment when the meter is connected up in service. No effect upon the disc shaft from side thrust is thus possible. The jewel is cup-shaped and the jewel supporting shaft is at an angle of about 45 degrees to the vertical disc shaft. This places the jewel in an oblique position under the pivot, and the pivot is thereby brought in contact with the junction between the sides and bottom of the cup, this junction being shaped in the proper curve. The jewel carrier is a separate piece on the upper end of the rotatable bearing shaft and can be quickly and easily removed and replaced by anyone, a skilled mechanic and special tools not being required.



A ROTATED JEWEL-BEARING WATTMETER, MADE BY THE STANLEY INSTRUMENT CO., GREAT BARRINGTON, MASS.

The new wattmeter retains many of the characteristic features of the very popular Stanley meters of previous manufacture. It is about the same size and of the same general appearance as the Stanley Model "H" wattmeter, and retains the balanced thrust principle whereby is obviated the vibration of the disc by the alternating current fluxes.

Without balancing of the thrusts the vibrations caused by the alternating current are transmitted from the disc down the shaft to the end of the pivot, producing a continuous hammering of the pivot upon the jewel, which very rapidly drills or quarries the jewel of unbalanced thrust, stationary bearing meters.

In addition to the elimination of hammering by the balanced thrust construction the new meter is provided against the effects of vibration by having its disc shaft pivot supported by a long spring contained within the disc shaft, which, for the purpose of containing the spring, is a tube or hollow bore for a large proportion of its length.

The upper end of the spring is in contact with the upper end of the hollow bore, the lower end being in contact with the head of the pivot. All the weight of the disc and its shaft rests upon the spring, which is of sufficient length to make it impossible for any vibration to be transmitted from the disc to the pivot end. The spring removes from the pivot all vibration whether of service, transformation, handling or of the premises. The meter is shipped ready for connection into service, no clamping or adjustment of staff of pivot end being required for transportation or handling.

The spring support of pivot and disc shaft is so arranged that when the meter is in any position, except when connected for service, the pivot end is held firmly to the bearing and cannot be jarred away or separated from it. When set up in position for service, the disc floats smoothly and freely on its bearing. The pivot end can be taken off and put on again, or replaced by another, within a very few moments, no skilled mechanic or special tools being required.

With vibration and hammer effect removed from the pivot end by the pivot spring support supplementing the balanced thrust construction, and with all possibility of friction wear on the jewel removed by the rotated bearing, it becomes permissible to use a heavier disc and thereby obtain a higher torque and its benefits without any of the disadvantages and injuries produced by high torque in other methods of construction.

In the new meter the disc is 0.035 of an inch thick, and 5 inches in diameter, and the torque obtained is 50 millimeter-grammes; the ratio of torque to weight is 10 to 7. It is, therefore, possible to obtain easily great accuracy on very small loads as well as with very heavy loads.

At whatever degree of accuracy the new meter is calibrated, there it will remain unchanged by increase of friction wear throughout an extremely great number of years of unknown and undefinable extent.

For example: A rotated bearing wattmeter of 10-ampere, 110-volt capacity has been in circuit constantly, day and night, during more than eight months. It has been operated during all that period without any brake magnet, the disc and its shaft rotating, consequently, at the very high rate of speed of about 660 revolutions per minute. During that period and under those conditions the disc and its shaft pivot have revolved upon the rotated jewel bearing more than 150,000,000 times, registering the equivalent of 120,000 K. W.-hours, representing a revenue earning at the rate of 10 cents per K. W.-hour of $12,000. If it be assumed that each of the twenty lamps, representing the full-load capacity of a 10-ampere meter, earns $2 per lamp, or $40 per meter per annum, the above earning of $12,000 represents a period of service of 300 years.

At the end of that service, and durevery week of the period, it was impossible to discover the slightest change in accuracy on any load from 25 watts up to 50 per cent. overload.

It is suggested by the manufacturers that these meters be tested by the purchasers for frictional conditions in the following very severe method. Before beginning the special test, ascertain the accuracy of the meter upon any desired load at stipulated rate of disc rotation; or determine the light-load accuracy by comparing the full-load rate of disc rotation with the light-load rate, which will denote the initial internal friction (if any) in the meters; then remove the brake magnet and let the disc spin round under full load for an hour, or a day, or a week; then replace the brake magnet and without change of pivot end or jewel, test the meter again in the same manner to ascertain the difference (if any) between rate of disc rotation at light load or at full load, or even 50 per cent. overload. No change in accuracy due to frictional conditions will, it is claimed, be perceptible.

Every meter man can make such a test; every meter man can take any one of these meters to pieces if he wishes and can reassemble it as easily and as well almost as the most expert meter maker. Another new and valuable feature of the meter is that it can be adjusted quickly and easily by any meter man for any frequency from 40 cycles to 133 cycles. This is accomplished by the magnetic shunt or bridge principle constituting an important part of the construction of all Stanley meters. The adjustment is of the simplest character, being merely the sliding of a contact on a small rheostat conveniently accessible; the change in resistance of the rheostat changes the reluctance of the magnetic circuit and thereby adapts the shunt system to alternating current of different periodicities.

The meter is made with two terminals, one at the bottom, the other at the top, for connection through the meter of the two wires of a 2-wire circuit, or of the two outside wires of a 3-wire circuit, the shunt connection being provided within the meter.

Where it may not be convenient or desired to take both wires of a circuit through the meter, a shunt connection from one wire can be made with the upper terminal connection. Another characteristic and valuable feature of the meter is the complete magnetic shield separating the shunt and current elements from the brake magnet system. This shield is the diaphragm or iron plate comprising the entire top of the front of the case. Between this cast-iron front plate and the back plate of the case are contained the shunt and current coils which are thus completely enclosed in an iron box. The brake magnet and brake adjusting screws, the disc shaft and the train system are mounted on the side of the shield plate opposite from the coils.

The excessively strong fields which necessarily result from short circuits from lighting, or from abnormal voltage, or current overloads of any kind, are confined within the iron box, and the brake magnet system is thus effectively shielded against the influence of these powerful fields.

The cover of the meter is all glass, in one piece, or of metal with glass windows, as may be desired. The method of fastening the cover to the case is patented, and consists of a sealing band or ring which not only forms part of the means of connecting the case cover, but also completely covers the joint between them.

The cover can be held to the case through the medium of the encircling band by the sealing wire which passes through a hole at one side of the band down along the side of the case, across behind the back of the meter, thence up the opposite side of the case to a hole in the other side of the band. Besides fastening the cover to the case, this wire is a perfect and easily made sealing of the moving parts of the meter while permitting ready access to the terminal boxes to make connections to the circuit wires. The cover is additionally held to the case, through the medium of the sealing band, by the covers of the two terminal boxes.

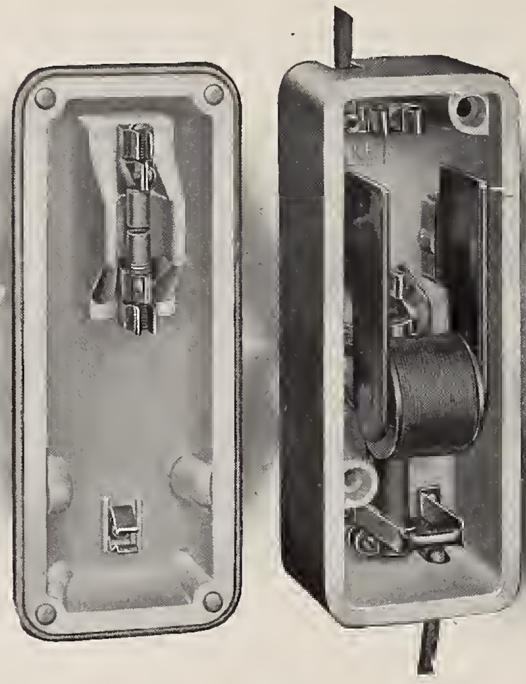
The cover is separately sealed, by wire and lead seal, to and around the case; each terminal box is also separately sealed, by wire and lead seal, through the heads of the screws fastening the terminal box covers to the case. By this method of enclosing and sealing, the meter with the glass cover cannot be tampered with without immediate visual evidence of the interference. The meter can be connected with or disconnected from the circuit in the terminal boxes without removal or unsealing of the cover.

An Improved Lightning Arrester

An improved form of lightning arrester, made by the General Electric Company, of Schenectady, N. Y., is shown in the annexed illustrations. It is suitable for all direct-current systems, whether railway, lighting or power. In railway systems it is installed in the station, on the cars and on poles carrying trolley or feeder lines. It is adapted for direct-current, three-wire lighting or power systems and for direct-current, series-arc circuits of from 2000 to 6000 volts.

The arrester consists of two rounded terminals forming an adjustable spark-gap, a non-inductive resistance and a magnetic blow-out coil, all of which are completely enclosed in a porcelain box. The line connection is made to one side of the spark gap, the other side of which is connected through the non-inductive resistance to ground. The spark-gap terminals are mounted on the underside of the cover of the porcelain box in such a manner as to make them readily accessible for inspection and cleaning.

Any attempt of the direct current to follow a lighting discharge to ground is immediately interrupted at the spark-gap by the action of the magnetic blow-out, the field of which is produced by the passage of the current through the blow-out coil connected in shunt with a portion of the non-inductive resistance.



A LIGHTNING ARRESTER MADE BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

In the porcelain cover is a blow-out chute surrounding the spark-gap and preventing any communication of the arc to other parts of the arrester. For outdoor service the arrester is enclosed in a wooden box.

In connecting the arrester to the ground, cable not smaller than No. 0, B. & S. gauge, should be used, and all sharp bends and inductive loops avoided. The cable should be carefully riveted and soldered to a copper

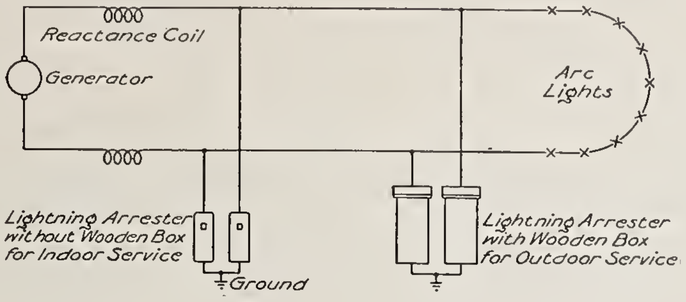
ANOTHER VIEW OF THE LIGHTNING ARRESTER, WITH THE CASE CLOSED plate, 2 feet square, and the joint covered with asphaltum. The plate is then buried in powdered coke in moist earth.

Although the total resistance across the arrester is less than the insulation resistance of the apparatus protected, choke coils should be placed between the point where the arrester is connected to the circuit and the generator or motor to be protected. The ohmic resistance of the coil should be very low, but the reactance considerable, so that it will divert a lightning discharge to the path through the resistance.

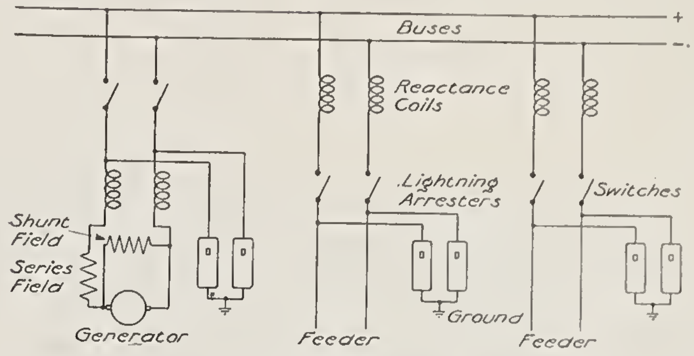
Where the arresters are used with generator panels, the common practice is to coil up 25 feet of the cables so as to obtain two or more turns near together, thus producing the necessary reactance in the circuit. For railway feeder circuits, the company furnishes on feeder panels a choke coil made of coiled rod copper, this being substituted for a connection bar.

A 12-WATT GENERATOR MADE BY THE R. M. CORNWELL CO., SYRACUSE, N. Y.

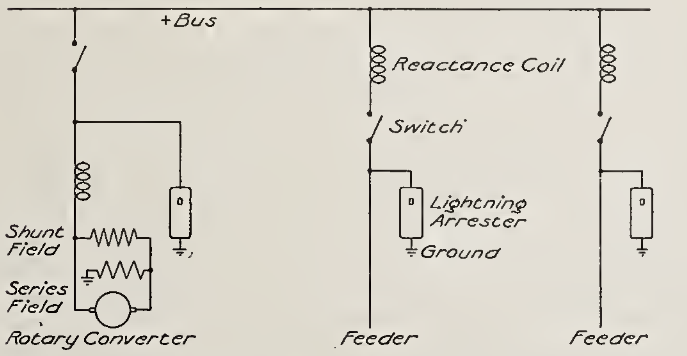
The usual connections of lightning arresters to ground and metallic return circuits are shown in the annexed diagrams. It is recommended that the arresters be isolated from the switchboard.



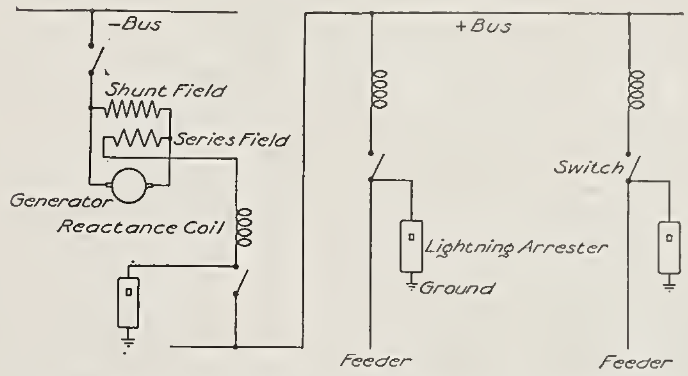
Connections for D. C. Series Arc Lighting Circuit up to 6000 Volts



Connections for D. C. Ungrounded Circuit up to 850 Volts



Connections for D. C. Grounded Return Circuit up to 850 Volts
Machine Equalizing on Negative Side



Connections for D. C. Grounded Return Circuit up to 850 Volts
Machine Equalizing on Positive Side

DIAGRAMS OF CONNECTIONS FOR GENERAL ELECTRIC CO'S. LIGHTNING ARRESTERS

Electricity in Chinese Schools

WRITING under recent date from Hangchau, China, United States Consul G. E. Anderson says: "Several of the larger mission schools in Mangchau and vicinity are considering the equipment of their schools with small electric light and power plants in connection with gasoline engine power. They are doing this both for the sake of the light and for the means such plants would afford for instruction.

"The president of one of the academies has asked me to obtain catalogues for such plants, and I will be glad to use any sent me, both with him and with others. Fifty-light or sixty-light plants will probably be about the size needed. The equipment of one or two schools with such plants will lead to the equipment of others, as a matter of course, but the chief importance of the matter is in the fact that these small plants will be object lessons for Chinese business men and officials of what can easily be done in the cities in commercial light plants.

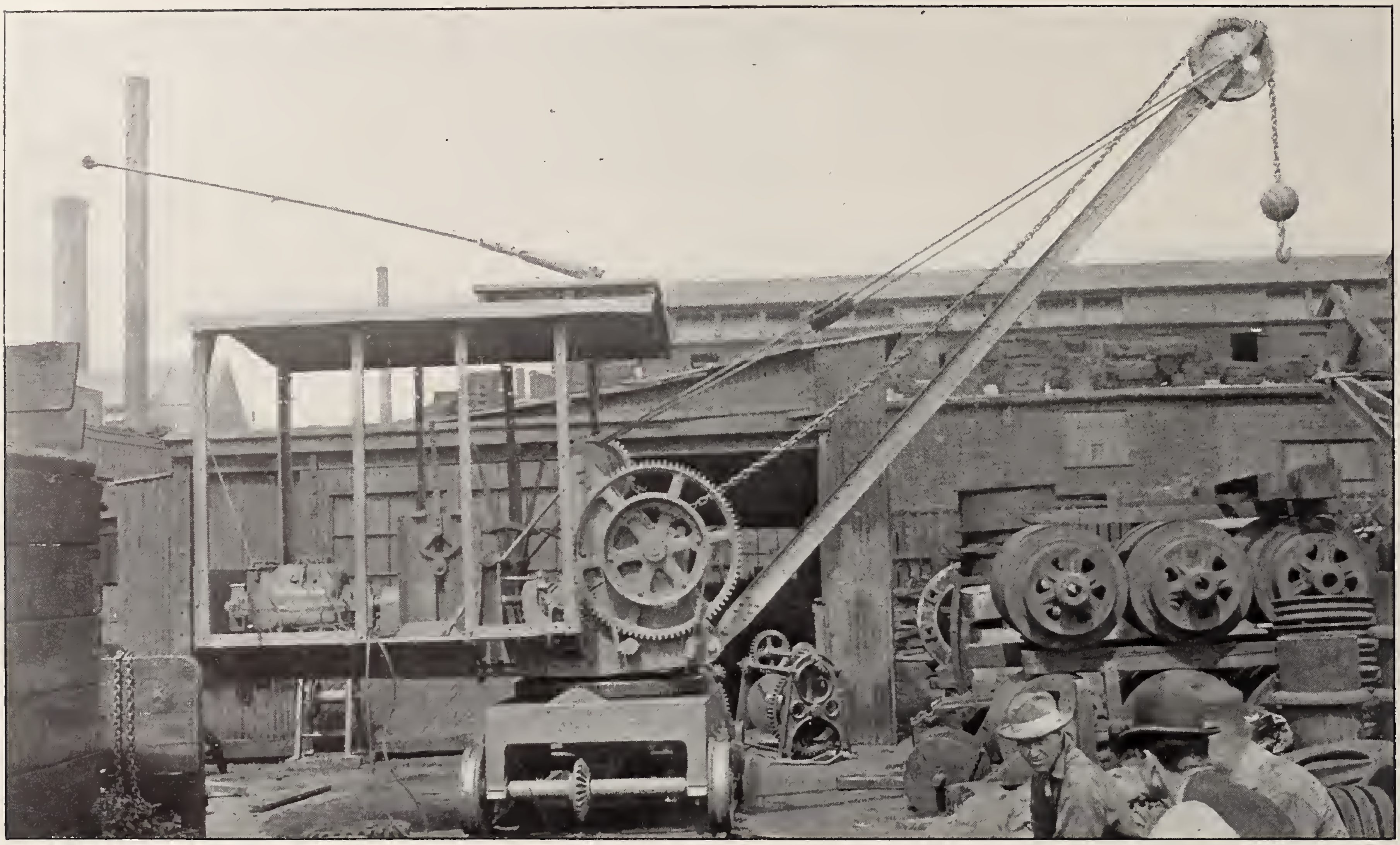
"Several American electric light people are considering schemes for establishment of light plants in cities of this province, but so far, among other hindrances, they have lacked the cordial co-operation of Chinese business men. With a few object lessons at hand this backwardness may be overcome. The development of trade in electrical supplies and machinery in this part of China will probably be very rapid when once it is well started, and the field certainly merits the attention of American business men."

Generators and Motors for Experimental Use

THE annexed illustration shows one of several direct-current generators and motors for experimental use now being placed on the market by the R. M. Cornwell Company, of Syracuse, N. Y. The machines are made in several different sizes up to 1 K. W., and may be wound for use as motors on lighting or battery circuits.

The little illustration on this page represents the smallest generator of its kind on the market. It has an output of 12 watts and may be wound for a number of different voltages. It follows in detail the construction of larger machines, the armature being laminated, the brushes adjustable, the bearings heavy and interchangeable, and the commutator is large and strong.

It is designed for use wherever a



A 3-TON ELECTRIC LOCOMOTIVE CRANE BUILT FOR THE WEST LYNN, MASS., WORKS OF THE GENERAL ELECTRIC CO., SCHENECTADY, BY THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO

small current is desired. It may be also run as a motor, consuming 2 watts at light load, the current being obtained from a battery or lighting circuit. In the latter case the motor is wound in series for 110 volts. All the parts are interchangeable and are made of high-grade material.

An Electric Locomotive Crane

THE simplicity of equipment of an electric locomotive crane, as compared with one operated by steam, is well shown in the annexed illustration of a 3-ton crane built by the Brown Hoisting Machinery Company, of Cleveland, Ohio, for the West Lynn, Mass., works of the General Electric Company, of Schenectady, N. Y.

The crane is equipped with a 35-H. P. motor, which serves for hoisting, traveling, swinging the platform, and raising and lowering the boom. The crane may be equipped with a trolley pole for overhead contact, with a contact shoe for third-rail service, or with leads for connection to the current supply.

The radius of the boom may be varied from a minimum of 10 feet to a maximum of 19 feet. With the minimum radius the hoist from the top of the rails is 15 feet 6 inches, and with the maximum it is 3 feet 9 inches. The truck is mounted on four 20-inch wheels, the wheel base being 5 feet 6 inches.

Alcohol Motors for Small Electric Light Plants

ALCOHOL motors seem to be coming into favor in Cuba, especially for driving small electric lighting and pumping plants. Consul Squiers, at Havana, for example, tells in a recent report that the city of Matanzas, with about 40,000 inhabitants, has installed an alcohol motor pump for its water-works, delivering in the neighborhood of 1,000,000 gallons a day. The motor is spoken of as a 45-H. P. machine, and the fuel cost is given as 40 cents an hour, or $4 a day of 10 hours. Alcohol sells at Matanzas at 10 cents a gallon. The water supply of Havana, we are told, is similarly to be handled by an alcohol motor pump installation, and the contractors who are to put this in are said to have also installed an electric plant alcohol motor of 45 H. P. One of the interesting points about these outfits is that they are of German manufacture. Germany and France, both, have in recent years given much attention to alcohol production and to the means of its utilization industrially, and a relatively advanced state of the art of what might be termed alcohol engineering was, therefore, to be expected in those countries; but there seems to be no good reason why the example thus set should not be followed elsewhere with equally satisfactory results.

The Telephone Situation in Paris

"DURING 1904," says "The Electrical Review," of London, "the dissatisfaction of the Parisian public with regard to the very inefficient telephone service furnished by the French administration of Posts and Telegraphs, took definite form in the organization of an association of telephone subscribers, constituted for the purpose of bringing sufficient pressure to bear on the administration to force it to adopt a reasonable attitude. The French Telegraph Administration acquired the telephone system of Paris in 1889, and since that date the service has gone steadily from bad to worse, until it has now reached such a pitch of inefficiency as to become almost unendurable to the users. The association has set about remedying this state of affairs, and has recently retained Herbert Laws Webb as consulting engineer to report on the general conditions of a modern telephone system, and on the principal causes of the defective service in Paris.

In his report, Mr. Webb points out that the underlying causes of the present bad service and relatively small development are that Paris has retained in use apparatus and methods of working which have been superseded in countries where the science of telephony is in an advanced state. It is hopeless, he says, to expect any great or general improvement in the personnel without a general improvement in the apparatus and methods, because such defective material and methods react upon the nerves, manners and general demeanor of the operators, as well as of the subscribers.

Pilot House Searchlights

SEARCHLIGHT projectors specially designed for pilot house service on steamships, and made by the General Electric Company, of Schenectady, N. Y., are shown in the several accompanying illustrations, the one above representing a searchlight effect obtained on one of the prominent Hudson River steamboats.

Four methods of control are provided for these lights—hand, pilothouse, rope and electric. With the first, the beam of light can be trained vertically or horizontally by means of handles on the sides of the barrel. With the second, the projector is placed on top of the pilot house and a rod extends downward with a lever and quadrant at the end. The projector may be locked at any angle by turning the handle of the lever until it binds against the quadrant.

In the rope control, the handle and quadrant of the pilot-house type are removed, and the rod is fitted with two pulleys, to be connected by means of steel or hemp rope to a controller mounted in the pilot house or other place. A more expensive, but more satisfactory, form of distance control is provided in the fourth method. In this the training is accomplished by two motors mounted in the base and electrically connected to a small controller, which is so wired that the beam of light follows the movement of the handle.

The lamps of these projectors are of the horizontal carbon type. They are entirely automatic, requiring the minimum of attention, and are very quiet in operation.

Neither springs nor gravitation is depended on for the feeding, which is accomplished by a positive screw feed. Each carbon is fed automatically at such a rate as to keep the arc in focus until the carbons are entirely consumed. The positive carbon clamp is adjustable in both planes, so that the carbons may be kept in perfect alignment at all times and burned to the best advantage.

These lamps are designed to run on direct-current, incandescent circuits in series with a resistance, which is necessary for close regulation and to reduce the potential to the voltage required at the arc.

The standard commercial sizes are 9, 13 and 18 inches in diameter, but larger projectors of 24, 30, 36, 48, 60 and 80 inches in diameter are manufactured and can be supplied on special order.

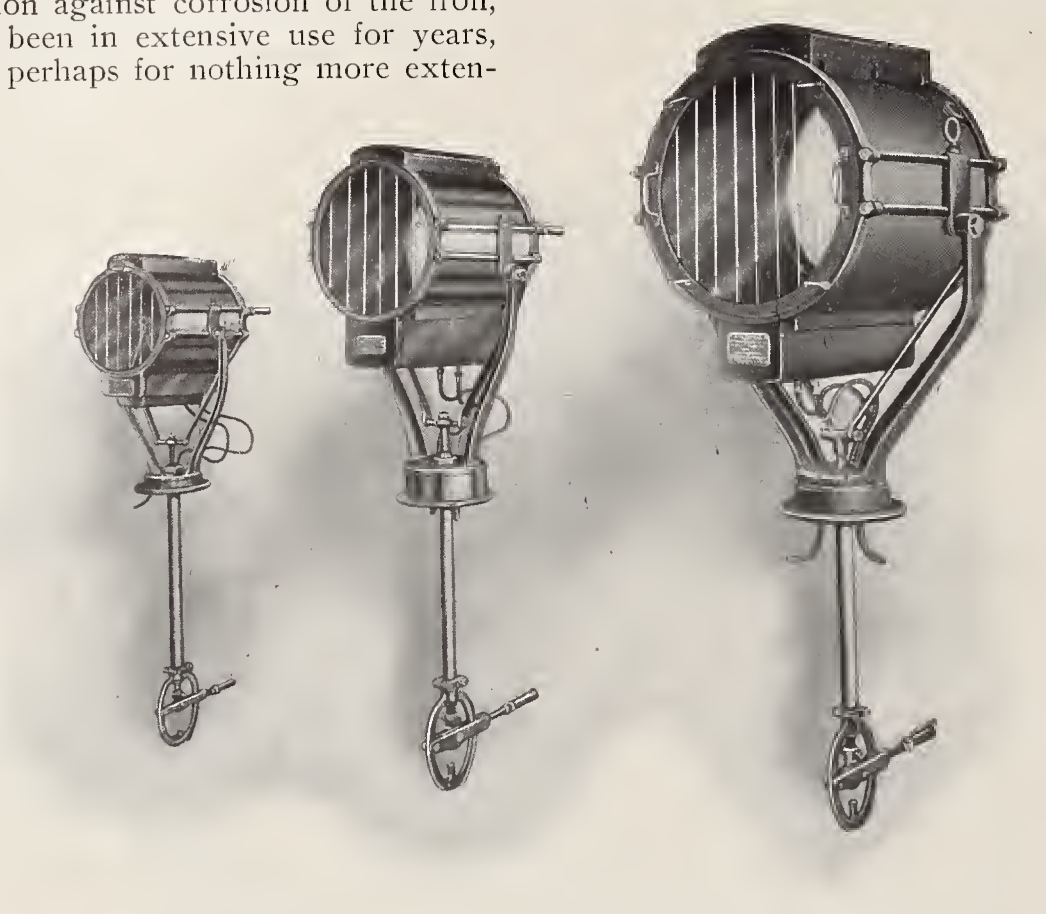
With each projector is provided a rheostat built up of ironclad cards wound with German silver strip, and provided with an 8-point switch, which adapts it for any voltage between 110 and 125 volts.

A 36-INCH GENERAL ELECTRIC SEARCHLIGHT ON THE STEAMER "C. W. MORSE," ILLUMINATING THE CAPITOL AT ALBANY, N. Y.

Zinc Electroplating

CONTRARY to the view held by many because of the application of the term galvanizing to the mechanical coating of metals with zinc, this term did not owe its existence to any actual electric deposition of that metal or other metals; but apparently the term was due to the successful experiments of Humphrey Davy, who, in the early part of the last century, availed himself of the galvanic action between zinc and iron, to guard the latter against corrosion, by applying strips of zinc to the iron when immersed in sea water, for instance, in the case of the hulls of ships, the iron in this way being protected at the expense of the most costly metal zinc, which fact doubtless operated somewhat against the general and continued utilization of this galvanic method of protection.

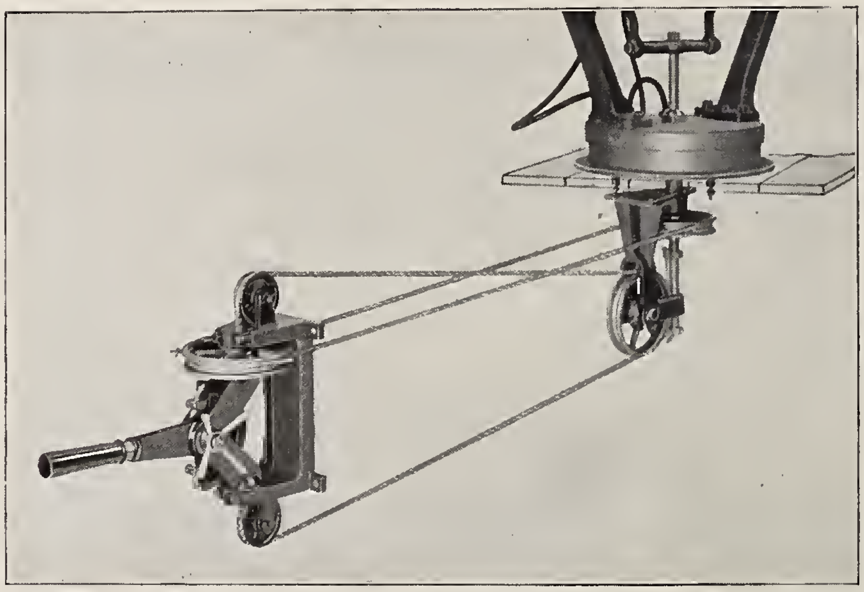
The mechanical deposition of a coating of molten zinc upon iron popularly termed galvanizing, as a protection against corrosion of the iron, has been in extensive use for years, and perhaps for nothing more extensively than iron telegraph wires and iron screw bolts for insulators. The zinc protects the iron by combining with the oxygen of the air, forming an oxide of zinc that is not attacked further, unless in the presence of gas or fumes, such as sulphuric acid, which combines with the oxide, forming sulphate of zinc. This, being soluble in water, is quickly washed off by rains, leaving the iron unprotected, when it soon corrodes and becomes useless. It is, by the way, one of the greatest mechanical advantages of hard-drawn copper wire over galvanized iron wire for telegraph purposes that it is practically indestructible under like conditions.



GENERAL ELECTRIC PILOT-HOUSE CONTROL PROJECTORS. SEE PAGE 153

In recent years the electric deposition of zinc upon other metals has received considerable attention, and numerous establishments have been equipped to carry on this industry. This latter process has numerous advantages over the mechanical deposition of zinc on metals for many purposes. Thus the electric, or true galvanic, method of deposition may be employed in many cases when the heating of the metal to the point at which the zinc adheres to it would be fatal to its use.

Again, it can be employed where a very thin coating of the zinc is essential, as in screws, screw bolts, door hinges, etc., where the hot or mechanical process is not always applicable, or, if so, not without some after treatment to remove the excess of zinc. For telegraph wire purposes the electric process would hardly be available, being too slow and too expensive. It may, however, be noted that the electrolytic deposition of copper on a steel wire was once carried on to quite an extent, and at least one circuit between New York and Chicago, measuring about 1.5 ohm per mile, is composed of this compound wire.



ROPE CONTROL FOR A PILOT-HOUSE SEARCHLIGHT PROJECTOR. SEE PAGE 153

The base of the electrolyte used in the process of zinc electroplating is usually a zinc sulphate, with a small amount of sulphuric acid, and one or more of a number of other compounds, such as aluminium sulphate, which have been found to improve the nature of the deposited zinc, the zinc sulphate being placed in the solution in the shape of a white dust. On account of the reasons indicated, the sulphate of zinc is now in considerable demand, at a fair price. This sulphate, or "white salts," as it is termed, is, or rather was, the bete-noir of telegraph battery men before the dynamo machine displaced the gravity, or Calland cells, in all of the large telegraph offices.

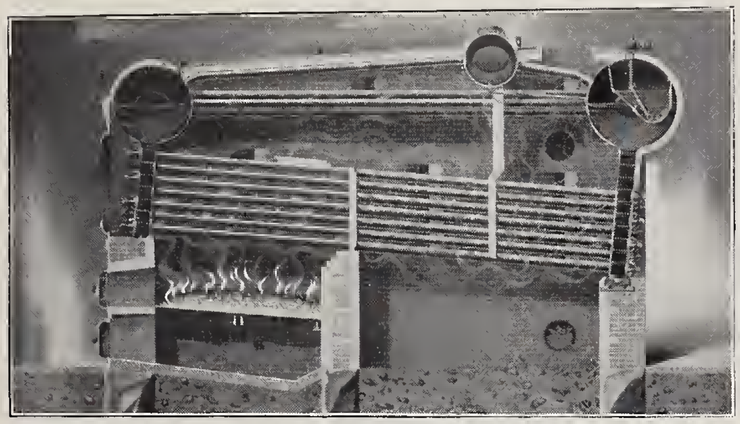
In the operation of this cell the copper of the copper sulphate, or "blue vitriol," solution is deposited as metallic copper on the copper plate of the cell, while the metallic zinc plate of the cell is dissolved, forming a sulphate of zinc solution. By capillary attraction this solution rises over the edges and runs down the sides of the glass cell. After a time the water of the solution evaporates, leaving a covering of the sulphate of zinc in the shape of a soft white salt extending from the cells to the battery stands, and inasmuch as the zinc sulphate is, in its humid state, a good conductor of electricity, it frequently short-circuited the battery.

After this battery is exhausted, the solution consists almost entirely of zinc sulphate, and as there was at the time mentioned no market for it, thouands of gallons of the solution were annually emptied into the sewers, where possibly it served some purpose as a germicide! There were, of course, many experimenters who endeavored, without success, to discover some economical method of recovering the zinc in metallic form from the waste zinc sulphate solution, there being quite an incentive for so doing, as will be understood when it is considered that in a telegraph office employing 10,000 or 12,000 of such cells the value of the dissolved zinc was from $4000 to $5000 per annum. There are yet several millions of gravity cells in service, but usually they are now so widely scattered in small lots it would be impracticable to collect the zinc sulphate for sale as a by-product.

A New Water-Tube Boiler

A NEW water-tube boiler recently brought out by the Atlas Engine Works, of Indianapolis, Ind., is shown in the annexed illustration.

It is composed of a nest of tubes, set on the ordinary incline between water legs, and three drums running across the tubes at the top. Two of these drums, the front and the rear, are each a part of the plate composing the water leg with which it is connected. This method of construction enables the builders to eliminate seams next to the fire or hot gases, since the only seam in each of these legs is at the bottom, where it is protected by the masonry, while the seams of the drums are located on the top, away from the fire.



A NEW WATER-TUBE BOILER, MADE BY THE ATLAS ENGINE WORKS, INDIANAPOLIS, IND.

This arrangement also gives a full-length opening at the throat, where the water passes from the leg to the drum, or vice versa. The throat is braced with a patent twisted brace which leaves more than 80 per cent. of the area open. The rear drum contains a mud pan through which the feed-water flows and where practically all the impurities of the water are precipitated to its bottom, a connection from it through the drum head admitting of the mud being blown out. The mud pan or purifier occupies a small space; it is built in sections and can be removed through the manhole of the drum and renewed at small expense when it becomes pitted.

The rear drum has a large generating surface. The fresh water from the purifier flows down through the rear leg and up through the tubes and front leg to the front drum, where there is a large releasing surface. The two drums are connected by straight equalizing tubes, arranged in three tiers along the ordinary water line. Each of these drums is connected with a middle drum by tubes, and the steam, as it is generated, travels through these tubes to the middle drum, from which it is taken for use.

Experience has shown that by thus carrying the steam to a third drum through tubes exposed to the furnace gases, not only is perfectly dry steam obtained, but the steam is superheated from 10 to 22 degrees, according to the state of the fire. Since all the tubes carrying water are straight and readily accessible, the boiler is easily cleaned.

Trade News

The Burt Manufacturing Company, Akron, Ohio, have just made a shipment of 21 of their celebrated Oil Filters to the agency at Havana, Cuba. They report that according to present conditions, Cuba will afford a very profitable field for American manufacturers. They have also worked up an extensive export trade in many other countries, and have recently made a shipment of 9 oil filters and 6 exhaust heads to their agency at Sydney, Australia; eighteen oil filters to their agency at St. Petersburg, Russia; 3 to their agency at Calcutta, India; 4 to Spain, and two 20-inch exhaust heads to their agency at London, England.

At the recent semi-annual meeting of the directors of Allis-Chalmers-Bullock Limited, of Montreal, Canada, a dinner was given to the office staff and representatives from all parts of the country. Among those present were: B. H. Warren, president; W. Chalmers, treasurer, and W. H. Whiteside, general manager of sales of the Allis-Chalmers Company, of New York, Chicago and Milwaukee; J. S. Neave, vice-president of the Bullock Electric Manufacturing Company, Cincinnati; R. W. Chapin, second vice-president and general manager; Colonel Henshaw, H. J. Fuller, J. W. Pyke, Alex. Pringle, Phelps Johnson, W. C. McIntyre, all of whom are directors; W. C. Brown, Lieutenant-Colonel J. S. Maclean, H. Markland Molson, E. Kirke Greene, C. E. Gudewell and others financially interested.

In the passenger list of the steamer "Vigilancia," which sailed Thursday, January 19, bound for Mexico, were fifteen men, all conduit experts, in the employ of G. M. Gest, subway contractor of New York and Cincinnati. These men are bound for the City of Mexico in connection with a contract which Mr. Gest has in that city for building a subway system for the Mexico Light & Power Company. Besides this several complete carloads of tools have been forwarded by the all-rail route. This is one of the largest contracts Mr. Gest has ever undertaken.

The Electric Controller & Supply Company, of Cleveland, Ohio, has placed Geo. Magalhaes in charge of its Eastern office at 136 Liberty street, New York. Mr. Magalhaes is a graduate of the Columbia University and has been connected with the engineering department of the company for some time. He is thoroughly familiar with the company's products, the chief of which are reversing controllers, solenoids, lifting magnets, magnetic switch controllers for reversing or non-reversing motors driving heavy machinery, direct-connected, variable-speed motor drive for planers.

At the recent annual meeting of the Prometheus Electric Company, of New York, the following officers were elected: President, D. T. Davis; vice-president, Dr. S. S. Wheeler; secretary, Max Lowenthal; treasurer, William B. Symmes, Jr., The following directors were elected to serve for one year: David T. Davis, Dr. S. S. Wheeler, William B. Symmes, Jr., F. S. Blackall, Max Lowenthall.

The Hamilton Cataract Power, Light & Traction Company recently started the 5000-K. W. Westinghouse generators in their De Cew Falls Power Station in Ontario. Power is supplied from Welland Canal feeders, tapped in about 14 miles above the power station, and at the station the water has a head of 267 feet. The Westinghouse generators are of the two-bearing type, direct-connected to Escher-Wyss water-wheels, and run at a speed of 286 revolutions per minute. They generate 3-phase current at a frequency of 66 cycles, and a pressure of 2400 volts. The power is transmitted about 35 miles over two separate lines to the city of Hamilton, Ontario, where it is used for lighting, street railway and manufacturing purposes. A reserve steam-driven station is located at Hamilton, containing two 1000-K. W. Westinghouse generators. The high-tension apparatus is designed for a pressure of 40,000 volts, but will be operated for a time at 20,000 volts.

The Municipal Council of Shanghai, China, through their New York agents, Fearson, Daniel & Company, of 96 Wall Street, are asking for bids on the construction and operation of about twenty-four miles of electric lines. The specifications call for alternative bids for single trolley and double trolley lines. Sealed tenders endorsed "Tender for Tramway Concession" are to be sent to the secretary, Municipal Council, Shanghai, and must be received on or before March 31.

A. L. Ide & Sons, of Springfield, Ill., the well-known engine builders, have established a New York office at 11 Broadway, through which all export, New England, and Middle States business will be hereafter transacted. Mr. J. G. Robertson is the manager.

At the recent annual meeting of the Northwestern Electrical Association, at Milwaukee, Wis., the National Electric Company, of that city, exhibited a new Lundell universal motor, with laminated field, having a speed variation of 3 to 1 by field control. The company also exhibited photographs of the 1000-K. W. rotary converters supplied to the Milwaukee Electric Railway & Light Company, and of two—eighteen being the complete order—1000-K. W. motor-generator sets supplied to the Union Electric Light & Power Company, of St. Louis. They also introduced their new publication, "The National Electrical Catechism," and distributed watch fobs bearing in relief a representation of their trade mark.

New Catalogues

A new catalogue sent out by the Abner Doble Company, of San Francisco, Cal., is devoted to tangential water wheels. Illustrations are given of the buckets, of the wheel assembled and of the jets obtained with different positions of the needle in the nozzle. A number of tables are given, showing the heads required to overcome resistance in 90-degree bends, the diameter of the jets and the revolutions per minute for different effective heads, the size of riveted hydraulic pipe for various pressures, the head required to overcome resistance in iron pipes, and the discharge in cubic feet per minute.

A new catalogue illustrating and describing the Morse silent chain drive, has been sent out by the Morse Chain Company, of Trumansburg, N. Y. The advantages of chain drive are mentioned, and the construction of the chain is shown and described, illustrations being also given of its application to a variety of service.

The first number of a publication entitled "The Valve World" has been recently sent out by the Crane Company, of Chicago. An illustration is given of R. T. Crane, the founder and president of the company, with an article by him on "The History of Making Wrought-Iron Pipe." Among other things, a description is given of the electrically operated machines in the company's works and of the piping system in the St. Regis Hotel, in New York. It is well illustrated and generally well arranged.

Standard instruments for resistance measurements are illustrated and described in a catalogue sent out by Queen & Co., of Philadelphia. The various instruments illustrated comprise several types of Wheatstone bridges and rheostats, resistance boxes and coils, several types of resistance bridges, a portable cable-testing set and a number for general use.

Electrically operated house tank pumps are illustrated and described in a catalogue sent out by the Prindle Pump & Engineering Company, of New York. The pamphlet sets forth the advantages of this type of pump and illustrates its direct connection to alternating and direct-current motors. An automatic tank switch is also illustrated, and a diagram is given showing connections for the pump, tank and motor.

A series of bulletins sent out by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., illustrates and describes starting and regulating rheostats, machine-tool controllers, non-reversible compound controllers and accessories for self-starters. Other bulletins contain tables and diagrams of sizes for enclosed resistances, and tables of fuses and the rating of motors

Personal

Cloyd Marshall, whose acquaintance many of our readers may have made at the St. Louis Exposition, where he was connected with the Department of Electricity, has been appointed superintendent of the power department of the Union Electric Light & Power Company, of St. Louis. Mr. Marshall was granted a gold medal by the Superior Jury of the Louisiana Purchase Exposition in appreciation of his services in connection with the Exposition and as Secretary of the Electricity Department, a well-deserved distinction. He is a graduate of Purdue University, and after acting as assistant in the electrical laboratory of the university, became designing and testing engineer for the Jenny Electric Manufacturing Company, after which he took up experimental work for the Railway Materials Company, of Chicago. In 1901 he became plant engineer, and later engineer of the sales department of the C. W. Hunt Company, New York. The latter position he resigned to accept the appointment in the Department of Electricity of the World's Fair.

The American Society of Refrigerating Engineers is the name of a recently organized engineering institution. The following are its officers for the current year:—

President—John E. Starr.

Vice-Presidents—P. de C. Ball and H. B. Roelker.

Treasurer—Walter C. Reid.

Governors—W. E. Parsons, Henry Torrance, Jr., E. I. Phillips, D. S. Jacobus, L. H. Jenks, Louis Block, Edgar Penny, W. T. Robinson, Thos. Shipley.

Erasmus D. Leavitt, Cambridge, Mass., the well-known mechanical engineer, was recently presented with a handsome silver service by thirty-eight of his former associates from Boston, New York, Philadelphia, and other places, the occasion being his retirement from the more active duties of his profession. He will retain his position as consulting engineer of the Calumet & Hecla Mining Company and do some other work, but his greater activities will be relinquished. Among the notable work that Mr. Leavitt has done was his service as a consulting engineer of the Manhattan Elevated Railway when it changed from steam to electricity; the designing of the large pumping engines of the sewage plant at Dorchester, Mass., the engines at the Chestnut Hill pumping station, the pumping engines of the Bethlehem 14,000-ton press, and as a commissioner of the new Cambridge bridge.

Henry C. Mortimer, Jr., of the General Electric Inspection Company, has joined the New York office staff of the Crocker-Wheeler Company. He will assist F. B. DeGress, manager of that office, and will succeed A. J. Thompson, who has accepted a position with the New York branch of the Bullock Electric Manufacturing Company.

W. N. Stevens, who has for some time filled the position of assistant mechanical engineer of the Rapid Transit Subway Construction Company, has accepted a position with J. G. White & Company, of 43 Exchange place, New York. Mr. Stevens has had a wide experience as a constructing engineer in the designing and active construction of important power plants. He had much to do with the design and construction of the Twelfth street power house of the New York Edison Company. He also has had charge of the design and construction of the mechanical department of the Seventy-fourth street power house, and was lately engaged on the work of designing and building the Fifty-ninth street power house, nine transformer stations, car barns, shops, and other adjuncts to the construction and equipment of the Rapid Transit Railroad in the city of New York. During his professional career, Mr. Stevens has also been engaged in engineering undertakings in other parts of this country and abroad, having made both the preliminary and afterwards the final plans for the machinery of the power house for the tramways of Sydney, Australia.

CARY T. HUTCHINSON

Cary T. Hutchinson is one of a special board recently appointed to report, for the city of New York, upon the cost of municipal electric lighting.

At the annual meeting of the Western Society of Engineers, of Chicago, the following officers were elected: President, Edward C. Carter; first vice-president, G. A. M. Liljencrantz; second vice-president, Charles F. Loweth; third vice-president, L. P. Breckenridge; treasurer, Andrew Allen; trustees, B. E. Grant, one year; T. W. Snow, two years; Geo. M. Wisner, three years; past presidents in the board of direction, W. H. Finley, Ralph Modjeski, H. W. Parkhurst.

Henry de B. Parsons was recently retained by the city of New York for the preparation of plans and specifications for the city's recently much-talked-of municipal electric lighting plant.

Charles H. Baker, who founded the Snoqualmie Falls Power Company of Seattle and Tacoma, Wash., and who, since its beginning six years ago, has been the active president and chief engineer thereof, and who also as manager and chief engineer has promoted and planned the White River Power Company, has sold a controlling interest in both companies to a party of capitalists who have elected N. H. Latimer, manager of the Dexter Horton Bank, of Seattle, as president. Mr. Baker is planning an early trip to Japan and China for pleasure and rest, and for the purpose of exploring the water power and electrical possibilities of those countries with a view to development by American capital. The capacity of the Snoqualmie Falls plant as built by Mr. Baker is 19,000 H. P. and of White River 50,000 H. P.

Max Lowenthal, secretary of the Prometheus Electric Company, was awarded a medal by the International jury of awards at St. Louis for his personal contribution to the art of electric heating.

W. Elwell Goldsborough, director of the School of Electrical Engineering, Purdue University, who has during the past three years held the position of chief of the department of electricity at the Louisiana Purchase Exposition, has become associated with J. G. White & Company, of New York City. Mr. Goldsborough will ultimately be permanently located in New York. For the present, however, his time will be divided between Lafayette, Ind., and New York City. Incidentally, he is still giving attention to the matter of closing up the affairs of the electric department of the Exposition, which will necessitate his being in St. Louis at times during the next month or so. Some weeks ago the Italian Commissioner-General of the St. Louis Exposition presented to Purdue University a fine collection of charts and paintings which were exhibited in the Palace of Electricity. They show the development of the electric power transmission plants in Italy, and have been given to the electrical engineering department of the university as a compliment to Prof. Goldsborough.

Edward Van Winkle, formerly of the firm of Pratt & Van Winkle, consulting engineers, 160 Fifth avenue, now has offices in the Flatiron Building, New York City.

C. J. Purdy has resigned his position with the Munder Electric Company, as New York sales agent, to become general manager of the American Incandescent Lamp Company, with offices at 26 Cortland Street, New York.

A. A. KNUDSON

Adolphus A. Knudson, of New York, who is making a specialty of electrolysis investigation, has just completed for the township of Bayonne, N. J., an exhaustive report of an examination and electrical survey of the water piping of that place with the view of determining what damage has been done to it by electrolysis, and what danger there may be of further damage. It is understood that the city will proceed against the trolley company as soon as possible to recover for damages inflicted.

GANO S. DUNN

Gano S. Dunn, vice-president and chief engineer of the Crocker-Wheeler Company, of Ampere, N. J., recently returned from San Francisco, where, as already noted, his company has closed one of the most important contracts of the year. The California Gas & Electric Corporation has placed an order for three 4000-K. W., 3-phase, revolving field alternators, to be driven by 6000-H. P. gas engines. These generators are the largest in capacity in the world driven by gas engines, and will furnish power for operating all the street railways in San Francisco and vicinity. This important sale by a company which has been building alternating current machinery only a few months has been a cause for comment, and Mr. Dunn is to be congratulated upon his personal share in the contract.

The announcement has been made by the well-known firm of Manning, Maxwell & Moore, of New York, that Henry S. Manning has sold his interest in the firm as well as in all of its allied manufacturing companies, to Charles A. Moore, who is now the sole owner of the entire business. In view of the importance of this firm in the machinery and railway supply trades this announcement is highly interesting. The firm name of Manning, Maxwell & Moore will be retained by Mr. Moore. The transaction was a most novel one, involving such great interests, and at the same time being carried out on a clean-cut, old-fashioned, straight cash basis. Mr. Moore offered a lump sum of cash for all of Mr. Manning's holdings in all of the interests which they controlled between them. These included:—

Manning, Maxwell & Moore, New York, Boston, Cleveland and Chicago.

The Ashcroft Manufacturing Company, Bridgeport, Conn.

The Consolidated Safety Valve Company, Bridgeport, Conn.

The Hayden & Derby Manufacturing Company, Boston.

The Hancock Inspirator Company, Boston.

The United Injector Company, Boston.

The price agreed upon has not been stated, but that it was a good round sum may be judged from the fact that among the assets of Manning, Maxwell & Moore purchased by Mr. Moore was $200,000 cash to the firm's credit in banks. Nothing was done in the cases of the Shaw Electric Crane Company, of Muskegon, Mich., and Pedrick & Ayer, of Plainfield, N. J., as Mr. Manning had no interest in the former company, Mr. Moore already being the sole owner, and because he was the sole owner of the lat-

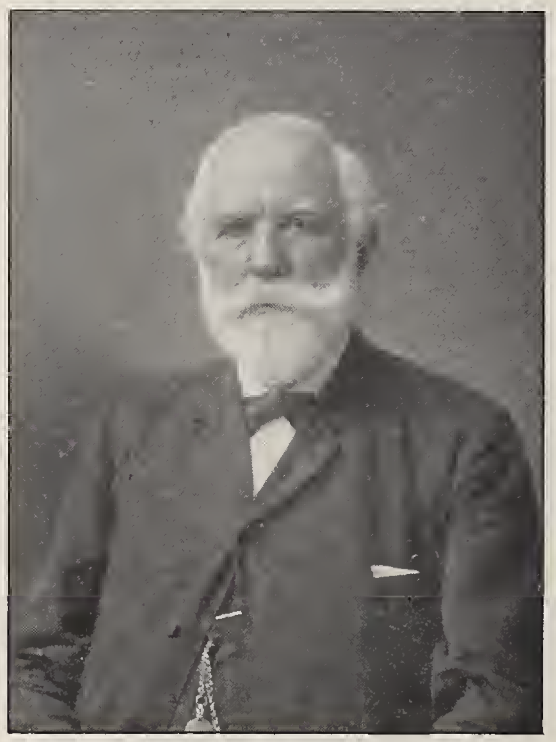
CHARLES A. MOORE

ter business and will retain it. The firm of Manning, Maxwell & Moore will, however, continue to act as selling agent for Pedrick & Ayer, for the time being at least. For the present Mr. Moore will take only his son Arthur into the business with him, but it is his intention to incorporate a company at a later date, in the formation of which the faithful labors of the older employees will receive recognition. Mr. Manning considers that the 30 years of work which he has devoted to the upbuilding of the business of Manning, Maxwell & Moore is sufficient justification for his retirement at this time. Besides, he is 60 years old and has important interests outside of Pedrick & Ayer, which include the International Banking Corporation, the Tennessee Coal & Iron Company and the Kansas City, Mexico & Orient Railway. Mr. Moore came to New York to enter the firm of Henry S. Manning & Co., which was established May 1, 1873, about 25 years ago. On May 1, 1881, the firm of Manning, Maxwell & Moore was organized. About 10 years ago Eugene L. Maxwell died and his interest was taken up by Messrs. Manning and Moore. The enormous growth of the business and its swift advance to the front rank of the machinery and railway supply trade is a story which need not be told to any one in the machinery business in this country. During recent years Mr. Moore's strong personality, energy and enterprise have predominated in the doings of the firm, and his final succession to the entire business is a step which appeals as a most natural one to any one in the machinery trade.

Obituary

William Sellers, the head of the firm of William Sellers & Co., Inc., of Philadelphia, died of kidney trouble on January 24. The name of Sellers has become almost a by-word for excellence among engineers and machinery users not in the United States alone, but wherever machine tools are employed. Mr. Sellers was in his eighty-first year. His life was an active one, and he was long identified with the industrial and political advancement of Philadelphia. His fame as a manufacturing machinist was world-wide. Beside being the head of the firm which bears his name, and the leading spirit in many other enterprises in the world of machinery, he was a prominent figure in club life, having been one of the founders of the Union League. In his busy life he found time to be active in municipal reform and to secure legislation in the State which has been of inestimable benefit to commercial interests.

Mr. Sellers' illness dated from last spring, although it did not become serious until a few weeks before his



WILLIAM SELLERS

death. He was taken to a hospital, where an operation was performed and he became apparently better. A few days later he became worse, however, and another operation was necessary, from which he did not rally.

The number of miles of electric railroad operating in Connecticut for the year ending June 30, 1904, was 685,128.

Edward Hemphill Mullin

THE news of the death of Edward Hemphill Mullin, which occurred on January 25, at his home at Milburn, N. J., came with startling suddenness to a very large number of friends and acquaintances. Mr. Mullin had not been ill so far as outward appearances indicated; indeed, he seemed the personification of good health and spirits, and his vigorous manner up to the last will always be remembered by those who knew him as one of his distinctive characteristics.

He was born at Castledey, in Ireland, in 1859, and was educated at the Methodist College Public School of Belfast, and in the Queen's College, Belfast, where he took his Bachelor's degree with honors in Physics and Chemistry in 1881.

Shortly afterward he came to New York and engaged in newspaper work. From 1887 to 1895 he was an editorial writer on the staff of the New York "Evening Sun." The two following years he spent on the staff of the New York "Times" in charge of the technical reporting of that newspaper, and subsequently he became editor of the "Bookbuyer" and a prolific contributor to the magazine and technical press.

Early in 1898 he entered the service of the General Electric Company, at first as manager of its advertising department, and latterly as a confidential representative of the company in many matters. He was the authorized representative of the company in all relations with the press, and the official host of the company whenever engineers or capitalists desired to visit the works or become acquainted with its methods.

He was a member of the Engineers, Press, Lotus and Transportation Clubs of New York. He was vice-president of the New York Electrical Society, and a director of the American Institute of Electrical Engineers, and also vice-president of the Association of American Advertisers.

Mr. Mullin had a great number of friends here and abroad, and was known among them for his erudition and wide acquaintance with electrical and engineering subjects. As a writer, he was distinguished for clarity of style and an Anglo-Saxon simplicity of diction which made his essays on mechanical and electrical matters excellent reading.

THE LATE EDWARD HEMPHILL MULLIN

According to a daily newspaper despatch from Chicago, a receiver was recently appointed for the Whitney Electrical Company, which was capitalized for $56,000,000, to promote the alleged inventions of Albert Gallatin Whitney. The principal assets of the company were alleged to consist of "mythical plans and absurd inventions." One of the inventions, it was said, consists in "ejecting or shooting above and beyond the atmosphere of the planet commonly known as the earth four brass balls, which are supposed to gently and peaceably remain beyond said atmosphere after once having been shot or thrown up there."

An Early Use of Trees as Grounds in Telegraph Practice

IN Major Squier's interesting report to Major-General Arthur MacArthur "On the Absorption of Electromagnetic Waves by Living Vegetable Organisms," an abstract of which is printed elsewhere in this number, mention is made of a successful experiment in which Lieutenant William M. Goodale, of the United States Signal Corps, found that "a much better 'ground' could be obtained in a wooded country by attaching the earth side of the instrument to an iron nail driven into the trunk of a tree or shrub than by the ordinary and more laborious method of burying a conducting plate, or by driving an iron spike into the earth itself." This experiment was repeated by Major Squier with excellent success.

The fact that foliage is a fairly good conductor of electricity has been so thoroughly forced upon the attention of telegraph and telephone engineers in their efforts to preserve the insulation of overhead wires intact, as to make it almost incredible that practical advantage has not in the past twenty or thirty years been taken of this well-known fact in telegraph or telephone practice. Without desiring to detract in the slightest from the credit due to Messrs. Goodale and Squier for their recent work, at least one hitherto unpublished, but well-authenticated use of trees as grounds in telegraph practice may be cited. The experimenter on the occasion referred to was Mr. F. A. Stumm, who was a military telegrapher at General McClellan's headquarters during the Civil War.

In 1878-79, while employed in the Cleveland, Ohio, office of the Atlantic and Pacific Telegraph Company, Mr. Stumm was assigned to obtain reports of the results of the grand circuit trotting races for the Scripp-Sweeny "Penny Press," of Cleveland, which, at that time was debarred from the trotting course. The races were held on the track of the Northern Ohio Fair Grounds, about four miles outside of Cleveland. The grounds were divided in two parts by a highway, but communication between them was maintained by two overhead bridges. The pole line of the telegraph company ran along the highway. In order to get the reports of the races promptly, Mr. Stumm set up his instruments on the railing of one of the bridges, tapping one of the overhead wires of his company. Two trees, one an oak, the other a maple, grew on the highway, adjacent to the bridge.

In order to obtain a convenient ground, Mr. Stumm drove a nail into each of the trees and had no difficulty in getting into communication with the main office at Cleveland, but he noticed that the oak tree made a more satisfactory ground than the maple tree, which may have been due to the tannic acid in the latter. The circuit thus obtained, while satisfactory and steady, was weak. A messenger brought the reports of the races to Mr. Stumm from the near-by race track, with the result that the returns of the races were forwarded at least as promptly by this route as by the opposition line.

At the time mentioned, Mr. C. F. Williams was chief operator, and Messrs. W. W. Umsted, O. F. Stow, and W. H. Phillips were operators in Cleveland and were aware of the manner in which the circuit was maintained in operation.

The New York Electrical Society

ELECTRIC WAVES AND THE REACTION OF TRANSMISSION LINES

THE last regular meeting of the New York Electrical Society was held on the evening of January 18, in the library hall of the American Institute, 19 West Fourth street. The secretary of the society, George H. Guy, presented the names of the following newly elected members:—Wm. C. Ward, C. G. Owens, G. H. Hodges, Joseph M. Roman, H. G. Stott, C. D. Gray, C. H. Nichols, Robert P. Parrott, M. J. Maguire, Charles C. Mathews, Walter Lawrence, Frank W. Utlal, Rea B. McVey, W. Guy Ritter, F. J. McMahon, Robert Thistlewhite and Paul T. Kenney.

The lecturer of the evening was Prof. W. S. Franklin, of Lehigh University, who had announced as the title of his lecture "Electric Waves and the Reaction of Transmission Lines," but he had found that the subject as thus stated was too large for one evening's treatment, and he would therefore, he stated, chiefly attempt to explain by analogy the mechanism of the ether and the operation of this mechanism in the propagation of electric and magnetic fields, together with some remarks on the best methods of reducing wave distortion and wave attenuation. In brief, he remarked his aim would be to convey to his hearers a clear view of the manner in which "distortion distorts and waves wave."

The analogies and models of the ether adopted by the lecturer, and which were illustrated by lantern slides, followed in a general way those described and illustrated by Lodge, in his "Modern Views of Electricity," in which rows of cells, represented as alternately positive and negative wheels, geared together by cogs, and free to turn about fixed axles, are employed.

The lecturer then briefly discussed the relative merits of inductance or leaks in circuits to reduce wave distortion, and appeared to give the preference to leaks.

The lecture was listened to with close attention by the large audience present. At its close Dr. M. I. Pupin who, it is well known, has given these subjects close study, was requested to open the discussion. Dr. Pupin congratulated Prof. Franklin on the interesting lecture to which they had listened, but thought that perhaps too much had been attempted in one evening. He also deprecated the use of mechanical analogies in the illustration of electrical subjects before electrical engineers. He thought it equivalent to an attempt to illustrate mechanical subjects by electrical analogies before mechanical engineers. Despite his dictum, however, the doctor himself was presently illustrating the difference between a circuit possessing little capacity and one possessing large capacity, by means of the analogy of energy conveyed by a short shaft and a long shaft, the distortion not being perceptible in the one case but quite so in the other. The doctor also apparently overlooked the fact that he had also employed, and very successfully, the analogy of vibrating strings, loaded and unloaded, to illustrate the principle of loaded and unloaded conductors. In fact, however, as Dr. Pupin subsequently explained, he does not take exception to the employment of mechanical analogies if one is given time to study them.

During the discussion the points on which Prof. Franklin and Dr. Pupin varied were so numerous that the audience was for some time treated to a spirited dialogue between these intellectual gladiators.

C. O. Mailloux also participated in the discussion briefly, and moved a vote of thanks to the lecturer of the evening, which was heartily seconded by Dr. Pupin, after which the meeting adjourned.

Rapid Advances in Rubber

MANUFACTURERS of articles in which rubber is used are confronted by radically increased costs on the raw rubber. Notwithstanding the fact that the production of rubber is increasing rapidly each year, the increase in consumption, according to "The Iron Age," is in a ratio so much larger that prices are mounting skyward, and there is no little danger of an actual shortage. The highest price for pure Para rubber in 1880 was 50 cents per pound. The average price from 1885 to 1892 was 76 cents. The price in March, 1902, was $1.02. The price November 1, 1904, was $1.13, and prices quoted within the past few weeks range from $1.30 to $1.32½. These prices are all f. o. b. New York in car lots. At no period since rubber has been a large commercial commodity have price increases been as startling as during the last few months. During the month of November a total of 14 cents was added to the wholesale prices.

There are a number of natural reasons for this increase in the price of rubber apart from whatever manipulation may be present in the market. The small item of rubber heels to shoes has consumed quite a tonnage. Automobile tires call for the purest rubber in a larger proportion compared with adulterants and fabric than in most other arts. The widespread use of rubber tires for carriages and other vehicles consumes to-day a greater tonnage than the total importation of rubber twenty years ago. It is estimated that last winter no less than 60,000,000 pairs of rubber boots and shoes were manufactured and sold. The rubber industry is daily assuming larger proportions and greater importance, and rubber is finding its way into a countless number of manufactured products in which it was not used some years ago. The rise in the price of raw rubber is therefore quite in line with the progress of the industry.

An 8-foot steel chimney, 230 feet in height, has just been completed and will be erected in Mexico.

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The Electrical Age Co.
New York and London

Some Examples of High-Potential Discharges

By PERCIVAL E FANSLER, E E.

EXCELLENT opportunity was afforded at the St. Louis Exposition last year for the study of high-potential electric discharges, and the results obtained are shown in the accompanying illustrations. The photographs from which these were made were taken in or near the Palace of Electricity, and cover a number of combinations of frequency, potential, and discharge length. The apparatus used consisted of a 1,000,000-volt transformer of 100-K. W. capacity, at 25 cycles; an induction coil capable of giving a 60-inch spark; and a 20-K. W., 60-cycle transformer, with a 1-inch spark gap. The first two are the largest of their kind in existence. The last named was installed at the transmitting station of the De Forest Wireless Telegraph Company.

The 1,000,000-volt transformer was constructed by C. H. Thordarson, of Chicago, on an order from Purdue University, a month before the opening of the Electrical Congress. Rapid work was therefore necessary, and at the end of 28 days, it was installed in a hastily constructed building north of the main entrance to the Palace of Electricity.

A pole line was erected along the bank of the lagoon, consisting of two bare copper wires supported by triple-petticoat insulators, which were, in turn, placed on the ends of 8-foot lengths of fibre conduit, set over long wooden pins 10 feet apart at the ends of long cross-arms. On the night of September 16, before a gathering of the members of the Congress, the switch was first thrown in, and a brilliant and intense corona effect resulted. The insulation to ground was not sufficient, however, and the enormous pressure soon caused a heavy leakage over the glass insulators and down the 8 feet of fibre. A spark gap, consisting of two brass rods, supported in a vertical position at the ends of long glass rods, was connected in parallel with the lines. The rods were slightly farther apart at the upper ends, and with a gap of 5 feet the discharge was intense and sounded like that of a machine gun. The capacity of the line broke up the low frequency into a rapid surging, and the discharge appeared to be a foot in diameter.

The heat generated was sufficient to raise to redness the copper wires lead-

FIG. 1.—DISCHARGE OF 1,000,000-VOLT TRANSFORMER. TERMINALS ABOUT 39 INCHES APART. SPARK ABOUT 8 FEET LONG

FIG. 2.—DISCHARGE IN STILL AIR OF 250,000-VOLT TRANSFORMER. SPARK GAP 28 INCHES

FIG. 3.—AN EIGHT-FOOT DISCHARGE OF A 1,000,000-VOLT TRANSFORMER

ing to the transformer, and after discharging for fifteen minutes the rods became hot, in spite of the excellent opportunity for radiation in the open air. The brass was slightly pitted, chiefly at the lower ends. After some experimenting, it was found almost impossible to maintain the insulation between the line and the ground; consequently the primary of the transformer was so connected as to reduce the secondary pressure to half a million volts. Even with this change, considerable trouble was encountered with the insulation, particularly after a rain, when the interior of the transformer house resembled a miniature lightning display. The switch controlling the primary was mounted on the outside wall of the house, and a wooden platform was erected for the operator to stand on; but after experiencing some severe shocks, a plate of glass was mounted on insulators and placed on the platform, from which the switch was operated during the rest of the season.

When the switch was closed, an instantaneous discharge would result, the spark jumping between the lower ends of the rods, as shown in Fig. 8. If the wind was not too high, the spark would gradually work its way up the rods, and finally blow off at the top, forming again at the bottom, as shown in Figs. 4 and 5. Very often, when blown out at the tops of the rods, the spark would attain a length of 10 or 12 feet. During the month following the installation, demonstrations lasting an hour were made on stated evenings of the week, and these invariably attracted a crowd of visitors. Figs. 1, 3, 4, 5 and 8 are from photographs taken late at night, after the lights on the buildings had been turned off.

The camera was placed about 10 feet from the discharge, the exposures ranging from the hundredth part of a second to a fifth of a second, nominal. It is possible, of course, to determine the exact length of exposure by counting the lines in the discharge and computing from the frequency, as all of the pictures were taken with no capacity in the circuit. In some instances, the heated path must have been suddenly displaced, as in Figs. 5 and 8 we find an isolated discharge, some distance from the others, although in nearly all of the pictures the discharges followed one another at short distances, the whole resembling a fabric with ragged holes appearing at intervals. In several instances, where an attempt was made to expose when the discharge was at the top of the gap, the spark blew out and was re-established during the time the shutter was open. The intensity is shown in Figs. 3 and 5 by the halation on the plate. All the pictures were taken with a spark gap of from 39 to 42 inches, the latter being about the limit of the transformer with the primary connected in series. With the two sections in parallel, the breakdown distance would be easily 8 feet, and even 10 feet should be possible in a closed room.

There are many interesting features

connected with this transformer, one being that, owing to the short time at the disposal of the builder, the coils were wound and shipped to St. Louis without being tested; yet not a single break-down occurred, and, at the end of a month, when the coils were lifted from the oil, they were as white and clean as when new. Although the exact data of this transformer cannot be given, it may be said that it is of the ordinary core type, so arranged that both primary and secondary can be raised from the tank to permit of easy inspection or replacement. The transformation ratio is 110—1,000,000 in one step, 1,000,000 volts at 25 cycles, half that amount at 16 cycles. The core weighs 6000 pounds, and the bare copper for both primary and secondary weighs 450 pounds. It required 52½ pounds of a special grade of silk to insulate the secondary wire, and the work was done by Mr. Thordarson on a machine of his own design.

The transformer has been installed in a special high-potential laboratory at Purdue University, where an interesting series of experiments will be made. This laboratory will be constructed with an eye to perfect insulation, and provisions will be made to safeguard the observer.

Before constructing the 1,000,000-volt transformer, Mr. Thordarson built for exhibit one of 20-K. W. capacity, stepping up from 110 to 250,000 volts at 60 cycles. A discharge from this is shown in Fig. 2.

The large induction coil exhibited by the Heinze Electric Company was of interest in that it was capable of producing a spark 60 inches in length, or 8 inches longer than that credited to the Spottswoodie coil. This makes it the largest coil in the world, and one is impressed not only by its size, but by the extreme simplicity of construction. The coil is 12 feet long, stands nearly 5 feet high, and weighs 1750 pounds. The primary is wound in a single layer over a core 4 inches in diameter, and consists of No. 8 triple-silk-covered wire, divided into two sections. A micanite tube, ½ inch thick, separates the primary from the secondary. The secondary is made up of two parts, each containing 143 sections of No. 36 double-silk-covered wire, weighing 275 pounds, with micanite washers between. The outside diameter of the secondary is 12 inches, and the two sections are 64 inches long. A full 5-foot discharge requires 2750 watts.

An interesting feature in the construction is that the secondary coils are not imbedded in insulating compound, but, after receiving special treatment, are slipped onto the tube covering the primary and clamped together. The entire coil is covered with glass, the construction making the replacement of a section remarkably simple. Figs. 6 and 7, showing the discharge of this coil, are from photographs taken under unfavorable conditions, and do not show the coil at its best. The sparks are 32 inches in length, and the intensity is well illustrated in Fig. 6. This discharge, like that from the Thordarson transformer, is of high potential, but differs in that it is of much higher frequency and of comparatively low energy.

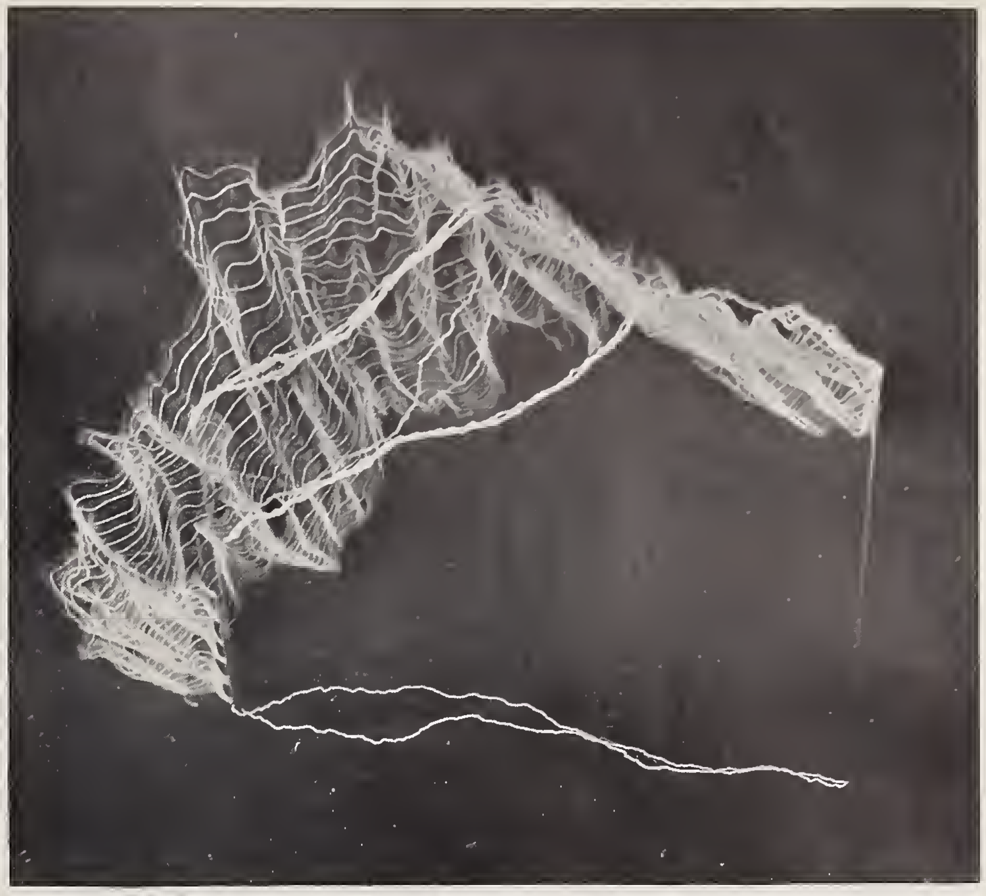


FIG. 4.—DISCHARGE OF 1,000,000-VOLT TRANSFORMER. TERMINALS ABOUT 39 INCHES APART. SPARK 8 FEET LONG

FIG. 5.—WITH THE SAME TRANSFORMER AND TERMINALS 42 INCHES APART. SPARK ABOUT 10 FEET LONG

Figs. 9 and 10 are from photographs taken at the De Forest station, and show the characteristics of this high-power, short-gap, high-frequency combination. The transformer is of 20-K. W. capacity, and discharges through a 1-inch gap, between ¾-inch carbons, a large condenser being connected across the gap. The tremendous amount of energy dissipated necessitates some special arrangement to keep the carbons cool. and the air blast shown in the photograph, besides blowing out the spark, works with the metal discs shown to accomplish this end. In Fig. 9 the spark may be seen apparently jumping from the middle of the gap to one of the discs. It is interesting to note that at the time this photograph was taken the operator was sending a message to Chicago, over 300 miles away.

Prices of Niagara Power

By GEORGE L. CLARK

NIAGARA power is now distributed in one large city, Buffalo, in two of moderate size, Niagara Falls, N. Y., and Hamilton, Ont., and in a number of smaller places. In Buffalo the electric energy comes

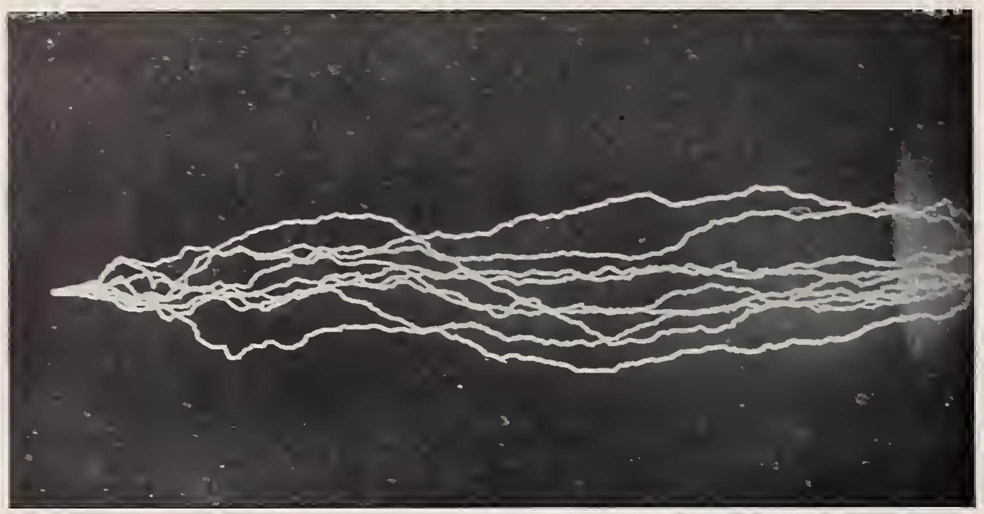


FIG. 6.—DISCHARGE OF HEINZE 50-INCH INDUCTION COIL WITH TERMINALS 32 INCHES APART. SEE PAGE 163

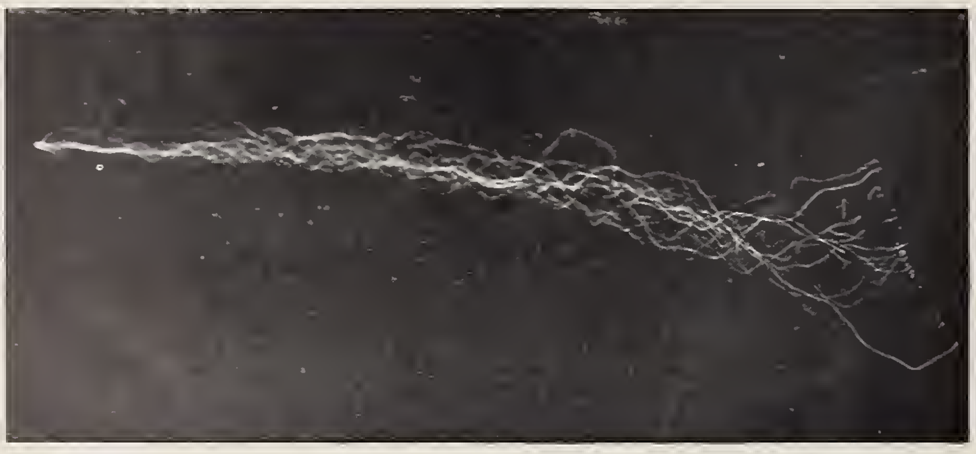


FIG. 7.—DISCHARGE OF HEINZE 50-INCH INDUCTION COIL. TERMINALS 32 INCHES APART. SEE PAGE 163

from the generating stations at Niagara Falls, in the city of that name, about 20 miles away. The same stations furnish power for local distribution.

For Hamilton the energy is generated at the foot of the Niagara escarpment, about 3 miles from the small Canadian city of St. Catharines, with water drawn from Lake Erie by way of the Welland Canal. In order to reach Hamilton this energy passes over a transmission line about 35 miles long.

It might readily be supposed that rates for electric energy in the city of Niagara Falls would be lower than those in Buffalo or Hamilton, and this is probably true for large units of at least several thousand horse-power each, such as are required in some of the electro-chemical plants in the first-named city. This conclusion is supported by the fact that few if any such plants are supplied with the transmitted energy in Buffalo or Hamilton, and by the further fact that in the two generating stations at the Falls, from which power is transmitted to Buffalo, about two-thirds of the load is delivered to local manufacturing plants.

In the case of smaller consumers, however, the advantages of a location

FIG. 8.—DISCHARGE OF 1,000,000-VOLT TRANSFORMER WITH TERMINALS 42 INCHES APART. SEE PAGE 163

at Niagara Falls are not so clear: Electric energy for power purposes is sold in the city of Niagara Falls on both flat or contract and meter rates. The flat rates are based entirely on the maximum power drawn from the supply line at any one time. Power purchased on these rates may be used during any desired part of the day, though it is probable that very few consumers can keep their motors at work during more than one-half of each 24-hour period. These flat rates are $35 per horse-power-year when the maximum load is less than 10 H. P., $30 per horse-power-year when the maximum load is between 10 and 25 H. P., and $25 per horse-power-year with a maximum load of 25 H. P. or more.

If a consumer is able to maintain a uniform load of 25 H. P. or more during all the 8760 hours of a year, his rate for energy is only 0.285 cent per horse-power-hour, or 0.380 cent per kilowatt-hour. Any such uniform rate of work is out of the question for the great majority of power users, and the electric company at Niagara Falls shows its recognition of this fact by charging 3 cents per kilowatt-hour for electric energy by meter when used for power purposes.

At Hamilton, Ont., the maximum charge for electric energy used in motors is 3 cents per horse-power-hour, or 4 cents per kilowatt-hour, by meter, and this rate holds until a consumption of 200 horse-power-hours per month is reached, when there is a drop to 2.79 cents per horse-power-hour, or 3.72 cents per kilowatt-hour. If a consumer in Hamilton uses 2000 horse-power-hours per month, his bill is made out at 60 per cent. less than the maximum rate, and the net charge for the energy is 1.2 cents per horse-power-hour, or 1.6 cents per kilowatt-hour.

For 2600 horse-power-hours per month the rate is 1.05 cents per horse-power-hour, or 1.4 cents per kilowatt-hour. On the basis of twenty-six working days per month, a consumption of 100 horse-power-hours per day, or 10 H. P. used continuously during ten hours per day, amounts to 2600 horse-power-hours, and would take the 1.4-cent rate per kilowatt-hour. If the consumption of energy reaches 2900 horse-power-hours per month the net rate is 1.005 cents per horse-power-hour.

In Buffalo the charge for electric power varies not only with the amount of energy consumed per month, but also with the maximum demand. For less than 1000 kilowatt-hours per month the rate is 2 cents per kilowatt-hour, plus $1 per kilowatt of the maximum load or demand at any time during the month. If this maximum demand is 8 K. W., and the consumption of energy amounts to 800 kilowatt-hours, as might fairly be the case with a 10-H. P. motor working on variable loads during a month of twenty-six ten-hour days, the entire charge for the 800 kilowatt-hours is $24, or 3 cents per kilowatt-hour.

A maximum demand of 80 K. W., and a monthly consumption of 10,000 kilowatt-hours in motors, by a customer of the Buffalo system, is charged for at the total rate of $160, or 1.6 cents per kilowatt-hour. Such a maximum demand and total consumption of energy might readily occur where an electric motor of 100 H. P. was in use on a variable load during 260 hours per month. If the motors of a consumer on the Buffalo system show a maximum load of 125 K. W., and consume 72,000 kilowatt-hours per month, as might be the case with motors rated at 150 H. P., and operated twenty-four hours daily for thirty days, the total charge for the electric energy would be $500.20, or 0.69 cent per kilowatt-hour.

Comparing the charges at Niagara Falls, Hamilton and Buffalo, on a meter basis, for small consumers, it may be noted that the maximum rate at Niagara Falls is 3 cents, at Hamilton 4 cents, and at Buffalo 2 cents per kilowatt-hour plus $1 per kilowatt of maximum demand. As above pointed out, in a case where the number of kilowatt-hours consumed was 100 times as great as the number of kilowatts of maximum load, the rate at Buffalo amounted to 3 cents per kilowatt-hour.

On this basis the rate to small consumers at Buffalo equals that at Niagara Falls, and is only 75 per cent. of that at Hamilton. If, under the Buffalo rates, a consumer uses any number of kilowatt-hours up to 1000, with motors operating under uniform load during a month of thirty 24-hour days, or 720 hours, the charge to him will be 2.139 cents per kilowatt-hour. A motor drawing 1 K. W. from the line every hour in the day and every day in the month would take this rate.

FIG. 9.—DISCHARGE OF THE 20-K. W. TRANSFORMER IN THE DE FOREST ST. LOUIS EXPOSITION STATION. SPARK GAP ONE INCH. SEE PAGE 163

As far as appears from the printed rate of 3 cents per kilowatt-hour at Niagara Falls, it is the same for large and small consumers of electric motive power. At Hamilton, a customer whose motors consume as much as 2175 kilowatt-hours per month gets the service at the rate of 1.44 cents per kilowatt-hour. In Buffalo, the consumption of 2100 kilowatt-hours per month takes the rate of 1.7 cents per kilowatt-hour, if the maximum demand is 10.5 kilowatts. If the 2100 kilowatt-hours are consumed by motors working under uniform load during twenty-four hours per day and thirty days per month, the Buffalo rate per kilowatt-hour drops to 1.34 cents. From these comparisons it appears that the rates for small and moderate amounts of electric power are somewhat lower in Buffalo than in Hamilton.

A school for the study of wireless telegraphy has been instituted in the New York Navy Yard, and at present the class comprises twenty-five. As soon as the students have become proficient they will be assigned as operators to the various stations and war vessels.

In some recent tests of Nernst lamps by Von Gaisberg, in Germany, the energy consumption per candle power ranged from 1.6 watts at the beginning to 2.1 watts at the end of 25 hours, and 3.5 at the end of 700 hours.

The Peat Industry in Sweden

THE peat industry in Sweden, according to United States Consul Bergh, at Gottenborg, is assuming proportions which promise to figure materially in the total of fuel consumption of the country. One company, which has adopted modern methods of treatment of the raw peat, is delivering the fuel at the rate of 5000 tons a year, though operations were begun on a commercial scale hardly twelve months ago. Of this amount, some 3000 tons are taken by the State railways, and are giving much satisfaction. This peat gives only 2 per cent. of ash, and it is naturally much appreciated by stokers. The price is $3.11 a ton, f. o. b. Landvetter, where the bogs are located.

It is also reported that a French-Swedish company is now being organized in the county of Jönköping. The business of the company will be to manufacture peat fuel and peat litter. It is stated that French capitalists have promised to subscribe 800,000 crowns ($214,400) for this purpose if Swedes interested will guarantee an equal amount.

The Scandinavian peninsula has vast peat bogs, and it is expected that the example set at the Landvetter bogs of the application of modern methods of production will result in a great increase in tonnage during the next decade. This is especially important in these countries, which mine little coal.

FIG. 10.—ANOTHER DISCHARGE OF THE DE FOREST TRANSFORMER. SEE PAGE 163

In a paper by Dr. Rideal and Dr. Baines, read before the Sanitary Institute at Glasgow, it was stated that complete sterilization was effected within twenty-four hours in a flask of polluted water by placing a piece of copper foil in it.

Plowing with Electric Power in Germany

By LOUIS J. MAGEE

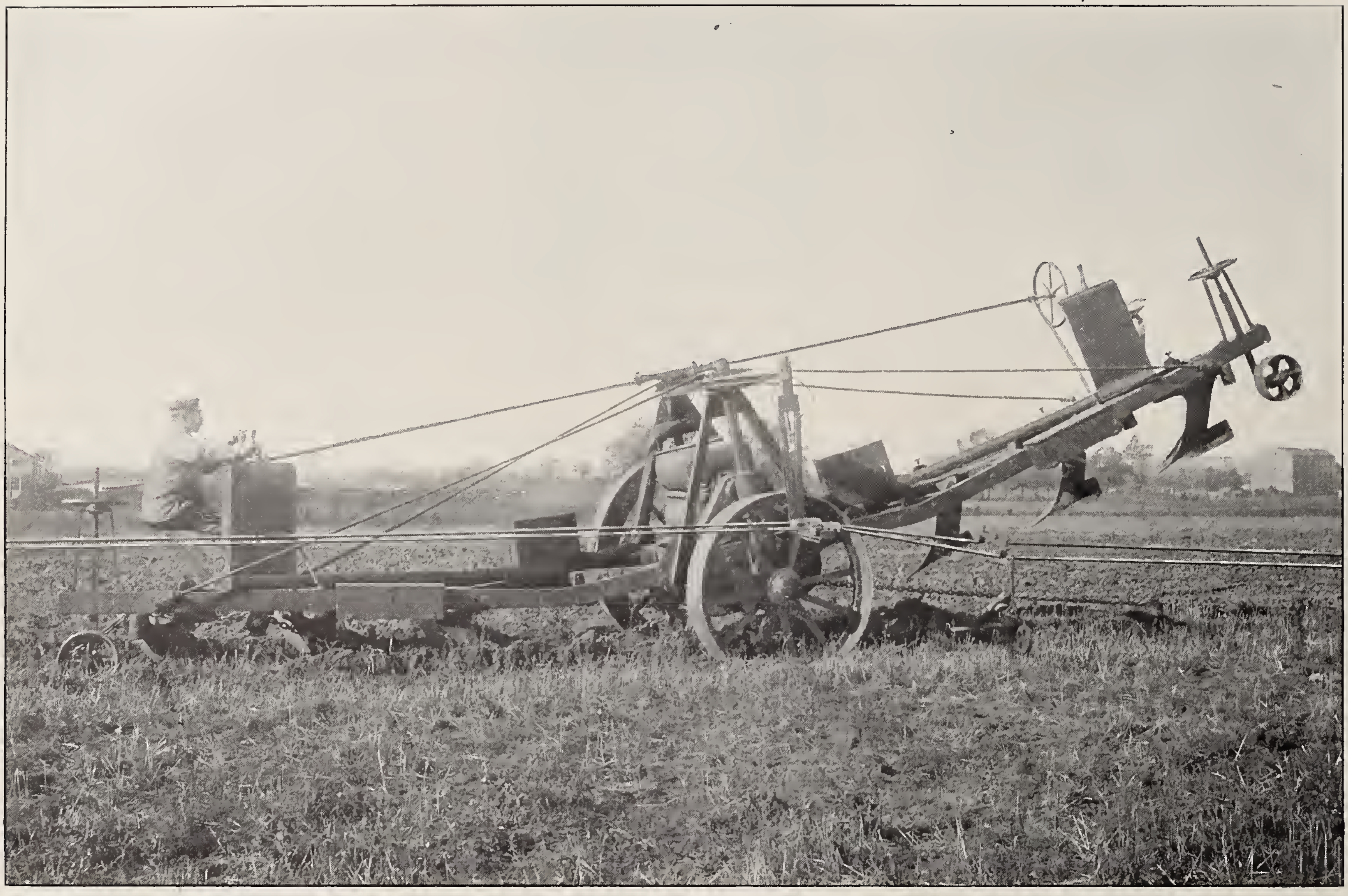


FIG. 1.—THIS ELECTRICALLY DRIVEN PLOW HAS ITS OWN MOTOR, TAKING CURRENT FROM, AND RETURNING IT TO, THE TROLLEY WIRES WHICH ARE CLEARLY SEEN. ON THE COMPLETION OF EACH FURROW, THE PLOW PICKED UP THE LITTLE TRIPOD SHOWN IN THE FOREGROUND AT THE RIGHT, SUPPORTING THE CONDUCTORS, AND MOVED IT OVER THE PROPER DISTANCE FOR THE NEXT FURROW

ALTHOUGH Germany is an industrial country exporting a far greater value of manufactured articles even than do the United States, it is at the same time the third grain producing country in the world. The sugar beet and potato crops are also enormous. German electrical firms have been very assiduous in cultivating their agrarian customers, and many of the large estates are equipped more or less thoroughly with electrically driven labor-saving appliances, such as drainage pumps, threshing machines, beet and fodder choppers and churns.

Electro plowing has been a favorite theme for discussion and frequent experiments have been made. A prize competition even was held several years ago. Most of the plows have followed the steam plow idea as developed especially by John Fowler in England. These steam plows work either by the two-machine system—that is, a pair of engines at opposite ends of the field, dragging the plow proper back and forth between them, or a single engine on one side and an anchor wagon at the opposite end of the furrow, serving as a support for the other end of the cable loop.

One of the most interesting attempts to solve the electric plow problem was made about four years ago on a large estate in Germany. This was a radical departure from the steam plow system, in that the plow proper was furnished with its own motor and dragged itself over the field on a heavy chain, just as the steamers on the Elbe, in Germany, drag themselves up stream from Dresden on the chain. The amusing element in this system, illustrated in Fig. 1, was the automatic transplanting of the "trolley line." As the plow passed, it picked up the little tripods which supported the conductors and moved them over to a proper distance for the next furrow.

Aside from some mechanical difficulties with the winding drum, which were most ingeniously overcome, there were no great obstacles. The system worked fairly well, its advantages being that the plow was self-contained, requiring no heavy winding engine at the edge of the field. The disadvantage lay chiefly in the fact that the weight of the motor (about 30-H. P. railway type continuous current), controllers, chain, drum, etc., had to be carried continually over uneven ground unsuitable for even broad wheels. The current consumption was naturally higher than by the other system, and it was difficult to find a long

FIG. 2.—ELECTRIC PLOWING EQUIPMENT COMPLETE. THE TRANSFORMER WAGON IS SHOWN IN THE BACKGROUND, BEHIND THE PLOW

FIG. 3.—THE TRANSFORMER WAGON IS HERE SHOWN IN ITS OPERATING POSITION, NEAR THE POLE CARRYING THE ELECTRIC TRANSMISSION LINE AND CONNECTED, FROM ITS OWN MAST, WITH THAT LINE

chain that would stand the great strain due to very soft, hilly or stony soil. Practically all interruptions were due to chain defects. As far as I know, no one else has taken up this system of late.

The equipment shown in all the other illustrations accompanying this article represents no especially new system, but is interesting rather because it is a success, and is the result of persistent effort to do away with the numerous petty mechanical difficulties which have hitherto made this application of the electric motor experimental.

These trials were begun in the late autumn of 1902, about 65 acres being worked then and in the ensuing spring, partly under weather conditions that made horse plowing quite impossible. The results again last summer, after a new winding engine had been built, were so entirely satisfactory that there seems now to be no trouble with electric plowing if the local conditions permit of it.

FIG. 4.—THE PLOW USED IN THE PRESENT OPERATIONS

The supply of energy is, of course, a prohibiting condition in some cases, and undoubtedly accounts for the slow development of electric drive for large agricultural implements. In this case the current supply company showed initiative which constituted just the deciding element. The Berggeist Company (a creation of the important "Gesellschaft für Elek. Unternehmungen," of Berlin) was formed to build a central station directly adjacent to a lignite mine at Brühl, near Bonn, and distribute three-phase current over an extensive district including thirty-five communities. Besides house, hotel and street lighting and power for some factories, there were motors installed for small "home industries" and some farms lying between the towns.

Commercially speaking (to digress a moment), the rentability of such cross-country plants, or as they call them, "Ueberland Centralen," is not beyond question. The exceedingly economical producer gas plants have been lively competitors of the electric motor. (A small suction plant for lignite brickets operates for one-eighth to one-quarter of a cent fuel costs per horse-power-hour.) The farmer or small factory owner can have a steam "locomobile" (portable engine type), for instance, of 45-H. P., which requires the equivalent of only about 1.32 pounds of coal for an effective horse-power-hour. This remarkable economy is combined with great simplicity, in so far as no boiler setting, special engine foundations or piping

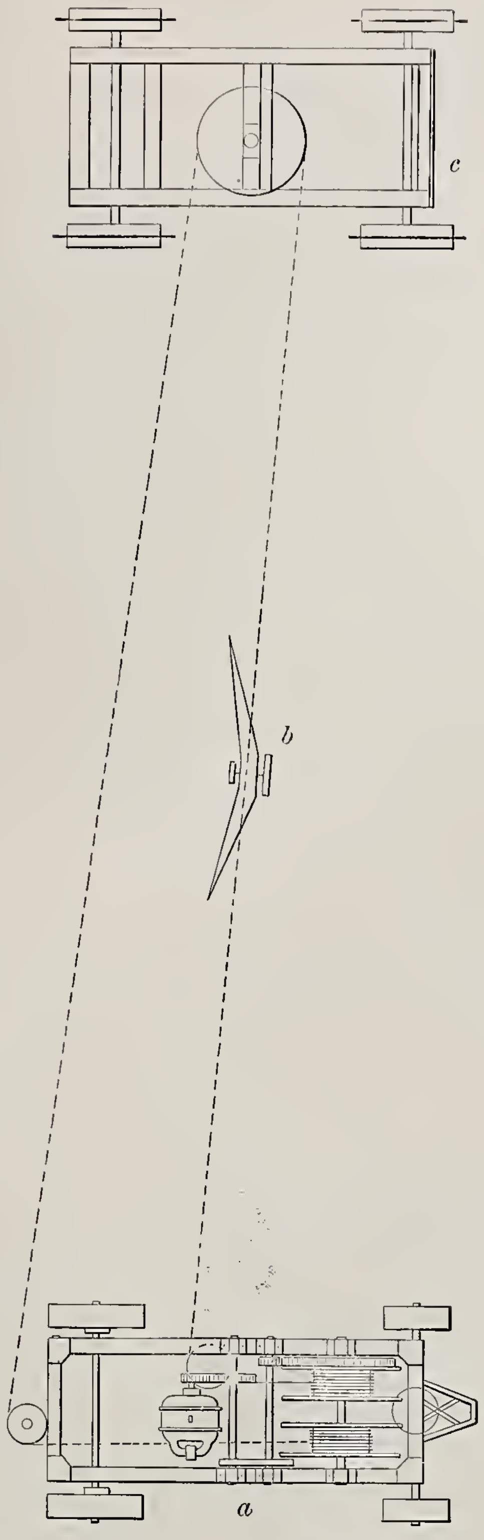


FIG. 5.—THE GENERAL LAYOUT FOR ELECTRIC PLOWING

are necessary. Spirit from potatoes is very cheap, and its use for power is being encouraged by the government.

One German firm, manufacturing electric plants, installed isolated farm plants in Brendenburg and Pomerania, and that district has called for 1850 H. P. in small motors, 22,000 incandescent lamps and 150 arc lamps, using for prime movers sixty ordinary steam engines, sixteen stationary "locomobiles," nine gas and spirit engines and eighteen hydraulic turbines. But the expensive attention, cost of re-

FIG. 6.—HAULING A LOAD OF BEETS OVER THE FIELDS TO THE ROAD BY ELECTRIC POWER. THERE HORSES TAKE UP THE BURDEN

pairs and various troubles connected with isolated plants make central station supply very desirable to farmers, especially for plowing, threshing or any service that requires a considerable current supply for a brief season. The interest in this direction is shown by the new co-operative cross-country plant, Vangerow-Breitenfelde, built especially for agricultural service. It has 65 miles of line and serves over thirty estates. The most distant substation is about 22 miles from the power house.

But to return to our plant at Brühl—it has gradually worked up a good business and erected an extensive network of conductors through the farms of that district. The Berggeist Company, in seeking customers on the farms, had to develop a plow. What seems to have helped materially to success was the transformer wagon—a sub-station on wheels. This is connected to the nearest high-voltage primary leads, and furnishes current at 220 volts to the winding engine motor through a flexible cable 660 feet long, lying on the ground. Thus the winding wagon has a distance of 1320 feet along the end of the field within which it can move for one connection. In fifteen minutes the substation can be transferred and connected for the next center of action.

Fig. 2 shows the whole equipment, the transformer wagon being behind the plow at the right. Fig. 3 shows the transformer wagon in operating position near the pole, connected from its own mast to the line. The diagrams Figs. 5 and 7 show the general arrangement. In Fig. 5, *a* is the winding wagon; *b*, the double plow, also shown in Fig. 4; and *c* is the automatically progressing anchor wagon. This latter is shown also in Fig. 10. At first the winding wagon had its drums arranged as indicated in Fig. 7, but this disposition caused heavy wear on the cables when they were not quite at right angles to the wagon. The position of the drums was then changed as shown at *a*, and finally put about halfway between the front and rear axles.

Figs. 8 and 9 show front and rear views of the latest type of winding wagon. Fig. 10 shows the plow arrived at the anchor wagon. In Fig. 6 a load of beets is being drawn out to the road, where the horses can then easily manage it—an incidental use of the equipment which appealed to the farmers. A combined cultivator was also operated in place of the plow. The anchor wagon wheels have rims at right angles to their broad tires to prevent lateral slip. Underneath the wagon is a horizontal sheave over

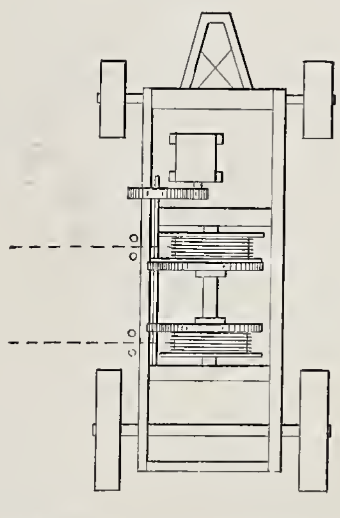


FIG. 7.—THE ORIGINAL ARRANGEMENT OF THE WINDING WAGON

which the plow cable runs. When the plow is leaving the anchor wagon this sheave causes a small drum above to turn with it, thus slowly winding a cable anchored at the extremity of the field. The anchor wagon thus gradually works toward the last furrow in

FIG. 8.—FRONT VIEW OF THE LATEST TYPE OF WINDING WAGON USED FOR ELECTRIC PLOWING BY THE BERGGEIST ELECTRIC CO., OF BERLIN

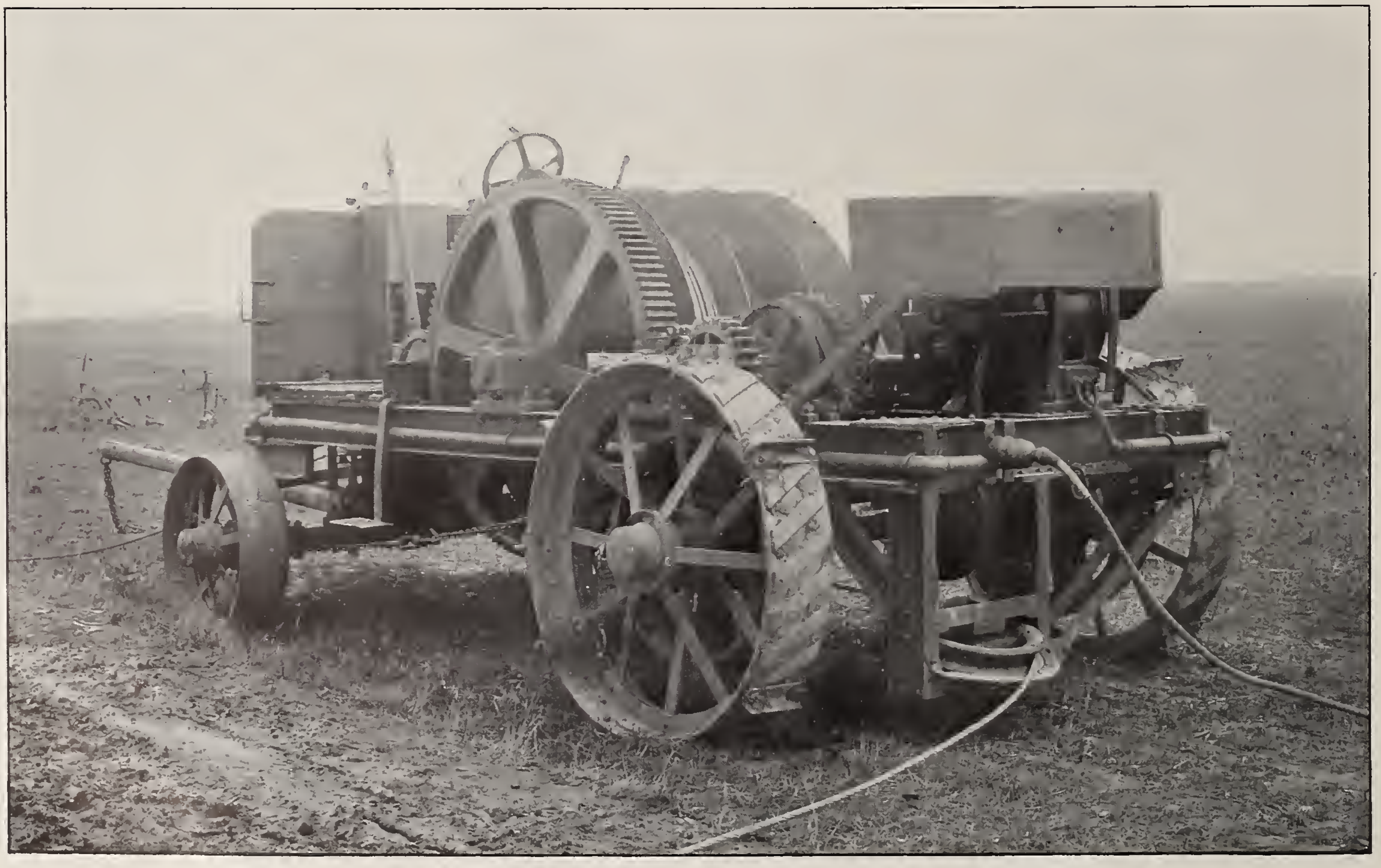


FIG. 9.—A REAR VIEW OF THE WAGON ABOVE

a line parallel with that taken by the automobile winding wagon.

In spite of the provisional character of the first equipment, the results were highly satisfactory. The motor was of 35 H. P. Owing to the small capacity of the drums, furrows only 990 feet long (15 chains) and 11½ inches deep could be made. The plow made over 5 acres per day with a plowing breadth of 3½ feet, three shares, and a speed of 170 feet per minute.

The improved winding machine shown in Fig. 8 weighs 8 tons, and each drum carries 4000 feet of cable. Furrows 1500 feet long and 14 inches deep have been plowed with its aid; fertilizer subsoil plowing and a variety of other work have also been done with it. A three share plow could make speeds up to 280 feet a minute and a daily run of 9 acres.

The total cost of electric energy was 60 to 90 cents an acre, according to length and depth of furrow. For a farm which has work for a plow on about 300 acres, the cost per acre would be about $2, counting the first cost of the plow equipment at about $3000, and assuming current supply from a distant central station.

Electric plowing will probably become popular in Germany if the capitalists who build the power transmission plants begin as the Berggeist Company intends to do by owning the equipments and renting them to the farmers.

In a lecture on "Electrical Engineering and Engineers," delivered in the Sibley Auditorium of Cornell University, Mr. Charles F. Scott, of the Westinghouse Electric & Manufacturing Company, spoke on the qualities and traits which predominate in successful and useful men of the present day. The more important of these he considered to be a keen sense of observation in all things, as this enabled a man to render quickly, good, sound, common-sense judgment; also the quality or trait of being able to get along well with one's fellow men. He mentioned several cases in which men of high faculty had become failures, owing to their inability to conform themselves to circumstances and act in harmony with their fellow workers.

A telephone system has just been installed by the Lehigh Valley Railroad covering all its lines from New York to Buffalo. The main lines are strung on poles parallel with the telegraph wires, and are connected into private branch exchanges located along the line of the road. The longest line is 310 miles.

FIG. 10.—THE PLOW IS HERE SHOWN APPROACHING THE ANCHOR WAGON. NOTE THE WHEEL TIRES AND RIGHT-ANGLE RIMS OF THESE TO PREVENT LATERAL SLIPPING

The Evolution of Electric Traction

By FRANK J. SPRAGUE

Remarks at the Recent Annual Dinner of the American Institute of Electrical Engineers

TO Thomas Davenport, blacksmith, of Brandon, Vt., belongs the honor of making the first recorded experiment in electric traction, for in 1834 he showed at Springfield, and again in Boston, a toy model, mounted on wheels, and propelled a few feet on a circular railway by the current from a primary battery. This was but one of his accomplishments, for history relates that in a few years he constructed and put into operation no less than a hundred motors of a type now of course obsolete.

Four years later Robert Davidson, of Aberdeen, constructed an electric locomotive, which was tried on the Edinburgh-Glasgow Railway. In 1847 Moses G. Farmer, one of the most prolific of early experimenters, exhibited a small electric model at Dover, N. H., and three years later, in Boston, Thomas Hall showed an automatically reversing motor. The next year Professor Page, of the Smithsonian Institute, with Congressional help, equipped and ran an electric car on a road near Washington.

All these and various other experiments of those early years depended on the use of primary batteries, and hence, irrespective of the shortcomings of the machines themselves, commercial success was impossible. It was not until the invention by Pacinotti, in 1861, of the continuous-current dynamo, improved and developed by Siemens, Whitestone, Varley, Rowland and others, and the discovery of the reversible functions of the dynamo-electric machine said to have been made originally by Pacinotti in 1867, but certainly proved, some say, at first by accident, by Gramme and Fontaine in 1873, that the key to the electrical transmission of energy was found.

Between this date and the beginning of experimental work on modern lines I find a mention of but one name, that of George Greene, a poor mechanic in Kalamazoo, Mich., who built a model car operated from a battery current passing through the track and an overhead wire.

About four years later three inventors, whose names are known the world over, became almost simultaneously and independently interested in electric railways. These were Dr. Werner Siemens, Stephen D. Field and Thomas A. Edison. To Dr. Siemens belongs the credit of actually operating from a dynamo the first road for carrying passengers; this was accomplished at the Berlin Exposition in 1879. A toy-like affair it was,—a miniature locomotive pulling three small cars, which seated about twenty passengers. As illustrating how trivial facts connected with early experiments stand out, one of the younger Siemens recently told me quite some anxiety was displayed when it was found that to accommodate the German emperor, a man of large physique, one of the division arms with which these small cars were provided, had to be removed. I note that this practice has been extended to the New York subway to provide room for Manhattan's everyday emperors.

This demonstration by Siemens was followed by other exhibition equipments, and in 1881 by the installation of a short line with one car at Lichterfelde, near Berlin, the first commercial electric railway. This was followed by others, and also by an ambitious project for an elevated railway in Vienna.

In 1879 Field filed a caveat, showing an electric railway taking current from a wire inclosed in a slot, and in 1881 made experiments in Stockbridge, Mass. In 1880, Edison, utilizing one of his old "Z" lighting dynamos, constructed and operated a small road in a yard of his laboratory at Menlo Park, using the two rails as conductors.

About this time various other inventors began to take up the study of the subject, and Jenkins, Ayrton and Perry began the development of telpherage or automobile railways. Chance is often responsible for inventions, and perhaps for my own entry into the railway field, for although I had become interested as early as 1879 in the possibilities of a somewhat eccentric motor, it was not until 1882, when my duties as a member of a jury at the Crystal Palace, Sydenham, London, took me on the underground railroad, that I seriously considered this special problem. I became interested in a project for operating that road by adopting the general system of constant potential supply developed by Edison for electric lighting, and used the tracks as one conductor, an overhead wire supported by the roof as the other, and made contact with the latter by a roller carried on a spring-supported saddle,—a forerunner of the modern trolley.

My ambition in this and other electric affairs cost the navy a possible admiral, and my friends much annoyance, for I very shortly afterwards resigned from the service and returned to America in 1883. In this year Field and Edison combined forces, and exhibited at the Chicago Railway Exhibition a locomotive called the Judge, which ran around the gallery, the motor used being a Weston electric dynamo. Siemens also installed the first line in Great Britain,—that at Portrush, Ireland, and another short line was installed at Brighton by Magnus Volk. Charles J. Van Depoele, a woodcarver by trade, but an electrician at heart and an indefatigable worker, began experiments at his factory in Chicago, using a 5-light dynamo on a car platform, and taking current from a wire laid in a slotted plank; he followed this by the installation of a short line at the Industrial Exhibition.

It was also in 1883 that that veteran of early struggles, Leo Daft, began his labors at Greenville, N. J., following them that fall with the operation of the Ampere at Saratoga, and soon after with small roads elsewhere. Bently and Knight began their experiments in the yards of the Brush Electric Company, and in the following year they installed a short conduit line in Cleveland, which was spasmodically operated during that winter. At this time Van Depoele operated a road in the Toronto Exhibition, and Anthony Reckenzaum, a particularly able engineer, actively conducted storage battery work abroad. The year 1885 was prolific. Daft began operations in Baltimore on the Hampden branch of the Union Passenger Railway with two locomotives, this being, I think, the first regularly operated electric railroad in the country. His ambitious work on the Manhattan Elevated Railroad with the Benjamin Franklin was a remarkable effort, but like all efforts then made on that road, as well as those made a number of years afterward, met with but little encouragement.

I had now resumed railway studies, and began the construction of motors for experiments on this road, these being used first on a private track in an old sugar refinery, and then on the elevated railroad in May of the following year. The motors used in the latter case, however, were built along somewhat different lines, being centered on the axles of regular trucks geared to them and freely supported at one end; this practice was subsequently generally adopted, but after some months I, too, quit, and then tried the construction of an electric locomotive car.

Meanwhile Van Depoele had begun operations at South Bend and Minneapolis, Henry had installed a small line in Kansas City, and Short had embarked on experiments with a series system at Denver. That year and the next two years saw active work by all of us who had ventured in this new field, some with central station power and others with storage battery supply. Van Depoele and Daft were responsible for the principal roads actually installed at this time.

Reviewing the conditions at the beginning of 1887, statistics compiled by Mr. T. C. Martin, including every kind of equipment, showed but nine installations in Europe and ten in the United States, with an aggregate of less than 60 miles of track and about 100 motors and motor cars. These were characterized by the utmost diversity of practice. There were high and low pressures; third rail and side contact; slotted overhead tubes; single and double overhead wires; single and double carriages on them; and upward-pressing arms carried on the cars. The motors were of varied construction and control, generally carried on a locomotive or on the front platform of the car, and connected to one wheel by a friction or chain drive. The cars were usually single-ended and controlled from one point. The art was in a chaotic state, and a commercial opportunity on a large scale as well as some departures in practice were necessary to bring home to railway men the possibilities of electric traction, which even then were thrusting themselves into prominence. That opportunity, the equipment of the Richmond Union Passenger Railway, fell by good fortune to my company, and that year may be fairly said to mark the beginning of active development.

Looking back these nearly twenty years, I am reminded of the cry of the prophet, "Oh, ye of little faith," and yet I for one, and I think I may speak for most of the others, would not have had it otherwise; for whether it be on the battle field or in civil pursuits, there is no victory so sweet as that wrung from almost certain defeat, and if you need encouragement in present or future struggles, let me bid you ask concerning the electric traction record from 1879 to 1888. You will be told of cynicism, ridicule and unbelief, of unremitting labor and disappointment, of poverty, sickness, wreck and ruin, but you will also be told of the inspirations, the exalted moments, the hopes realized and of the victories won.

The years between 1888 and 1898 were marked by continued and vital improvements in electrical apparatus and equipments, among which must be specially mentioned the introduction of the carbon brush of Van Depoele, the Thomson magnetic blowout by Potter, form-wound armatures by Eickemeyer, and the combination of resistance and series parallel control, which was originally proposed by Hopkinson in 1880. Cast iron gave way to steel, two-pole motors to four-pole, self-open motors to closed and self-protected, and the single gear again resumed sway. The single trolley retained first place, as it still does, when we consider simplicity, effectiveness and minimum first cost.

The Allegheny and Boston conduits had been abandoned, but in 1893 a short line was tried in Washington on the Love conduit system, and in the following year work was begun in New York on the Lenox Avenue line and carried to that successful conclusion which warranted the adoption of the conduit system there, under the auspices of William Whitney and Henry Vreeland. The conduit system was soon afterward installed in Washington under Connett, although a line had been in operation on this system at Budapest for some time.

Train operation as distinguished from that of single cars began on the South London Railway in 1890, and this was followed by various proposals for the New York Elevated Railroad, the installation of the Intramural road at the World's Fair, Chicago, the equipment of the Lake Street Elevated Railway, and by other installations. Heavy electric locomotives were built in 1892 and 1893, both for experimental work and for regular operation in the Baltimore & Ohio tunnel.

Meanwhile the limitations of direct-current motor work were greatly extended by developments in polyphase transmission, and the transformation of alternating current into direct current at a lower pressure by static and rotary transformers, through the work of Tesla, Stanley, Scott and others. The first actual proposal to use this combination was made in 1896 by Mr. Arnold, past president of the American Institute of Electrical Engineers, and it has now become standard practice. One immediate result of this was the rapid introduction of comparatively long-distance high-speed interurban electric railway lines, which, although generally operating single cars, have exerted a great influence upon steam railways and been instrumental in welding together urban and rural communities.

But with all these advances train operation was still limited, and largely because of adherence to old-established locomotive practice. Having been for a long time engaged in developing the indirect control of elevators, the thought suddenly flashed upon me that trains could be better operated by simultaneously operating a number of controllers, each with its own motors, thus allowing any desired aggregation of independent units in a train having all the characteristics of the individual. This, known as the "multiple unit" system, received its baptism on a train of cars at Schenectady in 1897, and was first adopted on the South Side Elevated Railway of Chicago, although I had for a long time plead for an opportunity to make a demonstration on the Manhattan Elevated Railroad of New York, and, in fact, for electric operation in all rapid transit work. It was, of course, a logical development, and has now received the stamp of universal recognition. Some measure of its practical importance may be gathered from the statement that, by reason of the increase in capacity alone it has the potentiality of adding at least $15,000,000 to the capitalized value of the New York subway.

Up to the present time almost all important work has been conducted with continuous-current motors at moderate potentials, but on any large system this requires the transmission of energy from a long distance by high-pressure alternating current, and reduction to a lower pressure and transfomation at sub-stations.

To economically extend the radius of electric operation from these substations it is, of course, essential to work at comparatively high pressure. In order to attain this end without running into serious or assumed difficulties with continuous-current motors, as well as to get rid of the moving element in sub-stations, the activities of leading engineers, among whom must be mentioned Tesla, Finzi, Lamme, Eichberg and Steinhetz, have for some time been bent on the development of the alternating-current motor. The earlier attempts in this direction were for a machine without a commutator, that is, one that could be operated by polyphase currents, and it is on these lines that the admirable work of the Ganz Company, and the high-speed tests on the Zossen military line in Germany have been carried out. But the recent developments, in America at least, have been almost entirely along lines of single-phase operation, in order to maintain the simplicity of the present trolley line practice. A large measure of success has already been attained in this direction, so much so that the single-phase motor can now be accepted as an essential contribution to railway operation, its adoption being a matter of individual determination. In this connection I should add that Mr. Arnold was one of the earliest, and has been one of the most consistent, advocates of single-phase operation.

Such is a brief and imperfect review of an industrial development whose spidery web has enmeshed our modern life, and is rapidly changing the course of our affairs. And where now are the men who have borne the brunt of the affray? Werner Siemens long ago has passed to his reward, after a life of useful activities. Charley Van Depoele, too, has gone, leaving behind an ineffaceable record. Then Reckenzaum, Henry and Short passed away. But Field, Edison and Daft are with us. Most of my own corps, the boys to whom my heart ever goes out in gratitude and affection, who stood loyally shoulder to shoulder and fought a good fight in the old days, are still living. One of my trusted associates, S. Dana Greene, found sudden death in the icy waters of the Mohawk in the midst of a splendid career, but Oscar T. Crosby, wearing the laurels of an intrepid explorer, has come out of the desolate East after achieving fame and nearly immortality in the frozen peaks and solitude of the Himalayas.

A younger generation is coming to the front, and new and splendid fields await them. The hum of the electric motor is no longer a song only of emancipation, but a hymn of praise, a pæan, challenging on its chosen ground the steam locomotive whose throbs have been rightly called the heart-beats of civilization.

Is it a siren's song? Not if listened to soberly and with the guide of experience. Perhaps I may on this occasion say a few words in answer to that ever-present query, "Will trunk lines be operated electrically?"

We stand in the midst of the solution of grave and complicated problems, incident to the demands of our local situation. Take, for example, the terminal improvements on the New York Central, Pennsylvania and Long Island Railroads, costing nearly $80,000,000, and made possible chiefly because of electric traction,—supplementing the equipment of the surface, elevated and underground railways; these problems may well dazzle the mind and lead to hasty conclusions, forgetting that in so far as they are out of the ordinary many of them are special in character.

Our esteemed senator, Mr. Depew, has been quoted recently as saying that in ten years the only place for a steam locomotive would be a museum. Is the wish father to the thought, or does it mean the awakening of our railway officials to the possibilities of the future? If so, then we indeed have reason to congratulate ourselves, for there is much work ahead. But let us be in no hurry to build museums, for in spite of any development which may take place, our old friend the steam locomotive will be doing business at the end of another decade, although his younger brother will be giving him an interesting tussle.

We have now 30,000 miles to the credit of the electric railway in this country alone, but the character of the traffic and the service performed by these lines is absolutely distinct from that pertaining to trunk line operation. Two hundred thousand miles of road, and over half a million miles of track are in its grasp, a prize worth fighting for, but not easily won. I do not for one moment take the position that a railroad, no matter how large, cannot be operated electrically. It can be. Energy of any amount can be transmitted any distance commercially required. Motors of large power and aggregated into combination will afford a capacity greater than that for which any steam locomotive can be built and perfectly controlled.

With increased power there is the possibility of higher speeds, but a well ballasted track, free from curves, grades and grade crossings, a reserved right-of-way, perfect brakes and signals, infrequent stops, and favoring outward conditions are equally essential to steam or electric traction of the first order.

What, then, will determine the future? Solely the financial factor, as it must determine the future of any other great industrial problem. When the savings in operation and the increased returns from traffic on any road will more than pay a fair dividend on money invested for electrical equipment, then, and then only, will trunk lines, great or small, be operated electrically. As I have often stated, the problem resolves itself into a question of relative density of population and the character of the load factor; these essentials are, of course, vitally connected with the allowable working potential on a trolley line. There is a tendency to assume that the limitation of operations by continuous-current motors has been reached, and that the only possible large development is with alternating-current motors. With all due respect, however, to the alternating-current motor, and every mile it adds to the radius of action, let me caution you not to forget its sister,—the continuous-current motor,—which has as yet by no means reached its limit of usefulness.

Electric Power in New Zealand

According to Consul-General Dillingham at Auckland, L. M. Hancock, an American electrical engineer, recently made a report in which he says that his tour through the colony has impressed him with its wonderful possibilities. He believes that both islands have great resources, which will richly repay investments, and that the development already reached is worthy of great praise.

From his observation of existing conditions he found it evident that the business of the colony is developed to such an extent that larger investments in plants for generating and transmitting power will be profitable; that the climate and the local conditions are such that it is certain that the work will be successful; and that the water-power is ample for all existing needs and all possible future growth. Mr. Hancock states that he has seldom seen so promising a country, and is sure that its people will find that, next to their railways, the utilization of their water-power, by means of electrical transmission of energy, will do more to advance their material interests than any other agency they can employ.

On the subject of electric power for railroads Mr. Hancock counsels caution. The New Zealand railway system would, in his opinion, have to be thoroughly studied before any definite outline of a plan could be recommended. He thinks there is no question that the water-power of the colony is ample to handle the whole system, and that there is no doubtful engineering problem involved. It is purely a question of business policy.

Akron, Ohio, claims to have been the first city in the United States to use an automobile police patrol wagon. It is an electric vehicle and has been in service since 1898.

Electric Cable Making

In Great Britain and on the Continent

By A STAFF CORRESPONDENT

What is given in the following pages is supplementary, in a measure, to the article on the same subject in these pages last month, from the pen of Mr. William Maver, Jr., a well-known cable expert. Mr. Maver, however, in that issue confined his remarks solely to the making and testing of cables in the United States, while in the present instanee British and European practice is outlined.—The Editor.

CABLE-MAKING and covering machinery may be said to have been evolved more or less directly out of that utilized in the wire-rope industry; indeed, the original machinery employed in that industry is now to be seen in improved and modified form performing work in the earlier stages of electrical cable manufacture.

Insulated cables may be divided into several classes, according to the nature of the insulating sheath, whether it be gutta-percha, India rubber, fibre, paper, or other compounds too numerous to mention, and the mode of manufacture varies somewhat, according to which of these various materials is employed. It is not proposed to discuss the various merits and demerits of these several compounds, which all have their advantages and disadvantages, according to the work which they are ultimately intended to perform; suffice it to say that the first-named, viz., gutta-percha, is practically limited in its uses as an insulator to telegraph and telephone conductors and other circuits where the electrical currents to be conveyed are extremely small, whereas the other materials mentioned are universally employed for the insulation of electric light and power conductors. As regards the conductor itself, copper is the metal almost universally used, although aluminium has of late threatened to rival it.

The earlier stages of cable manufacture are the concern of the wire drawer and the rubber manufacturer. Wire drawing, being a familiar process, will not be enlarged upon here, whilst rubber making, which is more or less secret, involving the mechanical and chemical mixing of various ingredients in certain quantities and proportions known only to those concerned, will also be disregarded, and the writer will pass on to cable manufacture proper, taking it for granted that the raw material, wire, India rubber, gutta-percha, etc., has been manufactured up to a certain state which leaves the wire in the shape of hanks or coils, varying in size and length, and the covering material in various forms to be described later in connection with the several processes involved in its manipulation.

One of the earlier processes which precede the actual covering or insulating of a cable is that of tinning the conductor when the latter consists of copper. This consists in applying a thin film of metallic tin to the surface of the copper in order to protect the latter metal from the corrosive action of the free sulphur always present in rubber compounds. This covering of tin is applied only in cases where rubber is used as an insulator, and the process consists in drawing the wire through the contents of a series of tanks, which vary in number, according to the desired thickness of the coating.

The first tank contains a dilute acid mixture corresponding to the flux employed in soldering, and serves to procure a clean, bright, metallic surface on the wire. The second and succeeding baths contain molten tin, usually with a slight admixture of lead, to give the necessary ductility to the coat. These tanks are maintained at a fairly constant temperature by suitably arranged gas jets, in order that the metal may flow freely, and oxidation of the surface is prevented by a layer of tallow or other heavy grease. After leaving the last bath the wire passes through a "snug" or die, of cotton waste or leather, which smooths down the surface and removes any superfluous metal which may adhere and be carried over. The coils of wire after tinning are well washed to remove all traces of acid, which, if left on, would in course of time exercise a corrosive effect upon the metal, and are then thoroughly dried in sawdust or by other suitable means.

A second important process, preceding that of covering, consists in stranding or laying the single conductors to the number of several into a composite conductor or strand which combines the advantage of greater cross-sectional area and consequent current-carrying capacity with those of flexibility and greater capacity for the radiation of heat, all of which are necessary adjuncts to the successful construction of a cable for electric light and power purposes where comparatively heavy currents have to be handled with a minimum loss through fall of potential, overheating and other causes. The strands most commonly adopted consist of 7, 19, 37, 61 and 91, and an even larger number for special purposes, such as the flexible connections between dynamo brushes, electrolytic tanks, etc., all of which call for an extra degree of flexibility to allow greater freedom of manipulation.

Stranding is effected by means of stranding machines, which are of various types and sizes, according to the nature of the work they have to perform. They are all, however, based upon a common principle, viz., that of a number of drums or bobbins, *A*, *B*, *C*, etc., Fig. 1, mounted upon a rotating carrier and feeding their contents, in the shape of single conductors, into a central die or hollow mandrel *X*, which finally closes the strand, and delivers it on to a drum placed to receive it. The drums or bobbins *A*, *B*, *C* are free to revolve on their own axes, and are severally provided with adjustable friction devices which prevent them from overrunning and allowing a sag or slack to form in the conductor as it leaves them. By an ingenious mechanical device they are all maintained in the horizontal position shown, as the carrier revolves, a necessary precaution to prevent the formation of twists and kinks in the wire as it enters the strand. The die *X* is interchangeable, and varies in size according to the diameter of the finished strand. The shaft of the carrier is hollow, and the central conductor of the strand passes through it, being fed horizontally from an extra drum at the rear end of the machine.

The "lay" of the strand or longitudinal dimension embraced by a complete turn of one wire in the strand is regulated by varying the speed of the pull-off gear in relation to the speed of rotation of the carrier and bobbins.

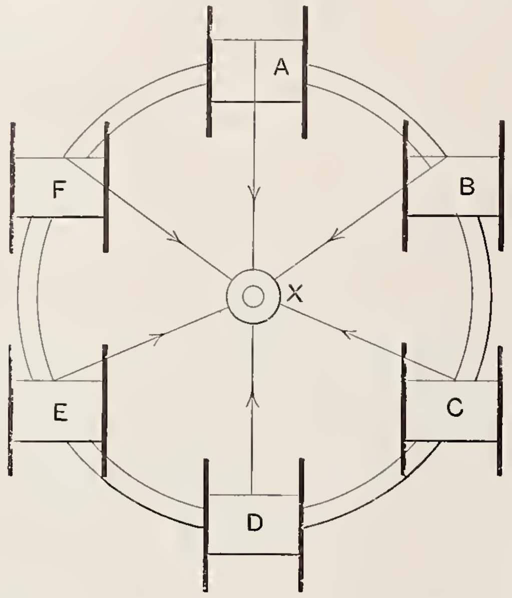


FIG. 1.—THE PRINCIPLE OF THE STRANDING MACHINE

When the number of wires in the strand exceeds seven, *i. e.*, one central wire and six encircling ones, the strand runs into layers, and each successive layer is then put on in a different direction to the foregoing one. For example, if the first layer of six wires in the seven-strand has a right-handed lay, or a twist in the direction normally taken by the hands of a clock, then the next layer of twelve wires, making up a nineteen-strand, will have a left-handed lay, or be arranged counter-clockwise. If this expedient were not resorted to the wires in the outer layers of the strand would tend to fill up the interstices between the wires of those below and thus force the lower wires out of position, besides detracting from the ultimate flexibility of the cable and reducing its total sectional area and radiation efficiency.

The several layers in a compound strand of 19, 37, 61 and 91 wires are frequently put on in one operation by means of suitable stranding machinery arranged tandem fashion, each carrier and its complement of bobbins revolving in an opposite direction to its immediate neighbor on either side. This device has a time-saving value, and is largely adopted in all manufactories where heavy stranding has to be done.

We now come to the actual covering or insulating of the conductor, either in the form of a single wire or one of the many strands whose process of formation has just been discussed. Gutta-percha was among the earliest insulators used in this work and, as its field of utility is somewhat limited, as before mentioned, it will be dealt with first. The earliest forms of gutta-percha covering machinery consisted, in the main, of a closed cylinder and piston *A* and *B*, Fig. 4. The walls of the cylinder were pierced at *a* and *b* to allow the passage of the conductor to be covered, which took the direction shown by the arrowheads. The aperture *b* was fitted with a die bored to the external diameter of the insulated core, and the cylinder *A* was filled with gutta-percha reduced to a plastic state by judicious heating. Pressure was applied to the piston *B*, causing the gutta-percha to exude through the die *b* at a similar rate to the passage of the wire itself, which constituted the moving axis of the die. The trough *C* contained molten Chatterton's compound, a combination consisting of one part Stockholm tar, one part resin and three parts gutta-percha. This compound was maintained in a molten state by the gas jets *c*, *c'*. The object of its presence in the shape of a thin film on the wire before covering was to provide an adhesive layer, and thus effect a sound junction between the gutta-percha and the copper core. A layer of this compound was similarly introduced between successive layers of the gutta-percha, with the same end in view, viz., that of securing a homogeneous coating. A shallow trough of cold water *D*, a few hundred yards or even more in length, served to cool the gutta-percha as it left the die, and thus toughen it before the conductor had an opportunity of sinking through the soft material by virtue of its own weight.

Some trouble was experienced in the manufacture of gutta-percha covering by this device, owing to the presence of air which it was found almost impossible to totally exclude, and which found its way, in the form of minute bubbles, into the substance of the insulating sheath, where its presence, especially in the insulation of submarine cables, caused considerable annoyance. This drawback is eliminated in the modern gutta-percha covering machine, which is the outcome of the inventive genius of Mr. Matthew Gray, and was patented in 1879. By this device, the principle of which is roughly indicated in Fig. 7, air is totally excluded. A pair of rollers, *A* and *B*, grip the pure gutta-percha in the form of sheet, and feed it into the enclosed chamber *C*, whence it is fed forward by the species of Archimedean screw *D* to the die *E*, from which it emerges around the conductor as a traveling axis. A subsequent patent lodged by Mr. Ludwig Loeffler in 1880 provides for the simultaneous application of several coats of gutta-percha to a conductor without the necessity for an intervening film of Chatterton's compound. This is secured by a species of multiple delivery box, consisting of several concentric and adjoining dies, gradually increasing in size as they approach the exterior, and which are all in connection with the gutta-percha receiver, and consequently receive a simultaneous supply of the latter under pressure of the screw *D*.

FIG. 2.—STRANDING MACHINES IN THE WORKS OF MESSRS. W. T. GLOVER & CO., TRAFFORD PARK, MANCHESTER

A similar system of application is adopted, especially in continental practice, with some of the inferior rubber compounds. The more a rubber compound is adulterated with

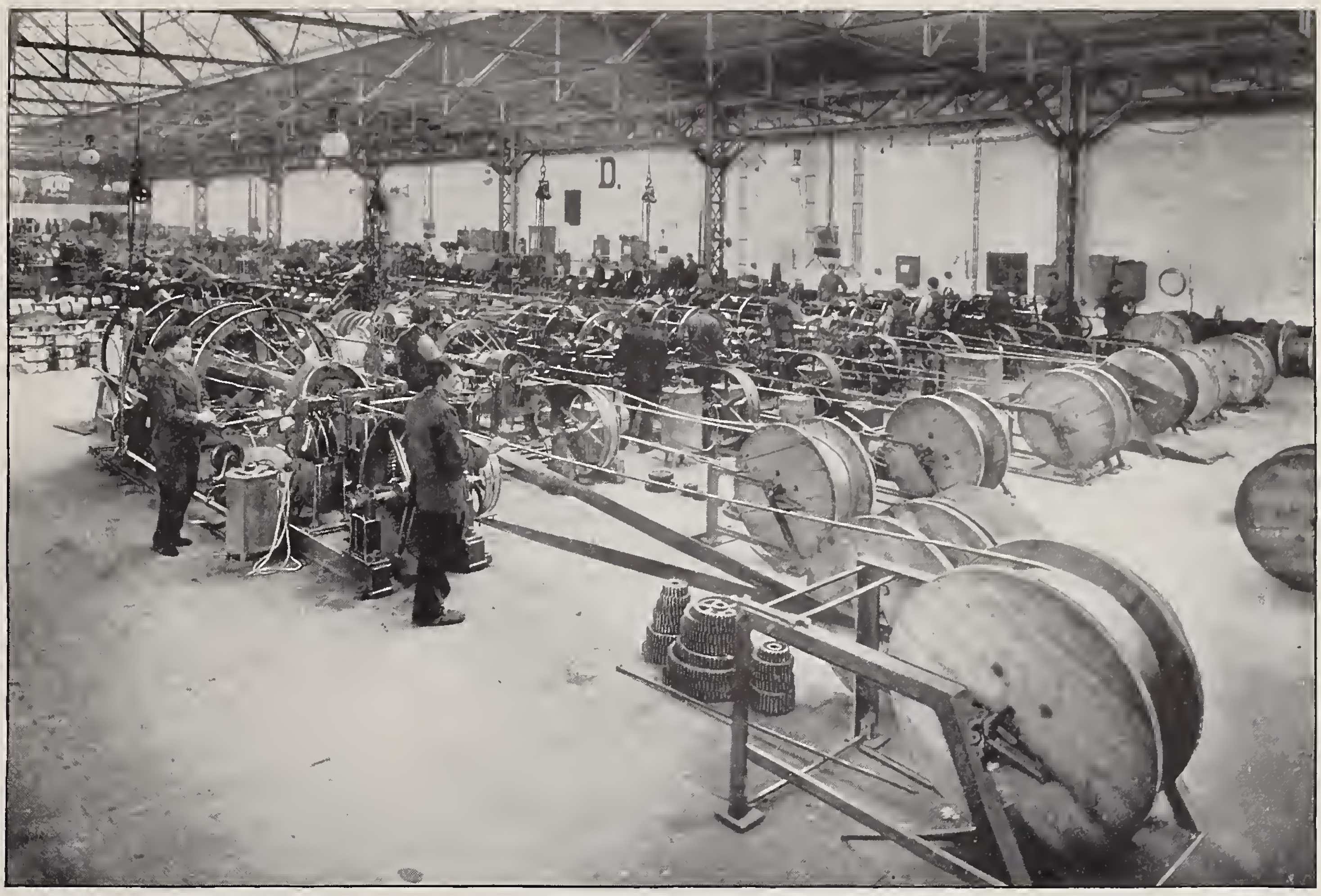


FIG. 3.—CABLE STRANDING BY THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT, BERLIN, GERMANY

foreign elements, the nearer it approaches the consistency of freshly made putty, and this fact was, at any rate in the early days, duly made use of by continental manufacturers as affording a ready and inexpensive means of applying the rubber coating. The process certainly yields an even and homogeneous insulation, and one which can be placed on the market at a comparatively low cost, but rubber-covered conductors insulated in this manner are not to be depended upon, so far as their insulation is concerned, and should be employed only on low-voltage circuits.

The manufacture of rubber-insulated cable as commonly practiced by British makers consists, in the main, of three distinct applications, so far as the rubber itself is concerned, these three grades being determined by the nature of the coating, which is a composite one. Analyzing a typical sample of rubber-covered cable, we find next to the conductor a thin coat of pure Para rubber, which determines, by its thickness and homogeneity, the ultimate electrical resistance of the insulation. Next comes an intermediate layer of compound rubber, which has no sulphur in its constitution and is known as the "separator." The object of this layer is to take up and incorporate in itself, during the process of vulcanization, the excess of sulphur in the outer surrounding layer of compound rubber, which is termed the "jacket," and thus prevent it from reaching the metallic conductor, to the detriment of the latter.

As regards the mode of applying these three coats, the rubber, pure and compound, as received from the manufacturer, is in the form of long sheets, rolled upon a wooden mandrel, centered at its extremities for the purpose of mounting in a lathe or cutting machine. The roll thus mounted is cut, by means of a knife-shaped tool, into sections of varying width, according to the size of the conductor to be covered. The strips thus formed are then applied to the conductor by either of the following methods:—The first, known as "lapping," consists in passing the conductor to be covered through a hollow mandrel *A*, Fig. 8, attached to which, at an angle capable of adjustment, is a spindle and bobbin carrier *B*, controlled by a lock-nut and friction washer, and carrying on the bobbin one of the reels of strip rubber mentioned above. The mandrel and its attached bobbin revolve, at a certain predetermined rate, according to the degree of "lap" required, relatively to the speed of passage of the conductor *a b*, which is operated by suitable pull-off gear.

In applying pure Para strip rubber by this method, considerable friction is maintained by means of the attached lock-nut and washer, between the bobbin *B* and its spindle, in order to stretch the rubber as it meets the conductor and so reduce it to the necessary thinness, besides imparting a binding action by reason of the inherent elasticity of the material, which causes it to form a close and homogeneous coat upon the conductor.

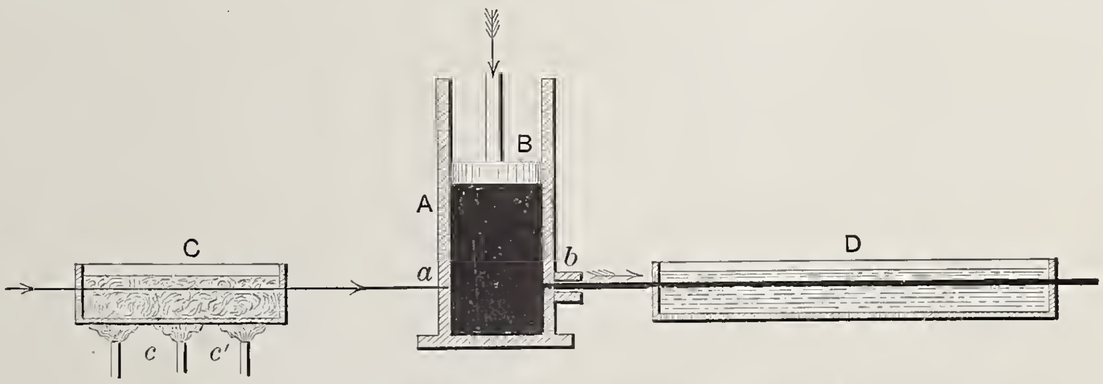


FIG. 4.—AN EARLY FORM OF GUTTA-PERCHA COVERING MACHINE

Compound rubbers, in the shape of separator and jacket, may also be applied in like manner, under a less degree of friction, which is, nevertheless, sufficient to cause the spirals to bed down close upon one another and form a firm, solid layer. The sepa-

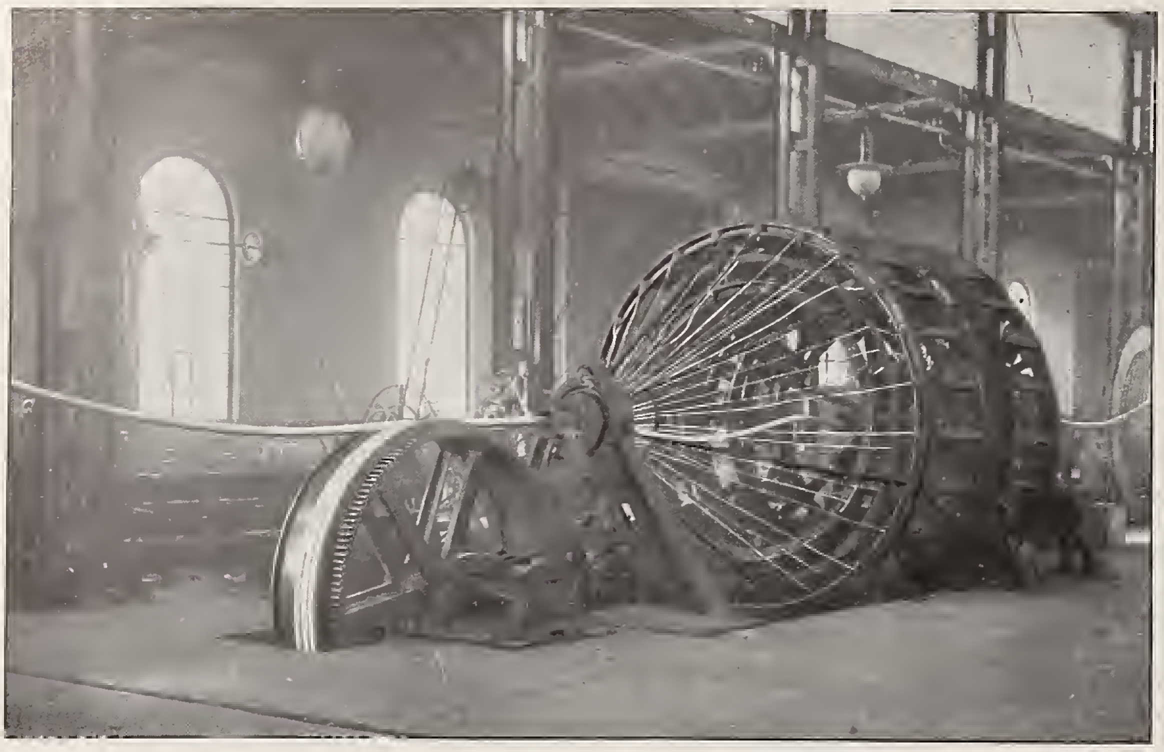


FIG. 5.—A 72-SPOOL COVERING MACHINE USED BY THE SÜDDEUTSCHE KABELWERKE AKTIEN GESELLSCHAFT, MANNHEIM, GERMANY

rator is lapped on in the opposite direction to the preceding coat of pure rubber, and a similar plan is adopted, as in stranding, with the subsequent layers, which are given a right and left-handed lay alternately. These several lapping operations are frequently performed in one operation on a single machine, the several "heads" being arranged tandem fashion, and so geared as to revolve, with their attached bobbins, in alternative opposite directions. The "lapping" system of covering is seldom adopted at the present day for the application of such compound rubbers as the separator and jacket, being somewhat slow and expensive as compared with the more general system known as "longitudinal compression." This system depends for an efficient joint between the various rubber strips forming the crude insulation upon that property of freshly cut, clean rubber surfaces, which causes them to adhere and, as it were, incorporate, one with the other when brought into immediate contact. This useful principle is practically applied to modern cable-covering machinery in the following manner:—In Fig. 11, *A B* represents two accurately turned hard-steel rolls about 6 inches in diameter, placed in contact as shown, geared together through the medium of their axes and attached toothed-wheels, in such a manner as to revolve in opposite directions like the rollers of the domestic mangle. These rolls are semi-circularly grooved, as shown, around their peripheries, in such a manner as to form, when placed in position together, a circle, equal in diameter to the insulated conductor. The conductor itself, *a b*, is passed longitudinally through the center of this circular aperture, in conjunction with two strips of compound rubber, one above and the other below, fed from the bobbins *c d* arranged just behind the active rolls *A B*. The latter revolve in the direction indicated by the arrows, at a peripheral speed equal to the linear speed of the conductor and, carrying the rubber strips along with them, close the latter around the conductor, and, finally, at the meeting point, cut off the superfluous rubber by dint of their accurately turned edges, leaving a perfect longitudinal seam along either side of the covered conductor. The superfluous rubber is fed off into a receptacle ahead of the rolls *A B*, placed to receive it, and can be remanufactured and used over again, so that there is no waste.

One groove only is shown in Fig 11 for the sake of clearness; but, as a rule, two, three, and in the smaller sizes of cable and single conductors six or even more grooves are turned in the same pair of rolls, so that a corresponding number of conductors can be dealt with in one and the same operation, with a considerable saving in time and material. As in the previous system, these sets of rolls are usually arranged in tandem, so that two or more layers may be applied simultaneously.

The next operation to be noted in connection with the manufacture of rubber-covered cables is that of "taping," or the application of a spiral, canvas, waterproof tape to the surface of the covered conductor, its object being to act as a binder to the rubber coatings and secure them in position during the process of vulcanizing, as well as to prevent contiguous turns on the drum or bobbin from adhering to one another by reason of the previously mentioned property of freshly cut rubber surfaces. This waterproof tape is made in the form of sheets by spreading a layer of compound rubber solution upon canvas, the surplus solution being "struck" off by means of a fixed straight-edge under which the sheet pases. The solvents in the solution are ultimately expelled by the aid of heat generated in a steam plate over which the prepared canvas is caused to pass.

The material thus prepared is then made up into a roll upon a suitable mandrel, and is cut by machinery into tapes of various widths. These tapes are applied to the rubber-covered core by a machine having a similar action to that of the rubber lapping machines previously described, the only difference being that a slotted tubular extension is added to the fore part of the revolving mandrel, to act as a guide

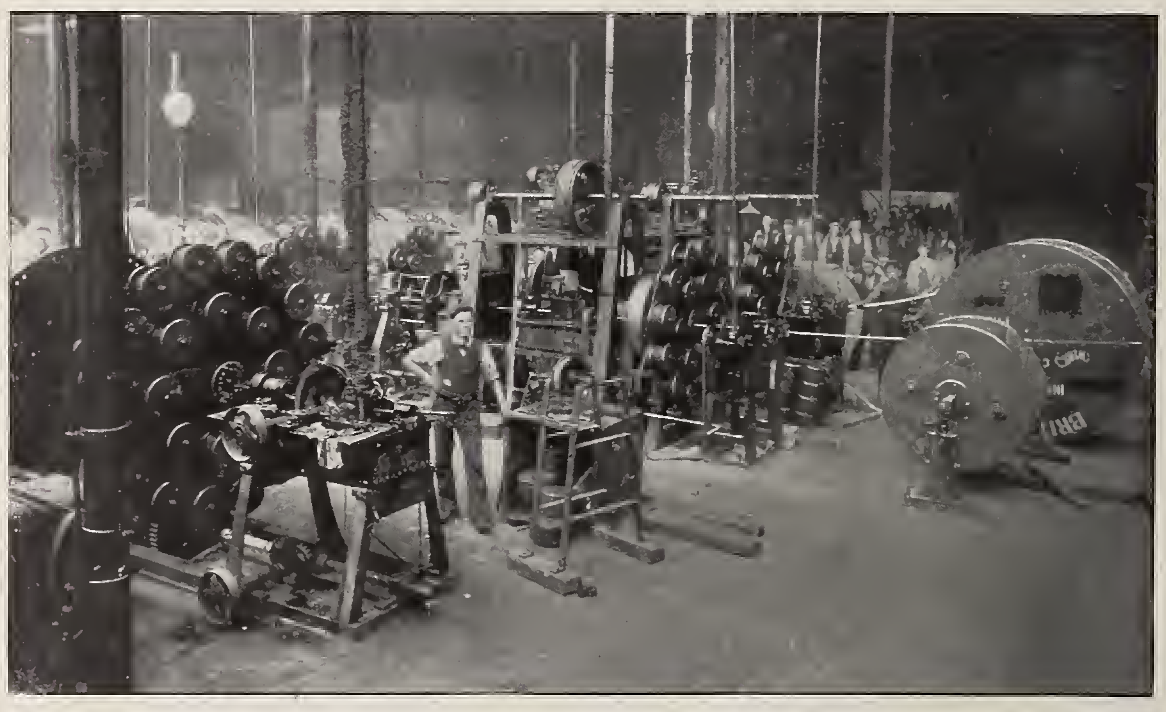


FIG. 6.—CABLING SHOP OF THE BRITISH INSULATED WIRE COMPANY, PRESCOT

to the tape and prevent it from becoming twisted or distorted as it approaches the periphery of the core to be covered. One layer of tape is gen-

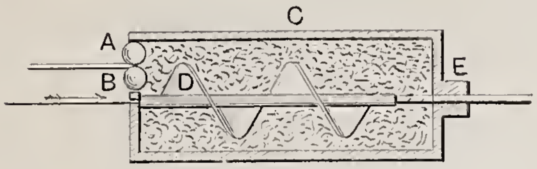


FIG. 7.—A MODERN GUTTA-PERCHA COVERING MACHINE

erally considered sufficient for the purpose, especially in the smaller sizes; but, if considered necessary,—in some cases to form a firm, even bed for the reception of an ultimate lead-sheathing or armoring of iron wires,—two layers are applied, the second coating being given a lay in the opposite direction to the preceding one.

After having received its coat, or coats, of waterproof tape in the above manner, the rubber-covered conductor is ready to undergo vulcanizing, which is effected as follows:—The core to be vulcanized is carefully coiled upon metal drums or bobbins which have been previously padded with some yielding material, such, for instance, as several thicknesses of canvas tape, in order that the soft rubber coating may not be injured by being indented. The coiling is effected in as few layers as possible, in order that there may be as little weight or pressure exerted upon the inner spirals as the capacity of the drum will allow; if these latter be subjected to excessive pressure, the rubber tends to flatten, thus throwing the conductor out of center.

Having been carefully coiled on the bobbins and secured in place by suitable lashings, the extremities are hermetically sealed by a rubber binding, to the total exclusion of moisture, and the whole bobbin is placed bodily into the vulcanizing receiver,—a massive cast-iron cylinder of the requisite dimensions to enable it to contain the largest drum of cable likely to require vulcanizing. This cylinder is fitted with steam attachments, blow-off and

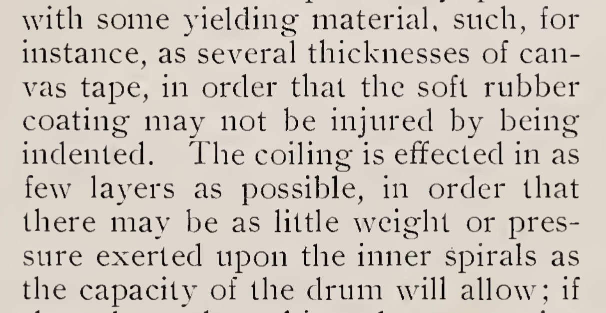


FIG. 8.—LAPPING A CONDUCTOR WITH RUBBER

drain cocks, and a pressure gauge, and is also provided with a recess in its cover to contain a special thermometer, recording temperatures up to three or four hundred degrees Fahrenheit. The cover is flanged and detachable, being secured in position pending the process by a number of bolts and nuts, the joint being made steam-tight by suitable packing introduced between the flanges. The bobbins having been placed in position, the cover is bolted on, and steam is allowed to enter. The pressure of the latter is raised to a certain predetermined point, as indicated on the pressure gauge, and the temperature also is regulated as nearly as possible within certain preconceived limits.

The application is continued for several hours, fresh steam being admitted from time to time in order to compensate for condensation. At the expiration of a stated period the steam is blown off and the cover removed; the contents are then taken out and allowed to cool previous to immersion in a tank of water for the purpose of testing the electrical properties of the insulation. The data respecting steam pressure, temperature, and the time involved in the above operation vary considerably with the nature of the cable undergoing vulcanization, and are largely the result of experience gained by those engaged in the industry.

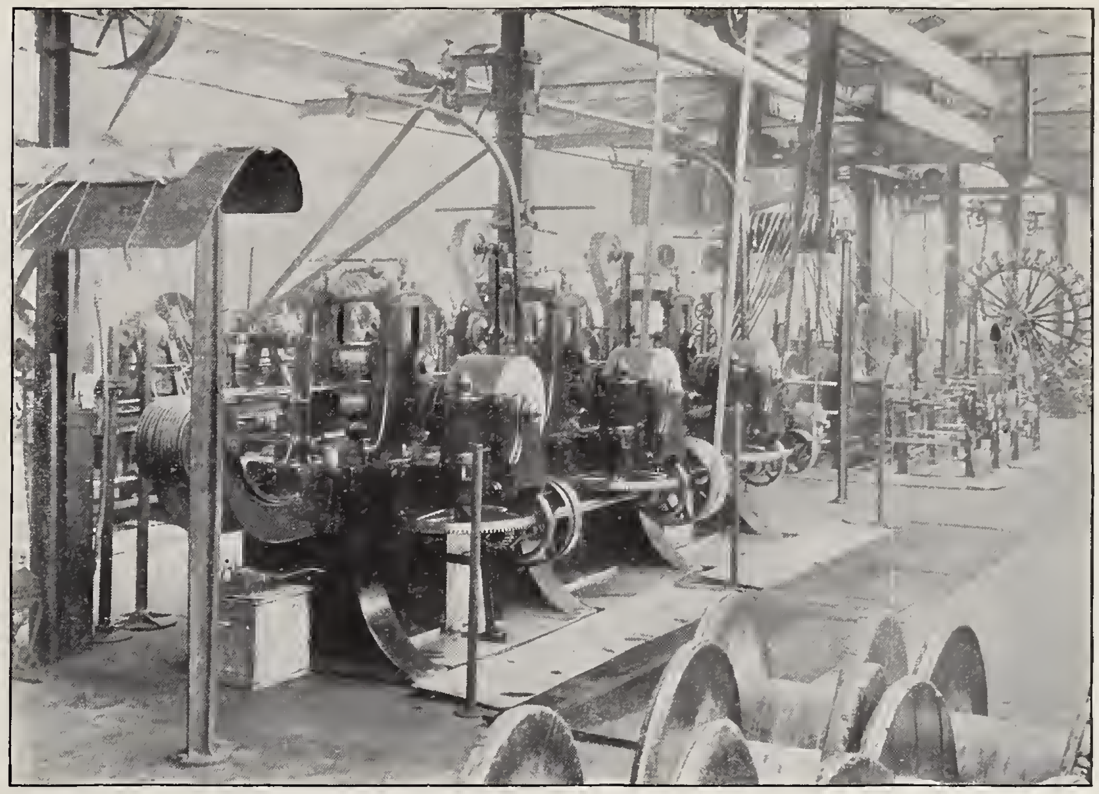


FIG. 9.—RUBBER-COVERING MACHINERY AT THE WORKS OF THE TELEGRAPH MFG. CO., LTD., HELSBY, NEAR WARRINGTON

Having undergone the various testing processes which do not come within the province of this article, the core is ready for the several finishing processes, viz., braiding, compounding, lead-covering, armoring, serving with jute, etc., each of which we will deal with in turn. Braiding is a species of finish given to a cable, chiefly in the smaller sizes, which is to be used for interior work, such as the electric light and power wiring in buildings, and similar situations where the cable is mechanically protected by the encircling trench, conduit or tube. It consists in surrounding the core with a woven or braided sheath of jute or cotton, the former being employed for the larger and the latter for the smaller sizes of conductor.

The process of application is one of the slowest in the whole series of stages involved in cable manufacture, and necessitates an extensive plant to cope with the supply of material from single machines performing the preceding processes.

The braiding machine is a somewhat complicated mechanism, consisting of a series of vertical spindles, carrying the wooden spools of jute or cotton, as the case may be, intergeared with one another, by means of a number of pinions, in such a manner as to pass one another alternately on the inside and outside while rotating, in two distinct sets, in opposite directions. The machinery is almost automatic, so much so, indeed, that one person can look after a series of them, the only attention required being that involved in replacing and splicing from time to time a spool of jute or cotton as it becomes exhausted.

The process subsequent to the above-described one of braiding is known as compounding, and consists in impregnating the jute or cotton braid with a preservative compound which shall at the same time assume an external polish and color, and so impart a selective and glossy finish to the cable. The compounds adopted

FIG. 10.—VULCANIZING AND HARD RUBBER DEPARTMENT, THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT, BERLIN

for the purpose vary considerably in their composition, but usually consist of a beeswax base, with which are incorporated various ingredients and pigments, the prevailing tones for the latter being black and red, the selective colors for the negative and positive poles of a circuit. The impregnating is effected by drawing the braided conductor through a series of tanks containing these various compounds in a molten state, the necessary heat being obtained by the use of steam jackets. The first tank starts the impregnation of the fibrous braid, while the last imparts a final coat. On leaving the last tank, the cable passes through a die of leather or rubber, which removes the superfluous compound from its surface, and finally through a dry pad of leather or canvas, usually applied by hand, which produces a final polish on the otherwise finished cable.

Lead covering or sheathing a cable consists in applying an even and homogeneous layer of lead to the exterior of the insulated core, as a general rule, next to the canvas tape. The lead coating varies in thickness with the size of the cable to be covered, and other details, and its province is to act as an air-tight mechanical protection to the cable and thus render it suitable for laying directly in the ground without any additional preservative in the shape of conduits or trenches. A small percentage of tin is usually alloyed with the lead in order to combat the corrosive action of the surrounding earths.

The application of the metal sheathing to the exterior of the insulated core is effected by the aid of a lead press similar to that used in the manufacture of lead tubing. It is a hydraulic press, mounted on substantial foundations, and fed from a separate pump, or series of pumps. The principle of the device is illustrated in Fig. 15, in which *A* represents the cylinder or "container," filled with lead, maintained in a semi-plastic state by the gas burners *c; B* is the hydraulic ram which exerts a pressure upon the soft mass of metal in *A*, and forces it out through the egress die *C*, around the core to be covered, *a b*, which passes through the press in the direction indicated by the arrows. The die *C* is interchangeable, and its size can be varied to suit the diameter of the cable to be covered.

An external finish is sometimes given to lead-covered cables by serving them with a layer of tarred jute which is afterwards impregnated with a bituminous compound to act as a preservative and binder. This serving and compounding is often effected in one operation by means of a special machine fitted with the necessary heads, arranged tandem fashion. The "serving" head consists usually of a disc or frame *A*, Fig. 16, carrying a number of spindles *a, b, c*, etc., arranged at right angles to one of its faces, and on which are fitted the wooden spools, each carrying a strand of the jute employed in the serving.

These several strands are led radially down after the manner of the wires in a stranding machine, through eyelets 1, 2, 3, etc., which guide them as they leave the bobbin and so prevent them from becoming entangled. From the eyelets the strands pass on to a central die or snug *F*, with the edges of its internal bore rounded, which finally closes them around the cable *B C* as it passes through, in the direction indicated by the arrow. The cable thus served with jute then passes on and around the grooved pulley *E*, which revolves, for the greater portion of its diameter, in the trough *D*. This is steam-jacketed, and contains hot molten compound to impregnate the jute serving. As it finally leaves this tank and pulley the cable is usually whitewashed on its outer surface in order to prevent con-

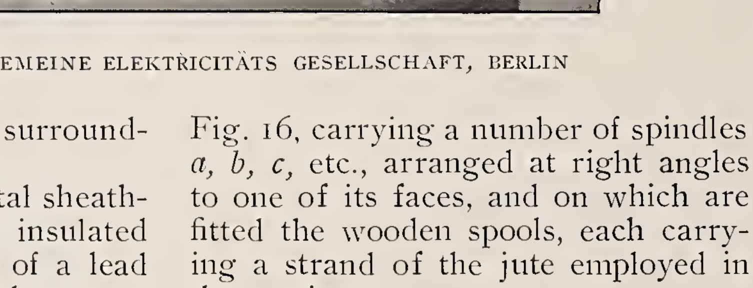


FIG. 11.—RUBBER COVERING BY LONGITUDINAL COMPRESSION

tiguous turns on the receiving drum from sticking together through the medium of the hot compound which retains its heat for a considerable period. Such a serving of jute as the one above described is usually applied to a cable both before and after armoring,—in the first instance to form a bed or foundation to receive the subsequent armor, and in the second to form a protective and weather proof coating over and above the armor itself, both servings being thoroughly impregnated with compound in the manner described above.

The process of armoring a cable may be subdivided under two heads, according to the nature of the armor employed, whether spiral steel or iron wires completely surrounding the cable, or a broad steel tape, lapped on it two layers, the latter of which serves to cover the butt joints between the spirals of the one beneath. The first method is effected in a machine similar to that used for stranding; it is, in point of fact, a stranding machine, the bobbins on the carrier being filled with galvanized iron or steel wires, and the cable to be armored being passed through the hollow mandrel from the rear of the machine, like the central wire of a strand, as before described. The armor is finally closed by a die, and subsequently layers are put on with an opposite lay to the preceding ones. When a bobbin runs out a fresh one is inserted in its place, and a brazed joint is made in the wire. The armoring of a cable with steel tape is effected in a machine similar to that shown in Fig. 8, used for rubber lapping, except that it is of a heavier build, and that the bobbins are filled with steel tape in place of rubber strip. The two layers are applied in one operation by two "heads" similar to that illustrated in Fig. 8, arranged tandem fashion, and so geared as to revolve in opposite directions respectively, thus imparting a right and left-handed lay to the two steel tapes. An armoring of steel tape such as the one described is finished by an outer serving of jute, applied as described in a preceding paragraph and subsequently impregnated with a preservative compound.

Fibrous insulated cables usually consist of a plain, untinned copper strand served with several layers of jute, each in an opposite direction to the preceding one. The serving is effected in a serving machine, such as the one already described, and each layer is thoroughly impregnated with an insulating compound, the composition of which varies enormously with different manufacturers. In order to insure a thorough saturation of the fibres composing the jute, the whole cable is sometimes immersed bodily in a large tank of the compound in question, and subjected to considerable heat for an appreciable period in order to insure the expulsion of all moisture and the absolute saturation of the jute. Cables insulated in this manner are finally sheathed with lead, without which their insulating properties would be of little avail, since all fibrous matter is naturally extremely susceptible to moisture, the presence of which, even in minute quantities, means ruination to the insulation of the cable. For this reason the lead coating must be absolutely homogeneous and free from pinholes or flaws, which are soon rendered apparent, where they exist, by the 24 hours' submersion under water and subsequent electrical tests to which the cables are subjected before finally approved.

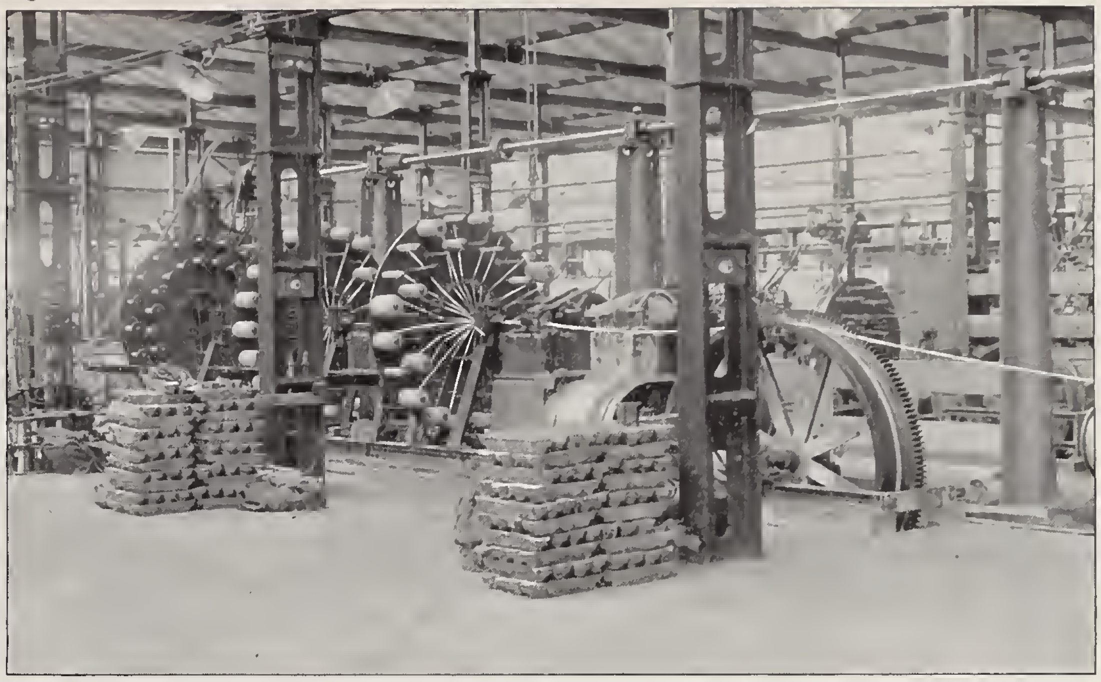


FIG. 12.—SERVING MACHINE IN THE WORKS OF THE TELEGRAPH MFG. CO., LTD.

Paper-insulated cables are also covered in a machine fitted with "heads" similar to the one illustrated in Fig. 8, the paper being applied, not too tightly, in the form of several layers of strip or tape, lapped, as before, in opposite directions. The paper is subsequently impregnated by immersion in an insulating compound of an oily nature and, like fibrous insulated cables, receives a final homogeneous sheathing of lead.

In dry-core paper cables, such as the multiple ones employed for underground telephone circuits, the paper, in the form of strip, is passed, together with the copper wire to be covered, through a die, which folds or wraps it loosely around the conductor. The paper, in this case, is not impregnated with any compound, but is thoroughly

FIG. 13.—BRAIDING MACHINES USED BY THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT, BERLIN, GERMANY

FIG. 14.—LEAD PRESSES

dried, and the wires, thus covered, are made up, to certain specified numbers, in a multiple wire cable which is subsequently lead-sheathed, the sheathing being provided, in certain cases, with devices at its extremities for producing a constant or periodical circulation of

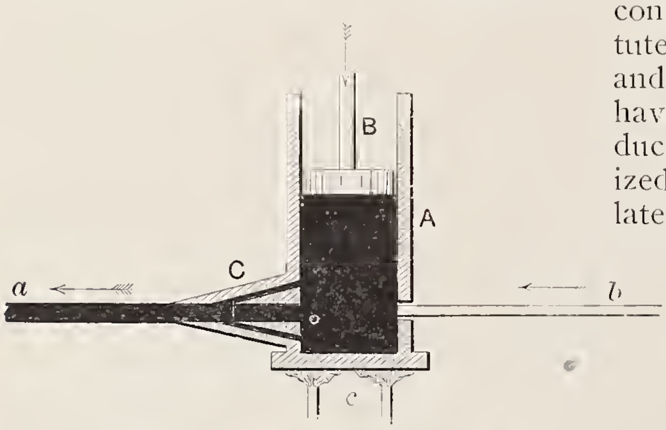


FIG. 15.—A LEAD PRESS DIAGRAM

dry air through the mass or interstices of the cable proper. In this manner the insulation of the various wires composing it is kept up to the requi-

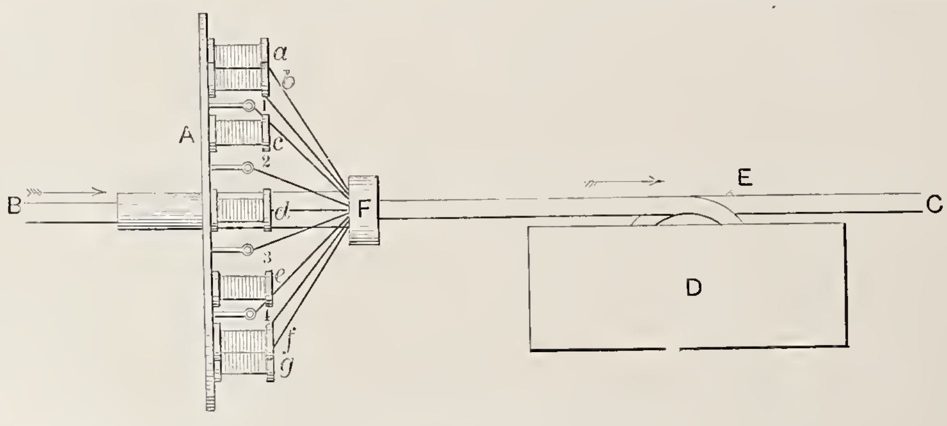


FIG. 16.—HOW LEAD COVERED CABLES ARE SERVED WITH JUTE

site limit, and moisture, so detrimental to insulation of any kind, is excluded.

Three or four years ago rubber-insulated cables were in much greater demand than at the present time, their use being now restricted to the smaller sizes, or such special instances where greater flexibilities, etc., warrant the extra expenditure.

During the last few years, owing to the increasing scarcity of india-rubber, cable manufacturers have been constrained to seek a cheaper substitute for the insulation of electric light and power cables. Their requirements have thus far been met by the introduction and improvement of vulcanized bitumen cables, and cables insulated with dielectric material of a fibrous nature, such as jute, cotton or paper, which are impregnated with semi-fluid insulators of the resin oil order, and subsequently sheathed with an impervious coating of lead.

So far as the actual manufacturing processes are concerned, the procedure is very similar to that already described in connection with rubber-insulated cables. The jute, or cotton, usually undergoes a preliminary immersion in the oil, and is then served on to the conductors in the form of yarns in a serving machine similar to that already described and illustrated in Fig. 16. In such cables the copper conductor need not necessarily be tinned, although the process is sometimes resorted to in the smaller sizes to facilitate jointing.

After serving, and often between contiguous layers, the cable is again immersed in a tank of the insulating compound, reduced to a fluid condition by heat, and allowed to remain in this until the fibres are thoroughly impregnated with it, and all occluded air has been dispelled. It is then ready for lead-sheathing, which is effected in the same manner as described in connection with rubber-insulated cables.

It will be readily understood that, in such cables, where the insulation is of a fibrous nature, and therefore hygroscopic, the presence of moisture, in quantities however remote, is fatal to the insulation. The lead sheathing must, therefore, be absolutely flawless. In order to ensure this and detect any imperfections which might subsequently develop into faults in the lead covering, Messrs. W. T. Glover & Co., Ltd., of Trafford Park, Manchester, have instituted a hydraulic pressure test, under which pressures up to as much 100 pounds per square inch are applied to the exterior of the lead sheathing, the drum of cable being placed in a special receiver for the purpose of undergoing the test. This pressure at once breaks down any weak points in the lead, and their presence may be detected by the subsequent electrical tests.

A similar manufacturing test is applied to dry-core telephone cables, which, as already intimated, include a considerable air space within the lead sheathing. In this case air is pumped into the interior of the cable under pressure, during such time as the cable itself is slowly drawn through a trough containing water. The presence of a flaw in the lead covering is evidenced by the passage of a stream of bubbles, the process much resembling that employed for the location or punctures in the air tube of a cycle tire.

Where paper is employed for insulating purposes, it is applied to the cable in strip form, in much the same way as the water-proof tape on rubber cables, shown in Fig. 8, the impregnation with resin oil being affected by immersion after the paper has been lapped on the cable. Paper made from pure Manilla fibre should be, and is used, by the best makers; and here, again, the importance of perfect and homogeneous lead sheathing applies in an equal degree.

A type of insulation for electrical conductors which has found favor on the European continent, and, to a limited extent in Great Britain, is that devised by Hackethal. It is more suitable for aerial than underground work, and its principal merit is its extreme simplicity. It consists in simply braiding the conductor in the usual manner, with one or two layers of cotton or jute, which is subsequently impregnated with a mixture of red lead and oil. This is said to be an excellent insulating material for the purpose, in that it improves with such oxidation as ensues from exposure to the atmosphere.

It is noted in the "Electrical Review," of London, that during the past year practically no profits—at all events, none commensurate with the capital invested—have been made in electrical manufacturing in Great Britain, and the few British firms that have shown some returns to their shareholders have made their profits in departments chiefly outside actual manufacturing. It is further stated that matters have been getting worse during the past few years, and that this might be accounted for by the fact that the manufacturing capacity of the country has increased, while the demand itself has fallen off.

Lifting Magnets

WHEREVER steel or iron is handled in quantities by means of cranes, a magnet will effect economies in time and labor sufficient to pay for itself in from one to six months. This statement is said to be borne out by experience in steel mills, jobbing houses, safe works and the like, and is evident when the methods, chain versus magnet, are compared.

In all cases an electro-magnet is used, suspended from the hook of the crane, direct current at any of the common voltages being employed to energize the magnet. A flexible twin conductor cable is used to convey the current to the magnet, and a small switch, operated by the crane man, is usually the only additional apparatus necessary. The amount of current used is small, being from 1 to 12 amperes, according to the service for which the magnet is designed. In operation, the magnet is lowered upon the material to be lifted and the switch closed, thus causing the magnet to attract and hold the material, which may then be hoisted by the crane and transported to the desired point. By simply opening the switch, the material is instantly released.

Comparing this method of operation with the common methods of connecting the load to the hook of the crane, with chains, hooks or clamps, the saving in both labor and time is apparent, as, in general, the attachment of the magnet to the load, as well as the release of the load, may be accomplished by the crane operator without assistance, thus saving the labor of one or more men for prying up the material, attaching hooks and chains at the point of loading and additional men at the point of delivery for unhooking the load from the crane.

Magnets can be so quickly attached to and detached from a load that by their use the work which may be done by a given crane is greatly increased, in some cases more than doubled. It frequently occurs that the attachment

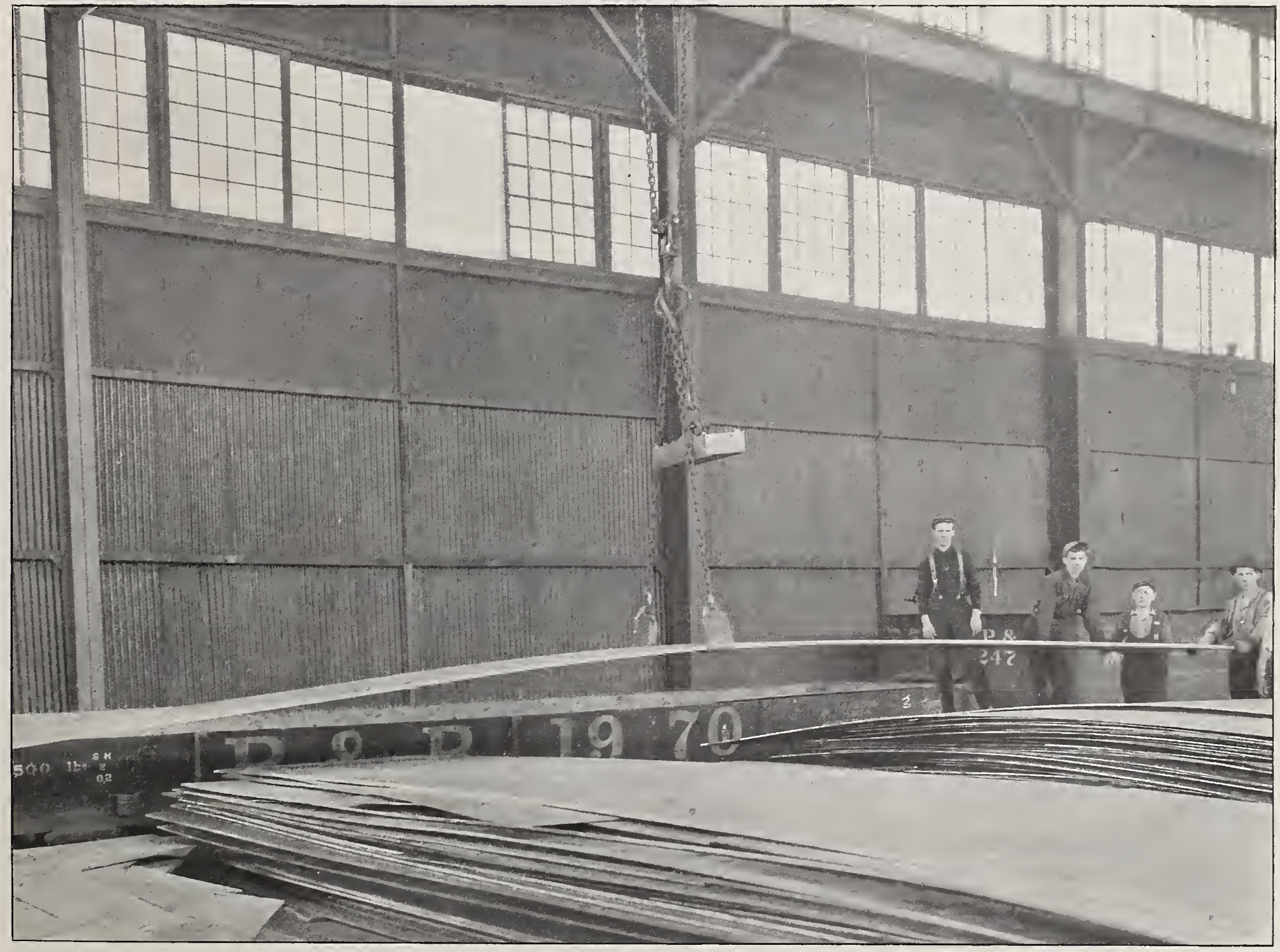


FIG. 1.—SHEET METAL IS MOST EASILY LIFTED OFF THE PILE WHEN A MAGNET IS USED. AFTERWARDS THE HOOKS ARE PLACED UNDER THE EDGES OF THE PLATE AND THE MAGNET IS RELEASED. THESE LIFTING MAGNETS ARE MADE BY THE ELECTRIC CONTROLLER & SUPPLY CO., CLEVELAND, OHIO

FIG. 2.—HANDLING SMALL ARTICLES IN BULK WITH A LIFTING MAGNET

of lifting magnets to existing cranes so increases their capacity for handling material that the purchase of additional cranes for handling an increased output is rendeied unnecessary.

Again, lifting magnets require much less head-room than hooks or chains for lifting material of considerable width, such as p'ates. Therefore, by the use of magnets, material can be conveniently piled to a greater height in the storage space under a given crane than is possible when chains are used, thus increasing the capacity of a given storage space without altering the crane runway or increasing the size of the building.

Lifting magnets also may be used to great advantage in handling pig iron, scrap, rivets, bolts and similar articles in bulk, as shown in Figs. 2, 3 and 4. These illustrate a design of magnet for handling pig metal, iron and steel scrap, cotters, rivets or nails in kegs, small castings and similar materials in bulk. This magnet is the result of some years of testing, during which time the makers, the Electric Controller & Supply Company, of Cleveland, Ohio, built and tested several designs, the one illustrated in these cuts being the only one to entirely meet their expectations.

Fig. 2 shows this magnet, which is about 33 inches in diameter and costs but 6 cents per hour to operate continuously, lifting twelve machine cast pigs, the average of a large number of lifts from a pile without arranging the material to favor the magnet being between eight and nine pigs per lift. With this magnet a car can be loaded or unloaded by the crane man alone, without any assistance, as no helper is needed on the ground, and at the same rate, it is claimed, and even faster than nine laborers could do the same work. By its use the cost of loading and unloading such materials should be reduced by a very large percentage both in time and labor.

Fig. 5 shows the magnet usually furnished for handling billets, slabs, plates and similar materials having flat surfaces. The magnets may be used to excellent advantage in handling plates, especially in hoisting plates off the pile. This is always the most difficult problem in transporting a plate, since where chains are used or similar apparatus, several laborers are always required to bar up the plate in order to attach these devices. With a magnet the plate can be lifted and the flat hooks, as shown in Fig. 4, placed under the edge of the plate, or plates, the magnet then released and the plate transported by means of the chains, an entirely simple operation which

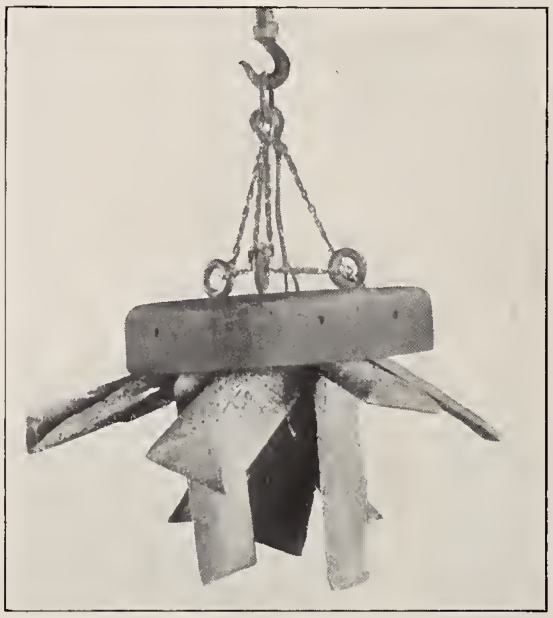


FIG. 3.—LIFTING PIG METAL WITH A MAGNET

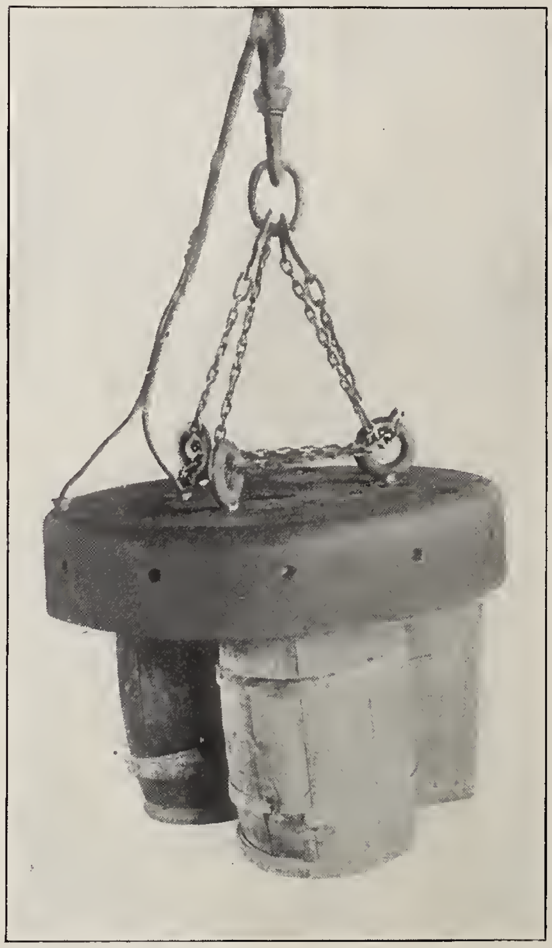


FIG. 4.—NAILS IN KEGS ARE EASILY CARRIED ABOUT

gives very appreciable saving in time. The Illinois Steel Company use fourteen magnets in their South Chicago works alone, and have found the economy in time and labor so substantial that they have decided to use them wherever possible in all their works.

A single design of magnet is not adapted to handling the full range of material above mentioned; on the contrary the magnet must in every case be designed to meet the form of material to be handled. For instance, there is a wide difference in the design of a magnet for lifting ingots or blooms and one adapted to the handling of thin plates. A magnet which would handle 5 tons in the form of an ingot

FIG. 5.—A LIFTING MAGNET FOR HANDLING BILLETS, SLABS AND SIMILAR MATERIAL WITH FLAT SURFACES

might not handle 500 pounds in the form of thin plates. It is therefore necessary to understand in each case the operating conditions with special reference to the form and range of material to be handled.

The question of risk of accident arises. The Electric Controller & Supply Company, of Cleveland, Ohio, report that in their experience with scores of lifting magnets in successful operation they have yet to learn of a single accident which has occurred through their use.

Magnets are always built and tested to from four to five times the specified load, and in addition to their wide practical experience in the application of lifting magnets, the Electric Controller & Supply Company have at their disposal most complete and valuable data, secured through the testing of about forty designs of magnets on a testing machine which they have constructed for this special purpose.

The Cost of Municipal Lighting

APROPOS of the present discussion as to the relative cost of lighting with a municipal plant, and that with a private plant, the following leter from Arthur Williams, of the New York Edison Company, to "The New York Times," will be of interest as showing the misleading figures quoted by advocates of a municipal plant:—

"An article allowed wide circulation in the press of to-day, concerning the cost of electric lighting on the Brooklyn Bridge, does great injustice—unwittingly, without doubt—to the electric light companies of the two boroughs. A characteristic error of municipal bookkeeping is made—the same error Mayor Carter Harrison recently fell into in publishing the cost of Chicago's municipal lighting.

"The annual cost of electric light on the bridge structure is placed 'in round numbers' at $20,000. But this figure represents labor only; and in this it is $3937 less than the cost appearing in "The City Record" of September 3, 1904, where the aggregate labor charge for lighting the structure is placed at $23,937. Even this item (for labor alone much in excess of the total cost given for lighting the bridge) includes no administration expenses.

"It should be understood also that the cost of fuel, estimated at more than $12,000 annually, and of labor, including firemen in the boiler room, and of removing ashes, are not included and do not appear as an element of cost in the lighting of the structure. Under an arrangement with the Brooklyn Rapid Transit Company, the steam required for operating the electric lighting plant is delivered to the engine without direct cost to the city.

"The investment expenses, such as interest, depreciation and insurance, are also omitted. There is no item offsetting the taxes that would be paid by a private company, and the city is not charged with water. Corrected, at least in part, the items of expense should be as follows:—

Labor	$23,937
Coal	12,740
Water	1,500
Carbons	1,350
Incandescent lamps	1,980
Repairs, electrical plant	2,000
Repairs, electrical equipment on the bridge structure	1,500
Fixed charges upon an investment of not less than $100,000 for generating plants, original and those now in use, and the electrical equipment of the bridge:	
Interest, 4 per cent	4,000
Depreciation, 7 per cent., allowing fifteen years of active life	7,000
Insurance or its equivalent in the risks assumed by the city, fire and accident, the latter for the public and the employees, 1½ per cent	1,500
Loss of taxes, 1½ per cent. on half value	750
Total	$58,257

"With these corrections, each arc lamp is costing the city annually $168.94; each incandescent lamp $29.

"The article is subject to one further correction; the private lighting companies have offered to supply the Williamsburg Bridge with arc lamps for $130; with incandescent lamps for $18 annually, not $146 and $25 respectively, as stated.

"Permit me to draw to your attention that in the service of the bridge are no subway or underground costs. The system is entirely overhead. According to ex-Mayor Matthews, of Boston, who made a very careful investigation, the difference between the two methods of supply is nearly $40 annually. Thus, if these lamps were distributed over the city, their total cost would be over $200 annually, as compared with the private companies' price of $146 upon the streets and $130 on the bridges.

"Mistake is also made in the statement that the system of lighting on the bridge is superior to that employed by the New York Edison Company—for the two systems are alike. The report that the Edison lamps suffered during the recent blizzard is also erroneous. A city official who was out during the storm for the special purpose of inspecting the lighting, afterward made a statement to the effect that he could not find a single lamp out of service."

Breaks in Overland Telegraphic Communication Due to Storms

Some Proposed Remedies

By WILLIAM MAVER, JR.

The snow and wind storm which swept over the whole eastern half of the United States several weeks ago—the worst in seventeen years—rivaling the great blizzard of 1888, makes Mr. Maver's article, reprinted from the February number of "Cassier's Magazine," particularly timely. No serious telegraph or telephone difficulties resulted from this storm, but this was a happy accident rather than an immunity to be expected.—The Editor.

THE severe wind and sleet storm in the United States last November that partook somewhat of the nature of a cyclone in eastern New York, Massachusetts and Pennsylvania, and which prostrated the overland telegraph and telephone wires to such an extent that the city of New York was cut off from the rest of the country for nearly twenty-four hours, renewed the agitation for some more stable means of telegraphic communication than is furnished by overhead wires.

The business communities were insistent in their demand for relief from these periodical disarrangements of the business of the country, and it was even suggested that the national government should undertake to provide a system of communication that would be dependable regardless of weather conditions.

It is not difficult to imagine the seriousness of a situation that might, in certain contingencies of national importance, arise in the event of the capital being deprived of telegraphic and telephonic communication by severe storms of possibly several days at a time. The situation would, of course, be worse if railway communication should also be temporarily cut off or seriously hampered, as it was at the time of the great snow storm of March, 1888. During the storm of last November, the railways were not seriously delayed, and it was, therefore, possible to send special messengers by train from Chicago to New York with important orders for the purchase and sale of stock that could not be handled by telegraph or telephone, owing to the collapse of the overland wires between those cities. Some messages of importance were also sent from New York to San Francisco by cable via Europe and Asia.

The possibility of the collapse of telegraphic communication was forcibly brought to the attention of telegraph officials and the public at least as long ago as 1849. In that year a heavy sleet storm visited Tennessee, Kentucky, Northern Mississippi and Alabama, levelling the wires and poles so completely that the territory named was without telegraphic communication for over four weeks. And since that time hardly a winter has passed during which the telegraph service has not been badly crippled in one section or another of the country by sleet or snow storms, notably by the great storm of March 12, 1888, already mentioned. This storm raged fiercely for three days in the neighborhood of New York, Philadelphia, and Boston. Eastern New York was deprived of telegraphic and telephonic communication in every direction. In the city of New York not an overhead telegraph, telephone, or fire alarm circuit was left intact, and the town was in darkness at night, except for the street gas lights. There was in operation at that time one underground telegraph circuit about twelve miles in length, which was used as far as possible for fire alarm telegraph purposes. Today practically all the electric light and power circuits and the telegraph and telephone circuits in New York City are in underground conduits. The consequence is that, notwithstanding the severity of the recent storm, as manifested by its effect upon the overhead wires outside of the city, the operation of the electric light circuits, as well as of the telephone and telegraph circuits in the city, was not disturbed.

The matter of securing uninterrupted telegraphic communication regardless of weather conditions is, therefore, one that has been frequently discussed during the past half century, and perhaps because of the observed beneficial results of placing the wires underground in cities the lay mind has, at every recent recurrence of a break in the telegraph service, demanded that the wires everywhere be placed underground forthwith, where they would be safe from the assaults of wind, snow, and sleet storms.

It may be premised that the officials charged with the management of the telegraph and telephone interests in America have not been blind to the enormous losses that these interests sustain by every extensive collapse of their poles and wires, and it may be safely assumed that every possible remedy has been very carefully considered by those most concerned.

Sleet storms and soft snow storms, which are the most disastrous in their wire-leveling effects, are not confined to any one part of the country. They occur in the Mississippi Valley, in the vicinity of St. Louis and Memphis; in Illinois; on the Atlantic coast between Boston and Baltimore; and one of the worst sleet storms the writer has ever known occurred in Nova Scotia and New Brunswick, in 1871. The damage done to the poles and wires is not always directly due to the sleet and the wind, but is often occasioned by the weight of the sleet breaking huge limbs of trees which fall on the wires. Frequently miles of sleet-laden pole lines fall, like rows of bricks, when one gives way, and in numerous instances fifty and more miles of pole line have been so completely demolished in one storm that the cost of repairing the line has been equivalent to building new lines.

Not only are overland lines subjected to widespread damage by abnormally severe sleet and snow storms, but they are also in many places exposed to the ravages of forest fires, to avalanches of snow, to washouts due to floods, and to destruction by lightning. Furthermore, the average normal life of a pole line in all parts of the country probably does not much exceed ten years. Consequently, if the financial and engineering difficulties in the way of placing and operating telegraph and telephone wires to long distances underground had not been deemed well nigh insurmountable, there is not much doubt that the proposed underground cable plan of avoiding the enumerated difficulties which beset overland telegraph and telephone lines would long ago have been adopted.

From an operative standpoint it may be said that for telegraph purposes an overland wire is from fifteen to twenty times more efficient than an underground or a submarine cable of equal length. For example, an Atlantic cable, operated with the apparatus employed in overland Morse telegraphy, would not have a rate of transmission exceeding two or three words per minute. On cables 400 to 500 miles in length a rate of not more than six or eight words per minute would be possible with the ordinary Morse telegraph apparatus.

It is only by using the most sensitive receiving instruments that rates of twenty-five to thirty-five words per minute can be obtained in long-distance cable working, and if receiving apparatus of this high sensitiveness were employed on land lines it would entail using twisted and paired circuits to avoid the effects of mutual induction. It would also involve equipping the various offices with the necessary apparatus and the keeping of a staff of expert operators at such stations to manipulate the cable apparatus.

The agitation for underground telegraph wires between important business centers in order to insure the maintenance of communication in times of severe storms has not been confined to America. In fact, the discussion of the matter on the American side of the Atlantic has been mild and desultory in comparison with the agitation that has been maintained in Great Britain for the past ten or fifteen years for the same object. Repeatedly during these years and prior thereto the breaks in the telegraph lines have resulted in cutting off London from other parts of Great Britain for days at a time, so far as telegraphic and telephonic communication is concerned. At the time of the severe storm of January, 1901, in Great Britain, the city of Glasgow was cut off from telegraphic communication with other parts of the Kingdom for two days, and in the December storm of the same year London could communicate telegraphically with Manchester only by way of Ireland, and with Glasgow by way of New York.

Owing to these frequent breaks in telegraphic communication in Great Britain the government, in 1897, began the laying of a so-called experimental underground cable between London and Birmingham,—a distance of 113 miles,—which cable was completed after some delay. The cable used is composed of seventy-six conductors, each weighing 160 pounds per mile. The conductors are insulated from one another by spirally wound strips of brown paper, and the whole is enclosed in a lead pipe 2½ inches in diameter. The cable is drawn into 3-inch iron pipes in lengths of about 600 feet, the pipes being laid in the earth about 2½ feet below the surface. The total cost of this cable, laid, was £160,000 ($800,000), or approximately £1400 ($7000) per mile. Subsequently other sections of underground telegraph cable were laid in Great Britain as standbys in case of collapse of the overland wires. For example, a cable has been laid underground between Manchester and Leeds, 58 miles, and between Warrington and Carlisle, 42 miles, together with an extension of 20 miles to Beattock Rise, the cost of which was about £1120 ($5600) per mile.

The routes for these sections of underground cable were selected with a view to protecting the portions of the country most exposed to violent storms. The difficulties and delays due to breaks in the telegraph lines were not, however, overcome by these and other portions of underground cables, and delegations representing the merchants and officials of municipalities of various parts of the country urged upon the government the completion of underground cables to Glasgow and Edinburgh and to Portsmouth, Bristol and Land's End.

In answer to these urgent and continued demands for underground telegraph wire facilities the government intimated that it did not feel warranted in proceeding upon so extensive an undertaking, especially in view of the expressed belief that poles and wires could be constructed of sufficient strength to weather the severest storms. Subsequent experience, however, controverted this view, for, despite the best efforts in this direction, the secretary to the post office, in the latter part of 1901, tacitly acknowledged that the heavy snow which accumulates on the wires either breaks them by its weight or tears the poles out of the ground.

It was admitted at the same time also, although the details furnished of its operation are meagre, that the London to Birmingham underground cable was not an assured success, inasmuch as to avoid the effects of mutual induction two wires must be employed for each telegraph circuit,—practically as in the case of telephony,—and that otherwise the underground circuits were less efficient than overland wires, the speed of the Wheatstone automatic telegraph system, which is in extensive use in Great Britain, being considerably reduced by the presence of the cable in the circuits.

To be able, however, to maintain communication, even if only at a comparatively slow rate, is so much more satisfactory than to be without any means of communication whatsoever that at each recurring snow or sleet storm and consequent loss of telegraphic communication the post office authorities continued to be waited upon by delegations from different sections of the country. Finally, on the occasion of the visit of a delegation from Glasgow in 1902, the government officials stated that the matter of providing emergency underground cables for use in times of collapse of the overland wires had resolved itself into one of finance; that a suitable underground cable from London to Glasgow would cost at least £700,000 ($3,500,000), and that the settlement of the question, therefore, must rest with the Chancellor of the Exchequer rather than with the postmaster.

As it does not often happen that all sections of the country are visited by severe storms at the one time, it has been pointed out that an emergency underground cable, when completed, need be used only in the sections in which the overhead wires and poles are temporarily prostrated. By substituting the underground circuits temporarily for the overhead wires for such distances as the severity and extent of a storm may require, the retarding effect of the underground circuits might not be very pronounced. It may also be noted that when longer distances are necessary, the introduction of automatic telegraph repeaters at shorter intervals than is customary or necessary in overland working would also reduce materially the retardation of signaling.

To give an idea of the cost of placing the existing overland wires in America in underground cables, it may be stated that a conservative estimate of the expense of laying a fifty-conductor telegraph cable underground between New York and Philadelphia places it at approximately £120,000 ($600,000), or, say, £1200 ($6000) per mile. This would afford facilities for only twenty-five telegraph circuits, as, for reasons already mentioned, two wires would be required for each circuit. As there are, perhaps, three hundred telegraph wires on the various pole lines from New York to Philadelphia, it is clear that such a cable would carry only a moiety of the business ordinarily transmitted over these circuits.

When the extent of territory traversed by the telegraph pole lines in America is considered, the conclusion is almost inevitable that the placing of all of these wires in cables underground is impracticable, owing to the enormous expense and the reduced efficiency of operation that such action would involve. This is true to even a greater extent, perhaps, of the telephone wires.

The financial, engineering and operating difficulties of placing the telegraph wires underground have, indeed, been so fully appreciated in America that the matter has never been seriously entertained by the telegraph companies, except in cities. In all the principal cities, however, the telegraph and telephone wires are now in cables underground. As already intimated, this disposition of the wires in cities has aided materially in keeping the wires in operation during the prevalence of storms.

The introduction of these underground cables, however, in the cities, comparatively short as they are, has noticeably lessened the efficiency of the automatic and quadruplex circuits, as well as the long-distance telephone circuits. The alternative appears to be to endeavor to employ more substantial poles or wires, or to lay comparatively small underground cables between the principal cities of the country, over which the most important business or government messages might be transmitted during breaks in the overhead circuits. Both of these alternatives have received careful consideration on both sides of the Atlantic.

About fifteen years ago, for instance, the Pennsylvania Railroad Company, in order to obtain a reliable telegraph service at all times, had under consideration the laying of an underground cable along its tracks between New York and Philadelphia, and perhaps for greater distances, and at that time the writer suggested the employment of a cable insulated with fibre or paper, to obtain low electrostatic capacity, and over which a rubber coating should be placed to exclude moisture; but the proposition was not carried out.

Appreciating the difficulties that attend the placing of telegraph wires underground between cities and towns, the question of building stronger pole lines and employing larger and stronger wires has frequently been mooted. One plan suggested several years ago consists of using two poles side by side, between which the crossarms for the wires would be placed. It was proposed, further, that such a pole line should be placed along a private right of way, and that it might be patrolled by linemen on overhead bicycles suspended from the poles by wires.

This plan has not, however, been acted upon, and when it is considered that sleet has been known to form on wires to a thickness of 6 inches, it is apparent that entire reliance cannot be placed on any type of overhead telegraph wire construction,—a conclusion to which experience has pointed in Great Britain.

It is probable that for a few years, while the pole line is new, the poles might resist breaking; but after the lapse of several years their resisting strength would be uncertain. It is possible that a light armored emergency cable, properly strung on the poles, would in many instances maintain its continuity even when the poles had collapsed.

In some instances where the wires are exposed to very high winds, or where the number of the wires on the pole line are excessive, the plan of doubling up the number of poles to the mile has been adopted, so that instead of fifty poles to the mile there are a hundred. This obviously divides up the weight on each pole very materially, and the results thus far obtained in these experiments have been very satisfactory. These lines have yet, however, to stand the test of a heavy sleet storm with wind.

It has also been suggested quite frequently during the past four or five years that wireless telegraphy should be available in the emergencies under consideration, but up to the present time it has failed to manifest its value on such occasions. In fact, there is no absolute surety that the masts or towers, or at least the vertical wires, would not be victims to the heavy storms that play such havoc with the overland telegraph and telephone wires, for it has already happened more than once that the masts of wireless telegraph systems have succumbed to severe wind storms. The reconstruction of these masts could not be effected during the continuance of the storm, and the overland wires would probably be in operation as soon as the wireless telegraph masts and wires could be reconstructed.

This is said on the assumption that if the vertical wires were intact, wireless telegraphy would be available for long distances overland. This, however, is not at present known to be the case, and there is no definite assurance that wireless telegraphy will be available for such purposes in the immediate future.

But granting that wireless telegraphy were available for long-distance overland service, the utmost aid it could afford in the present state of the art would be the equivalent of one overland circuit working in one direction at a time, and at a low rate of transmission. Wireless telegraphy may, therefore, be disregarded in present calculations as a substitute for overland wire telegraphy in times of total collapse of overland telegraph wires, although its importance would be undoubtedly great if it should be found capable of providing but one circuit at such times.

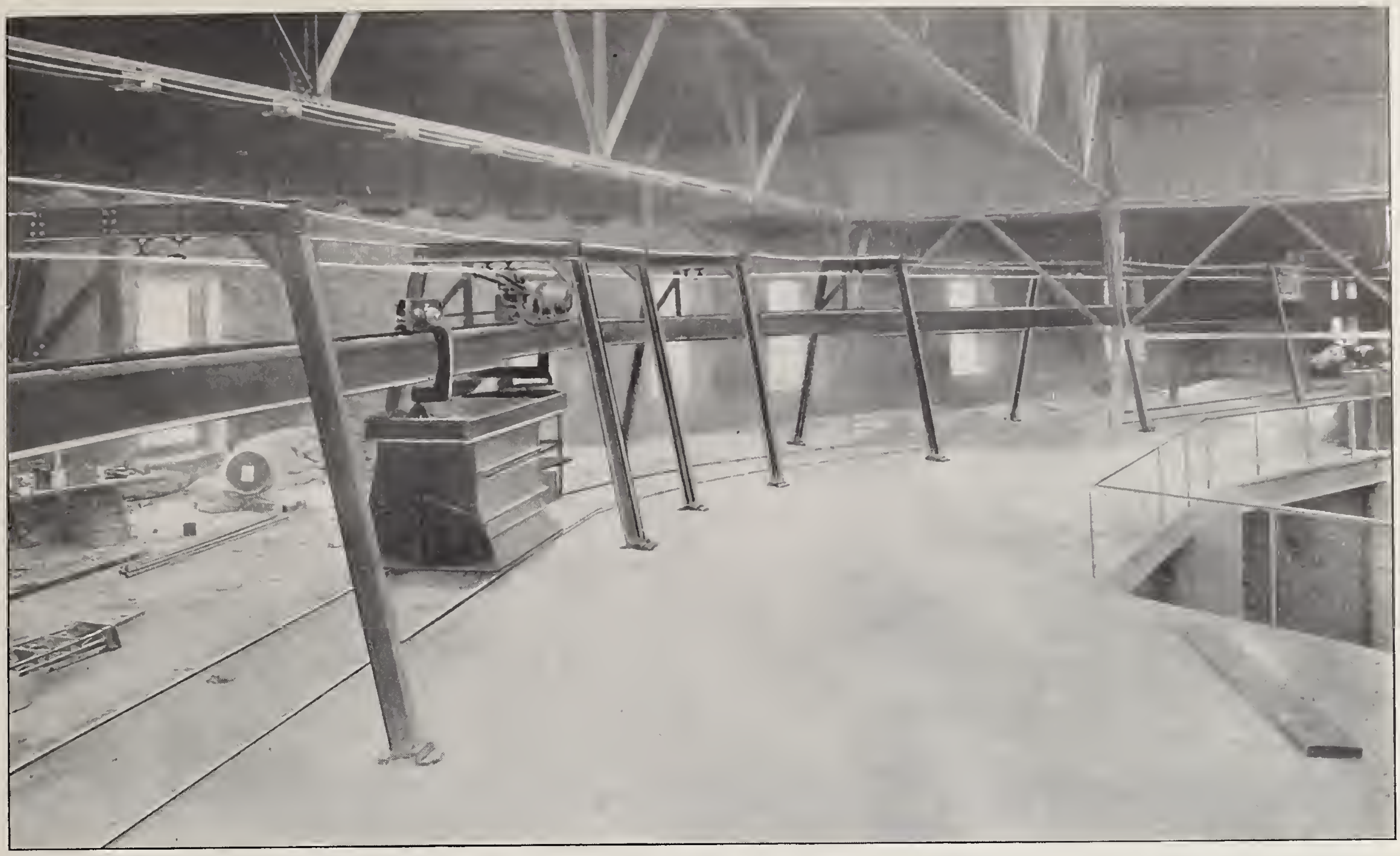
A Telpherage System for Handling Lime

By SHELDON LEAVITT, JR.

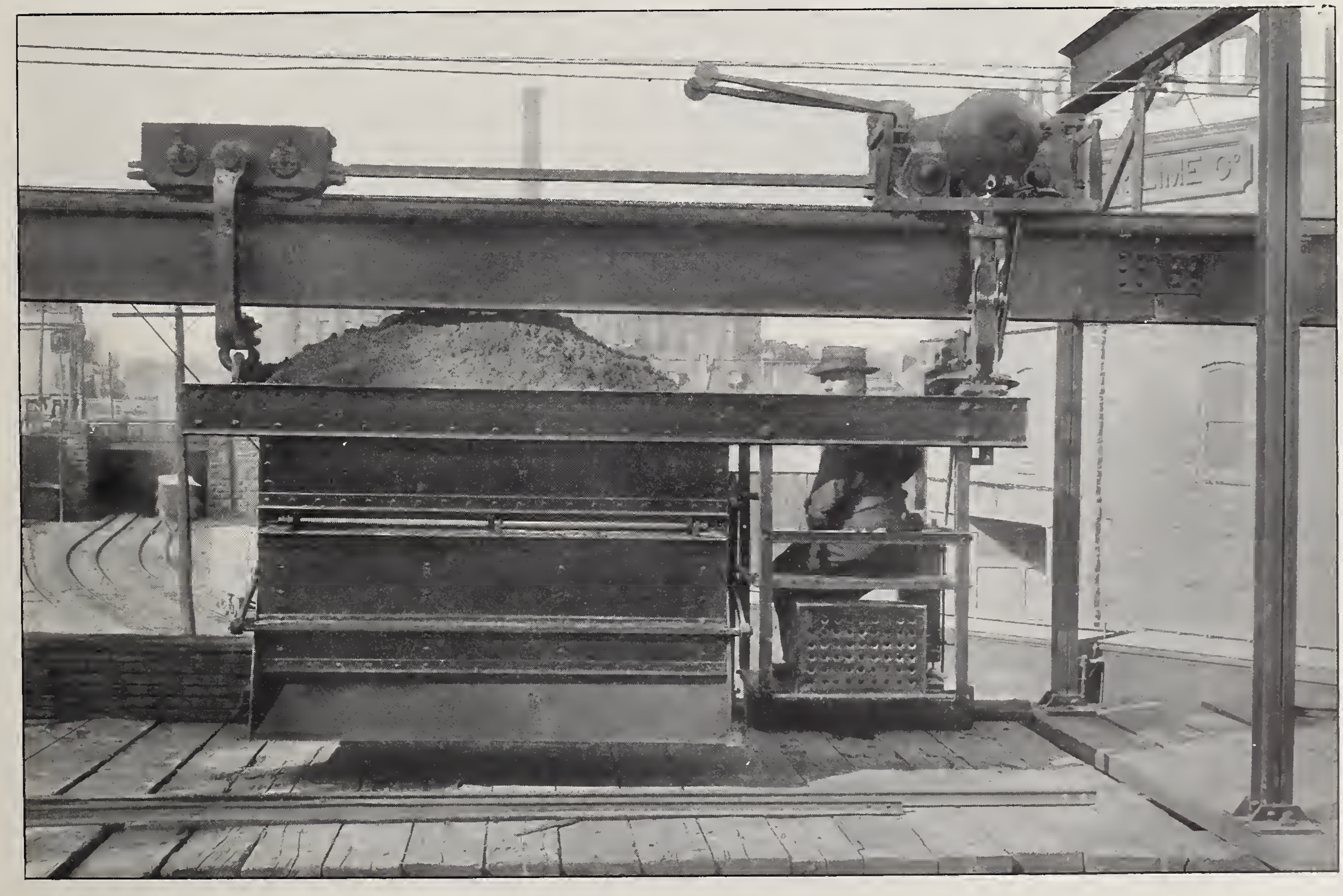
THE adaptation of electricity to the handling of material has seemed slow when compared to its development in other branches—notably in the way of street railway work. Considering the advantages of electricity over any other power, and the room for radical changes in the methods of handling material, it seems strange that those employed in many cases to-day are the most expensive form of labor, that is, manual, the use of steam engines, or the mere supplanting of the last named by the electric motor.

The crane, for instance, was originally run by steam, and while the advent of the motor made possible a much more efficient and economical machine, still the main features of construction remained the same. This is also particularly true of any conveyor depending upon the cable as its means of locomotion. It remained then to perfect some kind of machinery, especially suited to electricity, and embodying in it all the features which would enable it to take advantage of the great flexibility and economy of this power. Telpherage supplied the new field, and since its introduction no such saving has been shown in the history of the transportation of material by mechanical means. In some cases, as in the Baker Chocolate Works, near Boston, material is now handled for one-fifteenth the former cost, the installation paying for itself within a year.

In the United States, great progress has been made in this work, and as a result, electric power is now becoming available at nearly every dock, pier, freight house or mill. Telpherage re-



INTERIOR VIEW OF THE KNICKERBOCKER COMPANY'S TELPHER LINE, INSTALLED BY THE UNITED TELPHERAGE CO., NEW YORK



A LOAD OF LIME IN TRANSIT

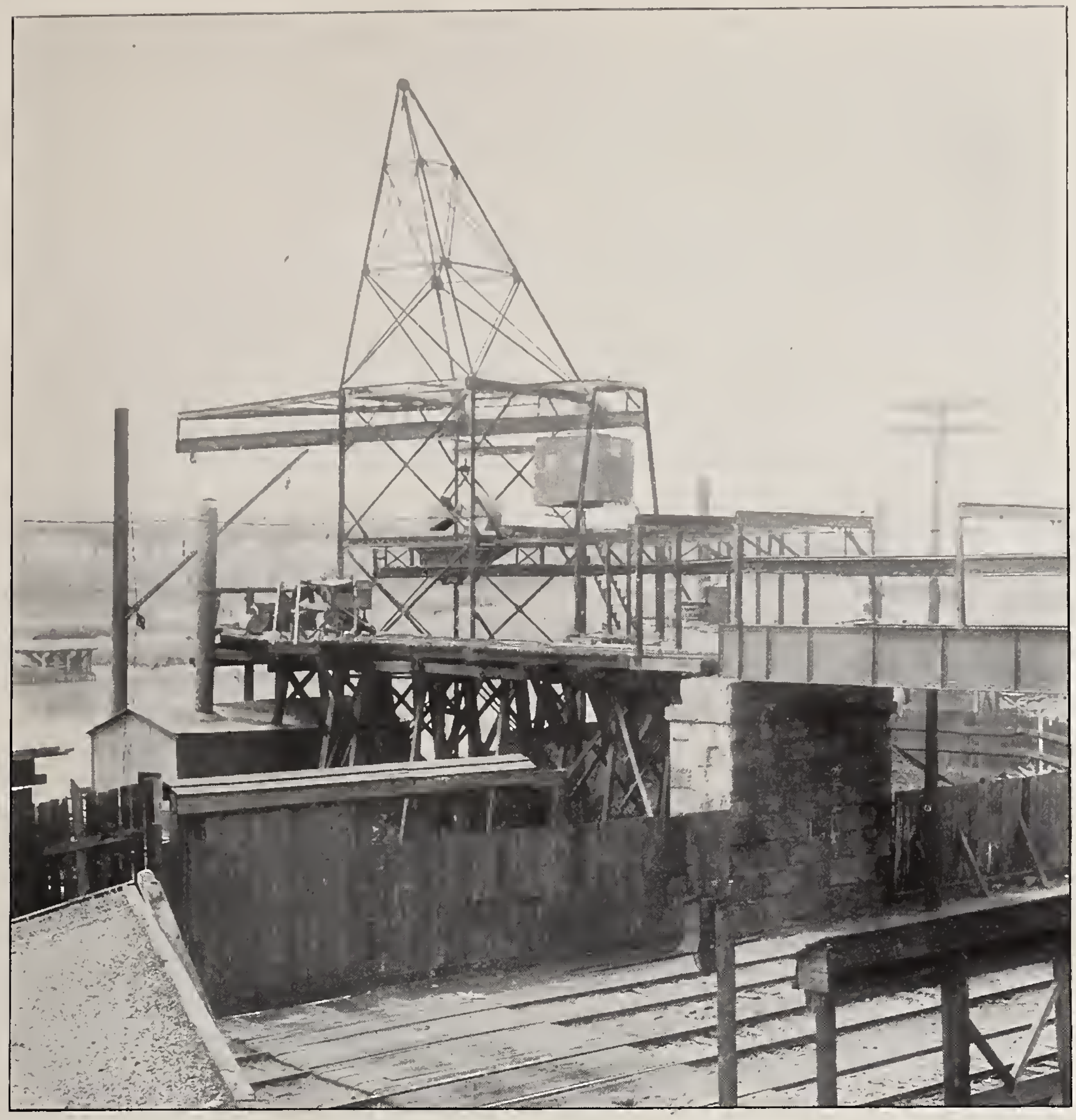
A TELPHERAGE SYSTEM FOR HANDLING LIME AT THE PLANT OF THE KNICKERBOCKER LIME CO., PHILADELPHIA. THE BOOM, TELPHER AND BUCKET ARE HERE SHOWN FOR UNLOADING LIME FROM SCOWS

quires the mere turning on of the electric current, and when the work has been done no loss accrues, as in the shutting down of a steam plant. The system may be operated by any man of average intelligence, as is the case with the electric street car. It therefore does not depend for its operation upon a skilled attendant.

A great many of these plants have been installed both in the United States and abroad, and the number is daily increasing. The annexed illustrations show a modern example of a large plant of the Knickerbocker Lime Company, at Philadelphia. In this case, it was necessary to transport a great amount of sand, gravel and coal from barges at the dock and to convey it to bins situated under the second floor of the storage building, which was at some distance from the dock.

The former method of unloading the barges was to shovel the sand into small buckets and hoist them by means of a steam derrick, then swing them by its boom over small cars and dump into them. These cars were on a trestle which led from the dock to the second story of the storehouse, and ran on a narrow-gauge track. They were then pushed by hand along the trestle to the second floor of the building and dumped into the bins placed on both sides of the track. With this method four men were required to shovel sand from the barge into the buckets, one engineer and a signal man for operating the hoist, one man to dump the buckets and four men to push the cars, making a total of eleven men.

To replace this method of handling a system of telpherage was installed. A steel tower, the top of which is 90 feet above the water, is placed close to the bulkhead. From this a steel boom projects out over the water for a distance of 50 feet and the same amount above the river. On top of this steel boom is placed a T-rail track, upon which runs the telpher, which is fitted with an electric double-drum hoist built by the United Telpherage Company, of New York, for operating the clam-shell bucket. The telpher, with its hoist and clam-shell bucket, is run out over this boom and picks up sand or other material from the scow, hoists it up about 40 feet and conveys it to a hopper placed in the center of the tower. A steel track about 700 feet long, supported by steel bents, runs under this hopper, thence along the trestle over the Baltimore & Ohio Railroad tracks on a steel bridge, over another trestle and into the storage house, where it passes to different bins.



THE KNICKERBOCKER LIME COMPANY'S TELPHER LINE. THE STEEL TOWER SUPPORTING THE BOOM ON WHICH THE UNLOADING TELPHER RUNS. THE BUCKET IS SHOWN DUMPING INTO THE HOPPER

Another telpher carrying a steel side-dumping bucket of 2½ cubic yards capacity travels along this track and, after getting its load from the hopper, conveys it to the bins in the building and dumps the load upon whichever side occasion demands. On account of the distance the material has to be carried, this second bucket was made double the capacity of the clam shell, so that it would only have to make one trip to the bucket's two. The telpher operating the clam-shell bucket is fitted with an inclosed cab in which is stationed the telpherman with the hoisting machinery and controllers. This one man is able to attend to the loading, hoisting, conveying and unloading, as he travels with the load and can see when the sand is on the barge, and deposit it in the hopper without the necessity of a signal man.

On the other telpher one man opens the gate of the hopper, fills the side-dumping bucket, travels with it, dumps it exactly where it is wanted and returns for another load.

Telpherage, therefore, requires one man to do the filling of the bucket, hoisting, dumping and returning; one man, part of the time, to clean up the scow in the corners, and one man to attend to the conveying. There are, therefore, required two men all the time and one man part of the time, as opposed to eleven men all the time with the old system. Much more material, also, is carried per hour than formerly, so that the cost of labor is less than one-tenth of what it was before.

There is no doubt that within the next year telpherage will be more widely used.

In England, the firm of Siemens Bros. & Co., the well-known cable manufacturers, have a special telpherage department, and are rapidly developing this branch of the business. In Norway and Sweden, in Denmark, Finland and other countries telpherage is finding a rich field. The Japanese Government has equipped two large plants, a number of governments in Europe are now preparing to use the system in large railway stations for handling baggage, and freight transfer companies in the United States are planning to handle freight in their transfer yards in this way.

An Elevator Telephone Service

An old studio building in the city of New York, built many years ago, has the next best thing to having a telephone service in each apartment. Instead of tenants being obliged to go down to the ground floor to answer calls, the telephone is brought up to them in the elevator. This is done simply by fixing the regular telephone instrument to the wall of the car and having enough wire to spare to allow the elevator to move up and down with it.

The elevator boy answers the calls and simply moves his elevator to the floor where lives the person desired. The tenants in the building have got used to it, and seem to have no trouble in carrying on conversations while the elevator goes up and down on its business.

Wireless Telegraphic Time Signals for War Vessels

Following out the plans proposed by the Bureau of Equipment of the Navy Department, says "The Army and Navy Journal," a wireless telegraph station has been established on the Farralones, those lonely rocks beyond the Golden Gate, the entrance to the bay of San Francisco. This plant will supersede that already established by the Weather Bureau, and has a capacity, or range, of 200 miles in place of the 50 miles of the Weather Bureau's system.

The installation of this plant is a step in the direction of giving time signals to vessels at sea. Wireless telegraphy will be used in sending noon signals to ships at sea in place of the existing methods of "taking sights" for navigating purposes, and the idea is being worked out in the Bureau of Navigation at the present time. Should it prove feasible, navigation will be a matter of time signals from the nearest observatory, from which wireless messages could be sent at noon of each day with absolute accuracy.

The Union Pacific road has successfully welded a broken frame on a Pacific type engine by the alumino-thermit process. This is one of a few attempts to be recorded of the use of thermit to weld a broken locomotive frame—the first being on the Pennsylvania Railroad early this year. There is now no room for doubt about the efficiency of a weld by thermit. The saving effected by welding a frame in position, making dismantling unnecessary, will be the force that will push thermit welding to the front in locomotive repairs.

Water-Power in Electrical Supply

By ALTON D. ADAMS

WATER-POWER is displacing steam-power in many systems of electrical supply, but there are divergent opinions as to the advantages of the change. A saving of fuel is most commonly assigned as the main reason for the adoption of water-power, but it is admitted that the steam plant must be retained in many cases, though its hours of operation are reduced.

In comparatively few systems is the available water-power sufficient to carry the entire load at all hours of the day and during all months of the year, so that the question of how much fuel can be saved is an undecided one for many plants. Again, the development of water-power often involves a large investment, and may bring a burden of fixed charges greater than the value of the fuel saved.

In spite of these conflicting opinions and factors, the application of water-power in electrical systems is now going on faster than ever before. If a saving of fuel, measured by the available flow of water during those hours when it can be devoted directly to electrical supply, were its only advantage, the number of cases where this power could be utilized at a profit would be relatively small. If, on the other hand, all of the water that passes down a stream could be made to do electrical work, and if the utilization of this water had other advantages nearly or quite as great as the reduction of expense for coal, then many water-powers would await only development to bring profit to their owners.

No part of the problem is more uncertain than the first cost and subsequent fixed charges connected with the development of a water-power. To bring out the real conditions, the detailed facts as to one or more plants may be of greater value than mere general statements covering a wide range of cases.

On a certain small river the entire water privilege at a point where a fall of 14 feet could be made available was obtained several years ago. At this point a substantial stone and concrete dam was built, and also a stone and brick power house with concrete floor and steel truss roof. In this power house were installed electric generators of 800 K. W. total capacity, direct connected to horizontal turbine wheels. The entire cost of the real estate necessary to secure the water-power privilege plus the cost of all the improvements was about $130,000. More than enough water-power to drive the 800-K. W. generators at full load was estimated to be available, except at times of exceptionally low water. At this plant the investment for the water-power site, development and complete equipment was thus $162 per kilowatt capacity of generators installed.

Allowing 65 days of low water, these generators of 800 K. W. capacity may be operated 300 days per year. If the running time averages 20 hours daily at full load, the energy delivered per year is 4,800,000 kilowatt hours. Ten per cent. of the total investment should be ample to cover interest and depreciation charges, and this amounts to $13,000 yearly. It follows that the items of interest and depreciation on the original investment represent a charge of 0.27 cent per kilowatt-hour on the assumed energy output at this plant. This energy is transmitted a few miles and used in the electrical supply system of a large city.

On another river the entire water privilege was secured about four years ago at a point where a fall of more than 20 feet between ledges of rock could be obtained and more than 2000 horse-power could be developed. At this point a masonry dam and brick power house were built, and horizontal turbine wheels were installed, direct connected to electric generators of 1500 K. W. total capacity. The entire cost of real estate, water rights, dam, building and equipment in this case was about $250,000.

Assuming, as before, that generators may be operated at full capacity for 20 hours per day during 300 days per year, the energy delivered by this plant amounts to 9,000,000 kilowatt-hours yearly. The allowance of 10 per cent. on the entire investment for interest and depreciation is represented by $25,000 yearly in this case, or 0.28 cent per kilowatt-hour of probable output. Energy from this plant is transmitted and used in a large system of electrical supply.

If, through lack of water or inability to store water or energy at times when it is not wanted, generators cannot be operated at full capacity during the average number of hours assumed above, the item of interest and depreciation per unit of delivered energy must be higher than that computed. With the possible figure for this item at less than three-tenths of a cent per kilowatt-hour, there is opportunity for a large increase before it becomes prohibitive. At the plant last named the entire investment amounted to $166 per kilowatt capacity of connected generators, compared with $162 in the former case, and these figures may be taken as fairly representative for the development of water-power in a first-class manner on small rivers, under favorable conditions. In both of these instances the power houses are quite close to the dams. If long canals or pipe lines must be built to convey the water, the expense of development may be greatly increased.

One advantage of water over steam power is the smaller cost of the building with the former for a given capacity of plant. The building for direct-connected electric generators, driven by water-wheels, is relatively small and simple. Space for fuel, boilers, economizers, feed-water heaters, condensers, steam piping and pumps is not required where water-power is used. No chimney or apparatus for mechanical draught is needed.

The modern electric station operated by water-power usually consists of a single room with no basement under it. One such station has floor dimensions 27 x 52 feet, giving an area of 1404 square feet, and contains generators of 800 K. W. capacity. This gives 1.75 square feet of floor space per kilowatt of generators. In this station there is ample room for all purposes, including erection or removal of machinery.

Next to the saving of fuel, the greatest advantage of water-power is due to the relatively small requirements for labor at generating stations where it is used. This is well illustrated by an example from actual practice. In a modern water-power station that contributes to electrical supply in a large city the generator capacity is 1200 kilowatts. All of the labor connected with the operation of this station during nearly 24 hours per day is done by two attendants working alternate shifts.

These attendants live close to the station in a house owned by the electric company, and receive $60 each per month in addition to house rent. Considering the location, $12 per month is probably ample allowance for the value of rent. This brings the total expense of operation at this station for labor up to $132 per month, or $1584 per year, a sum corresponding to $1.32 yearly per kilowatt of generator capacity.

At steam-power stations of about the above capacity, operating 24 hours daily, $6 is an approximate yearly cost of labor per kilowatt of generators in use. It thus appears that water-power plants may be operated at less than one-fourth of the labor expense necessary at steam stations per unit of capacity. On an average, the combined cost of fuel and labor at electric stations driven by steam-power is a little more than 76 per cent. of their total cost of operation. Of this total, labor represents about 28, and fuel about 48 per cent. Water power, by dispensing with fuel and with three-fourths of the labor charge, reduces the expense of operation at electric stations by fully 69 per cent.

But this great saving in the operating expenses of electric stations can be made only where water entirely displaces coal. If part water-power and part coal are used, the result depends on the proportion of each, and is obviously much affected by the variations of water-power capacity. In such a mixed system the saving effected by water-power must also depend on the extent to which its energy can be absorbed at all hours of the day. By far the greater number of electric stations using water-power are obliged also to employ steam during either some months in the year or some hours in the day, or both.

It is highly important, therefore, to determine, as nearly as may be, the answers to three questions:—

First, what variations are to be expected in the capacity of a water-power during the several months of a year?

Second, if the daily flow of water is equal in capacity to the daily output of electrical energy, how far can the water-power be devoted to the development of that energy?

Third, with a water-power sufficient to carry all electrical loads at times of moderately high water, what percentage of the yearly output of energy in a general supply system can be derived from the water?

To the first of these questions experience alone can furnish an answer. Variations in the discharge of rivers during the different months of a year are very great. In a plant laid out with good engineering skill some provision will be made for the storage of water, and the capacity of generating equipment will correspond to some point between the highest and lowest rates of discharge.

Curve No. 1 in the diagram on the opposite page represents the energy output at an electric station driven entirely by water-power from a small stream during the twelve months of 1901, the entire flow of the stream being utilized. During December, 1901, the output of this station was 527,700 kilowatts, and was greater than that in any other month of the year. Taking this output as 100 per cent., the curve is platted to show the percentage attained by the delivered energy in each of the other months. At the lowest point on the curve, corresponding to the month of February, the output of energy was only slightly over 33 per cent. of that in December. During nine other months of the year the proportion of energy output to that in December was over 60 and in three months over 80 per cent. For the twelve months the average delivery of energy per month was 73.7 per cent. of that during December.

PERCENTAGES OF ENERGY DELIVERED IN DIFFERENT MONTHS, 1901

January	68.0	May	77.9	September	79.3
February	33.1	June	58.6	October	65.9
March	80.5	July	07.7	November	95.8
April	81.7	August	75.8	December	100.0

At a somewhat smaller water-power station on another river with a watershed less precipitous than that of the stream just considered, the following results were obtained during the twelve months ending June 30, 1900. For this plant the largest monthly output of energy was in November, and this output is taken at 100 per cent. The smallest delivery of energy was in October, when the percentage was 53.1 of the amount for November. In each of seven other months of the year the output of energy was above 80 per cent. of that in November. During March, April, May and June the water-power yielded all of the energy required in the electrical supply system with which it was connected, and could, no doubt, have done more work if necessary. For the twelve months the average delivery of energy per month was 80.6 per cent. of that in November, the month of greatest output.

PERCENTAGES OF ENERGY DELIVERED IN DIFFERENT MONTHS, 1899 AND 1900

July	68.6	November	100.0	March	98.5
August	69.1	December	87.0	April	85.7
September	73.3	January	84.9	May	80.8
October	53.1	February	91.3	June	74.9

The gentler slopes and better storage facilities of this second river show their effect in an average monthly delivery of energy 6.9 per cent. higher as to the output in the month when it was greatest than the like percentage for the water-power first considered. These two water-powers illustrate what can be done with only very moderate storage capacities on the rivers involved. At both stations much water escapes over the dams in several months in each year. With enough storage space to retain all waters of these rivers until wanted, the energy outputs could be largely increased.

As may be seen by inspection of curve No. 2, the second water-power has smaller fluctuations of capacity, as well as a higher average percentage of the maximum output than the water-power illustrated by curve No. 1.

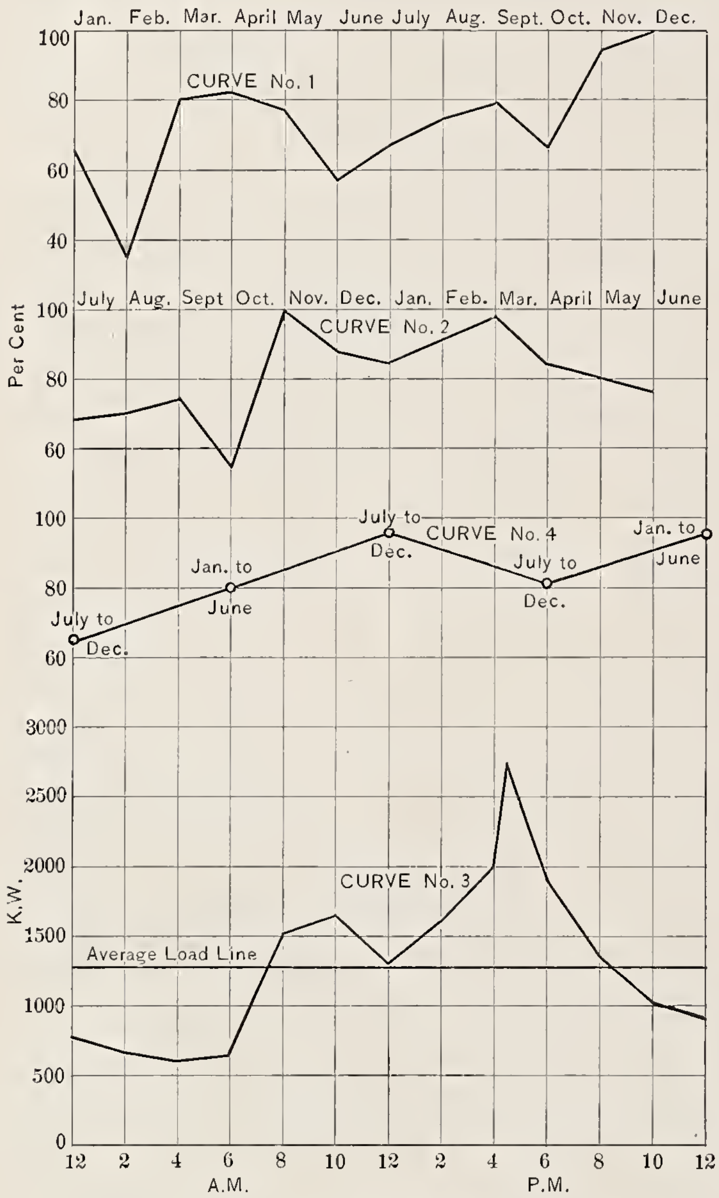
If the discharge of a stream during each 24 hours is just sufficient to develop the electrical energy required in a supply system during that time, the water may be made to do all of the electrical work in one of two ways. If the water-power has enough storage capacity behind it to hold the excess of water during some hours of the day, then it is only necessary to install enough water-wheels and electric generators to carry the maximum load Should the storage capacity for water be lacking, or the equipment of generating apparatus be insufficient to work at the maximum rate demanded by the electrical system, then an electric storage battery must be employed if all of the water is to be utilized and made to do the electrical work.

The greatest fluctuations between maximum and minimum daily loads at electric lighting stations usually occur in December and January. The extent of these fluctuations is illustrated by curve No. 3, which represents the total load on a large electrical supply system during a typical week-day of January, 1901. On this day the maximum load was 2720 and the minimum load 612 K. W., or 22.5 per cent. of the highest rate of output. During the day in question the total delivery of energy for the 24 hours was 30,249 kilowatt-hours, so that the average load per hour was 1260 K. W. This average is 46 per cent. of the maximum load.

Computation of the area included by curve No. 3 above the average load line of 1260 K. W. shows that about 17.8 per cent. of the total output of energy for the day was delivered above the average load, that is, in addition to an output at average load. It further appears by inspection of this load curve that this delivery of energy above the average load line took place during 12.3 hours of the day, so that its average rate of delivery per hour was 438 K. W.

If a water-power competent to carry a load of 1260 K. W. 24 hours per day be applied to the system illustrated by curve No. 3, then about 17.8 per cent. of the energy of the water for the entire day must be stored during 11.7 hours and liberated in the remaining 12.3 hours. This percentage of the total daily energy of the water amounts to 36 per cent. of its energy during the hours that storage takes place.

If all of the storage is done with water, the electric generators must be



ENERGY CURVES FROM WATER POWER ELECTRIC STATIONS

able to work at the rate of 2720 K. W., the maximum load. If all of the storage is done in electric batteries, the use of water may be uniform throughout the day, and the generator capacity must be enough above 1260 K. W. to make up for losses in the batteries. Where batteries are employed, the amount of water will also be somewhat greater than that necessary to operate the load directly with generators, because of the battery losses.

In spite of the large fluctuations of electrical loads throughout each 24 hours, it is thus comparatively easy to operate them with water-powers that are little, if any, above the requirements of the average loads.

Perhaps the most important question relating to the use of water-power in electrical supply is what percentage of the yearly output of energy can be derived from water where this power is sufficient to carry the entire load during a part of the year. With storage area for all surplus water in any season, the amount of work that could be done by a stream might be calculated directly from the records of its annual discharge of water. As such storage areas for surplus water have seldom, or never, been made available in connection with electrical systems, the best assurance as to the percentage of yearly output that may be derived from water-power is found in the experience of existing plants.

The question now to be considered differs materially from that involving merely the variations of water-power in the several months, or even the possible yearly output from water-power. The ratio of output from water-power to the total yearly output of an electrical system includes the result of load fluctuations in every 24 hours and the variable demands for electrical energy in different months, as well as changes in the amount of water-power available through the seasons.

In order to show the combined result of these three important factors curve No. 4 has been constructed. This indicates the percentages of total semi-yearly outputs of electrical energy derived from water-power in two supply systems. Each half year extends either from January to June, inclusive, or from July to December, inclusive, and thus covers a wet and dry season. Each half year also includes a portion of maximum and one of minimum demand for electrical energy in lighting. The period of largest water supply usually nearly coincides with that of the heaviest lighting load, but this is not always true.

Electrical systems have purposely been selected in which the water-power in at least one month of each half year was nearly or quite sufficient to carry the entire electrical load. The percentage of energy from water-power to the total energy delivered by the system is presented for each of five half years. Three of the half years each run from July to December, and two extend from January to June, respectively. The half years that show percentages of 66.8, 80.2 and 95.6, respectively, for the relation of energy from water-power to the total electrical output relate to one system, and the half years that show percentages of 81.97 and 94.3 for the energy from water-power relate to another system.

For the half-year when 66.8 per cent. of the output of the electrical system was derived from water-power, the total output of the system was 3,966,026 kilowatt-hours. During the month of December in this half-year more than 98 per cent. of the electrical energy delivered by the system was from water-power, though the average for the six months was only 66.8 per cent. from water.

In the following six months, from January to June, the electrical supply system delivered 4,161,754 kilowatt-hours, and of this amount the water-power furnished 80.2 per cent. For the six months just named, one month, May, saw 99 per cent. of all the delivered energy derived from water-power.

The same system during the next half-year, from July to December, without any addition to its water-power development or equipment, got 95.6 per cent. of its entire energy output from water-power, and this output amounted to 4,415,945 kilowatt-hours. In one month of the half year just named only 0.2 per cent. of the output was generated with steam-power.

These three successive half years illustrate the fluctuations of the ratio between water-power outputs and the demands for energy on a single system of electrical supply. The percentage of 81.9 for energy derived from water-power during the half year from July to December represents the ratio of output from water to the total for an electrical supply system where water generated 94 per cent. of all the energy delivered in one month.

In the same system during the following six months, with exactly the same water-power equipment, the percentage of output from water-power was 94.3 of the total kilowatt-hours delivered by the system. This result was reached in spite of the fact that the total outputs of the system in the two half years were equal to within less than one per cent.

The lesson from the record of these five half years is that comparatively large variations are to be expected in the percentage of energy developed by water-power to the total output of electrical supply systems in different half years. But, in spite of these variations, the portion of electrical loads that may be carried by water-power is sufficient to warrant its rapidly extending application to lighting and power in cities and towns.

Swedish Copper

THE following translation from a Swedish commercial publication relating to the high price of copper and the outlook for working the Swedish copper mines, has been transmitted by Consul S. S. Bergh, of Gottenborg, Sweden:—

"Among the economic phenomena at present arresting attention is the rise in the price of copper. Sweden is largely interested in the copper industry, though the present production of copper ore in the country is not large. A part of the combined Swedish copper works have based their production on foreign raw material. This is to be deplored all the more, as Sweden is the only country in Europe (Norway, Portugal and Spain excepted) that has mines capable of a considerable copper output, although these mines are almost unworked. The import of copper ore for the past few years has amounted to 3,000,000 to 4,000,000 crowns ($804,000 to $1,072,000) annually. With the large increase in the price of copper that has taken place, the price being now £10 ($48.66) a ton, the value of the import would be increased to not less than 7,000,000 to 8,000,000 crowns ($1,876,000 to $2,144,000).

"How are we to avoid this unnecessary payment to foreign countries? Is the increase in price momentary, or will the price of copper keep steady at a high level for some time? This is a question of the greatest importance for the Swedish copper industry. If the price of copper, on account of the small supply and the great demand, will keep high, the time may have come for us to work several of the particularly important copper mines of Sweden. The market prospects are at present very favorable for the Swedish copper works. The rise in the price of the ore will probably not influence the consumption, but will be an increased tax on the countries which have to buy."

In the North of France an electric motor car stops in villages on stated days to receive such sums as thrifty country people may be desirous of depositing in a savings bank. The car carries a small safe, a desk with folding shelves for the depositors, with accommodations for two clerks and a cashier and a seat for the driver.

An Indicating Steam Meter

THERE has been for many years a demand for some practical device which will measure or indicate the amount of steam in pounds which is delivered through pipes to an engine, radiator, or steam pump. Several devices have been designed for the purpose, but on account of the changing conditions of steam only partial success has been attained.

With a permanent gas of practically uniform pressure and temperature, such as illuminating gas, the metering would be a simple problem, but steam is not a perfect gas and usually varies in pressure and temperature many pounds and degrees, and contains more or less water, depending on the distance from the boiler and the efficiency of the insulation of the radiating surfaces. As the steam pressure in various plants varies from below atmospheric pressure when used for heating to as high as 200 pounds per square inch where used for power in multiple cylinder engines and steam turbines, meters with considerable range are required, no matter where or for what purpose they are to be used. To design a meter to operate successfully under these varying conditions has been the aim of Mr. C. E. Sargent, and the device, described by him as follows, in a recent paper before the American Society of Mechanical Engineers, is believed to overcome many of the difficulties which have heretofore been obstacles to success. To the central station engineer it ought to appeal specially as a probably serviceable engine room adjunct.

If there is a constant difference between the pressures each side of a certain opening the amount of steam flowing through that opening will depend on the area and the density of the steam, which varies with the pressure. If the initial pressure and the difference in pressure remain constant, then the weight of steam flowing through will depend on the area of the opening and if the opening is constant the weight of steam flowing through will vary with the pressure and the difference of pressure on either side of the opening.

If the difference in pressure between two tanks is 1 pound, and the initial pressure varies from 50 to 100 pounds, twice as much steam will flow through a certain opening with 100 pounds pressure as would flow through with 50 pounds pressure. In the meter under consideration, which is designed for steam pressure of 50 to 100 pounds, a drop of 2 per cent.

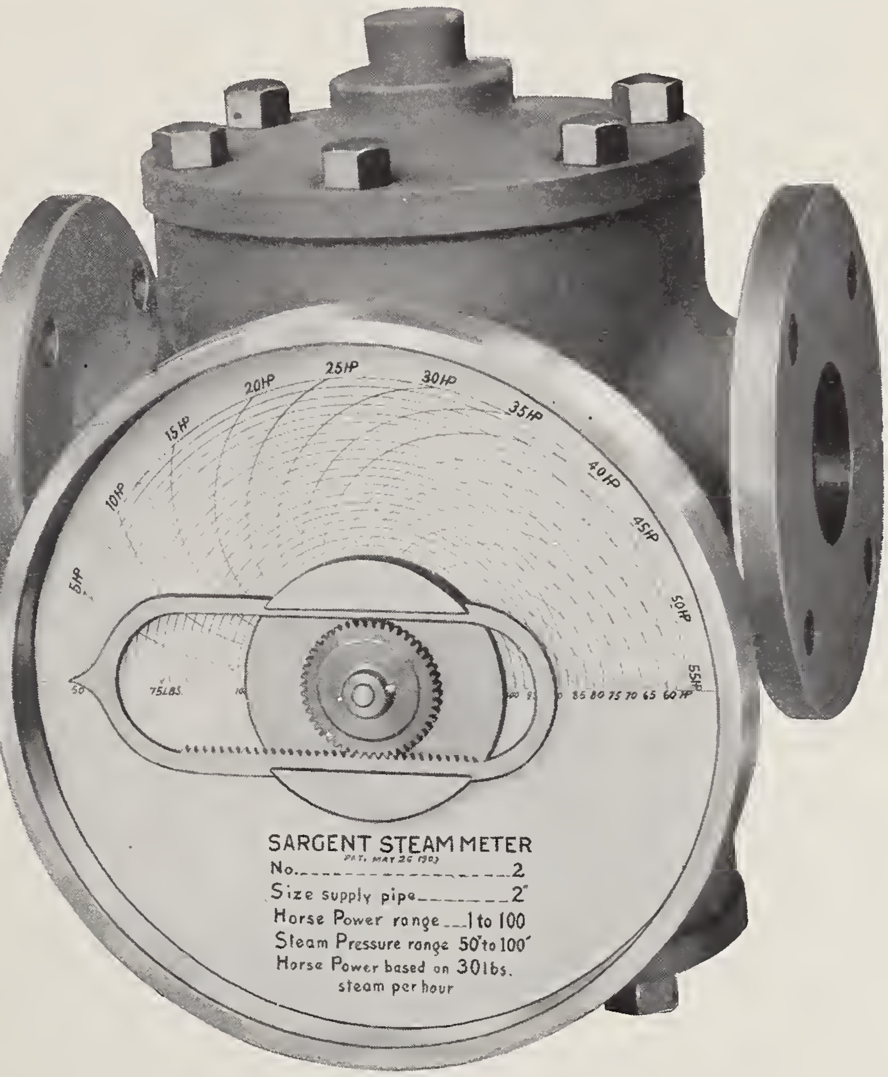


FIG. I.—A 2-INCH INDICATING STEAM METER

is thought advisable, and the areas are proportioned accordingly. When steam is flowing through, the opening will adjust itself, so that the difference of pressure is always a percentage of the pressure on the inlet side. Any tendency of the pressure to equalize will immediately close the valve, and by thus throttling the passage reduce the outlet pressure below the inlet pressure, as designed. Any tendency for the outlet pressure to reduce more than 2 per cent. below the inlet pressure will raise the valve and increase the area of the steam passage. Slugs of water coming with the steam cannot by inertia open the valve *D*, Fig. 2, because they cannot strike the valve except radially, and it is balanced against such a force. As the opening *F* is small and changes the direction of any water which might tend to go through should the valve suddenly open, no harm can arise from water in steam, except, possibly, to introduce an error in indication.

The main valve stem *E* will stand between the position of the full opening or the complete closure of the valve, depending on the amount of steam passing through, and the position of this stem determines the movement of the indicating finger around the center of the dial, through mechanism hereafter described and shown in Figs. 1, 3 and 4.

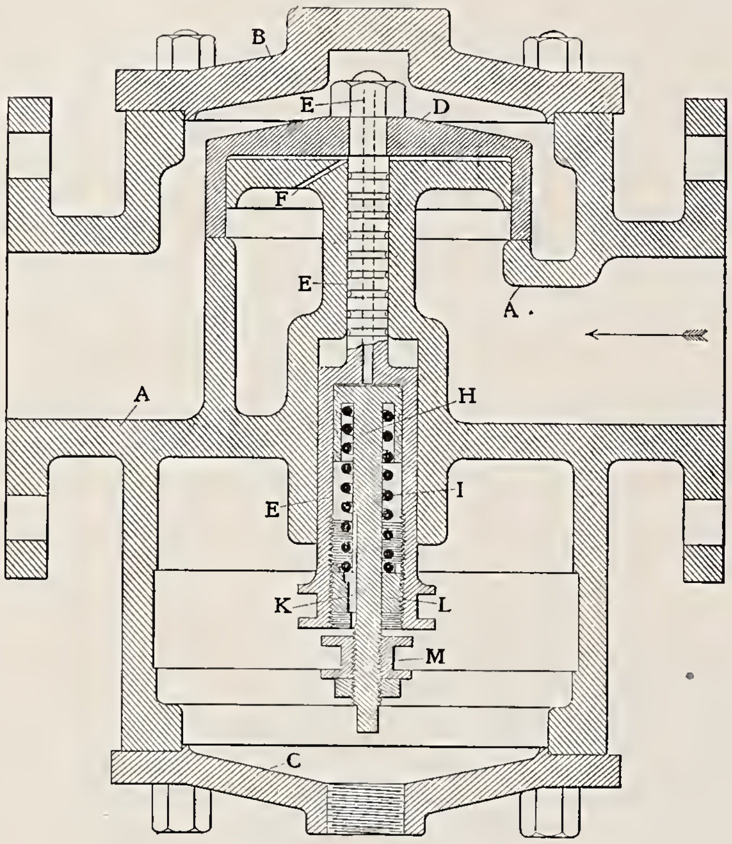


FIG. 2.—LONGITUDINAL SECTION

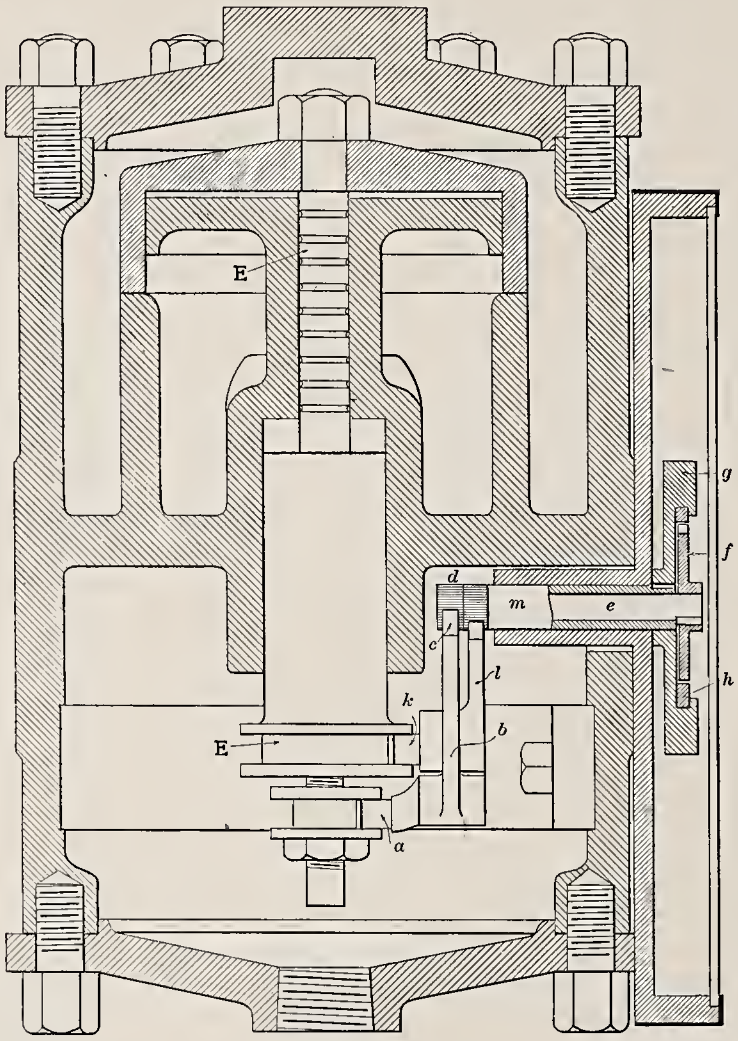


FIG. 3.—TRANSVERSE SECTION

If the steam always had the same density no further indicating apparatus would be necessary, but as the weight per volume varies with the pressure, the same quantity of steam under double the pressure will flow through one-half the area for the same length of time; also, if the difference in pressure increases with the absolute pressure more steam will flow through a certain opening when the pressure increases than if the difference in pressure each side of the opening remained constant. On the assumption, then, that pressure times volume equals a constant ($PV = C$) which is near enough for practical purposes, we can determine the amount of steam passing from one receptacle to another, if we know the difference in pressure in the two receptacles, by determining the area of the opening through which the steam flows; but as the weight of steam passing through a defined opening will vary with the pressure, and the difference in pressure each side of the opening, then we must vary our opening with the pressure if a uniform weight is flowing through. And this is the principle upon which this meter is based. With a constant weight or horse-power passing through the pointer will follow the horse-power curve on the dial, though the pressure of the steam varies between the limits of the meter.

In any steam pipe in which the steam is not superheated there is more or less condensation. While any steam meter should have a separator between it and the boiler, water can in no way affect the mechanism of this meter, as all moving parts are protected from derangement caused by inertia of water passing through the openings.

Fig. 1 is a general view of a 2-inch meter, showing the dial side and compensating pointer. It is flanged and faced and can be inserted in the steam pipe as an ordinary 2-inch globe valve. This particular meter is calibrated to show the horse-power (based on 30 pounds of steam per horse-power hour) passing through with a steam pressure of between 50 and 100 pounds. Fig. 2 is a longitudinal section, Fig. 3 a transverse section and Fig 4 an elevation of the indicating mechanism looking toward the back of dial. Referring to Fig. 1, if no steam is flowing through the meter the pointer will indicate zero horse-power, as in the figure, but will indicate the pressure if it ranges between 50 and 100 pounds. As the end of the pointer will not begin to move toward the center of the dial until the pressure reaches 50 pounds, it will stand at 50 pounds when there is no pressure in the meter. If the pressure were maintained exactly at 50 pounds, and 150 pounds of steam passed through per hour (5 H. P. at 30 pounds of steam per horse-power hour), then the pointer would stand at 5 H. P. and 50 pounds pressure. If 40 H. P. were passing through, the pointer would so indicate, and if the pressure were raised from 50 to 100 pounds the end of the pointer would follow the curve of 40 H. P. from the 50 to the 100 pressure limit. In like manner the pointer would indicate the weight of steam passing through, no matter how the quantity of pressure varies, provided it remains within the limits of the machine.

In Fig. 2, which shows the steam passage and moving parts, *A* is the body of meter, *B* the top cover and *C* the bottom cover; *D* is the self-adjusting valve, which remains seated when no steam is passing through the meter, and which is held in place by and fastened to the valve stem *E*, which works in two diameters in the body *A*. The bottom cover *C* is tapped for ¾-inch pipe, which connects the meter to the atmosphere or sewer. The action of the meter is as follows: Steam is admitted on the side of the arrow and surrounds the valve stem guide; as soon as pressure accumulates it passes through the small hole *F* and raises the self-adjusting valve *D*, allowing the steam to pass to the outside and top of the valve. As the bottom

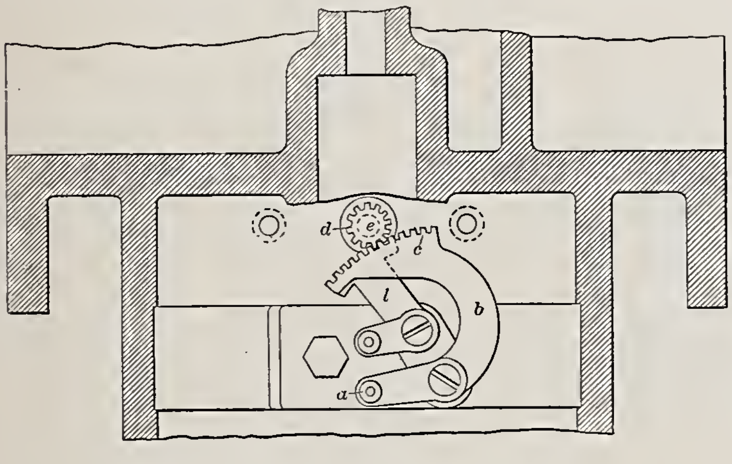


FIG. 4.—THE INDICATING MECHANISM

end of the stem *E* is open to the atmosphere the pressure on top of the valve *D* tends to close same by an amount of pressure equal to the pressure in the meter into the area of the valve stem immediately below the valve. As the pressure under the valve is always tending to open it, and the pressure on the stem is always tending to close it, there will be a difference in pressure between the inlet and outlet of the meter equal to the difference in area of the valve and valve stem. As these areas are so designed that the ratio is about 50 to 1, the pressure of steam on the discharge side of the meter will be 2 per cent. less than on the admission side with any pressure carried. If 100 pounds pressure is carried on the boiler side of meter 98 pounds pressure will be delivered on the engine side, and if the admission pressure is only 50 pounds the discharge pressure will be 49 pounds.

Referring to Fig. 2, the pressure of steam above the valve *D*, and on the outlet side of the meter, may pass through the hollow valve stem *E* and act on the piston *H*, compressing it, and the spring *I*, which in the present case is of such a tension that 50 pounds pressure per square inch is necessary to overcome its statical conditions, and 100 pounds per square inch is sufficient to compress it to its full limit. The movement of this piston *H* is transmitted to the roller *a*, Figs. 3 and 4, which, through the bell crank *b*, the segment *c*, and pinion *d*, the shaft *e* and the large pinion *f*, Figs. 1 and 3, and the rack *h*, transmits the movement of the end of the pointer to and from the center of the dial, showing the steam pressure per square inch on the meter.

The position of the main valve stem *E* is transmitted through the roller *k*, the bell crank *l*, the holow shaft and pinion *m* and the disk *g*, which revolves the pointer around the dial center. The amount of movement around the center depends upon the opening of the valve, and the distance of the end of the pointer from the center of dial depends on the steam pressure per square inch between the limits of the meter of 50 and 100 pounds, and, on account of the compensating mechanism, the pounds avoirdupois of steam or horse-power passing through are always indicated.

The size of the pipe and meter determines the maximum possible horse-power on the dial, while the number of the spring determines the range of pressure required.

In measuring exhaust steam for heating, the spring and dial are designed to show a pressure from 0 to 30 pounds absolute, and the dial may indicate pounds of steam instead of horse-power. If the steam pressure upon which the horse-power of the engine is based is 150 pounds, then the meter spring and dial would show a range of horse-power from 0 to full meter capacity and a pressure range from 125 to 175 pounds, or greater range if desired. By carrying extra springs and dials to correspond meters for any range may be furnished from stock on short notice, fully graduated for the pressure desired.

It was the intention to calibrate each meter sent out, but when two or more of the same size are calibrated in series the indications correspond so closely that it is expected that the calibration of only one of a size and range will be found sufficient. The method of calibrating a meter is as follows:—

From the meter's construction there must always be a difference in the steam pressure each side of the meter, depending on the inlet pressure; therefore the amount of steam flowing through will regulate the amount of valve opening. As the difference in pressure between the two sides of the meter increases as the pressure increases, the opening through which the steam flows will not increase as fast as the pressure in order to let the same weight of steam through in a certain time, and this is advantageous, because the valve will require less movement as the pressure increases. In order to calibrate the meter it is necessary first to get a spring of the proper tension to move the end of the pointer from the outside to the inside of the dial through the range of pressure required. The spring is first calculated, then can be adjusted when hot and in place, if necessary, by holding the outside valve stem *E* and turning the inside valve stem with a socket wrench.

The meter is connected up between the steam header and condenser with a pressure regulating valve in series between the meter and steam supply. Accurate gauges are connected to both the inlet and outlet sides of the meter, and the pressure regulator is set to carry the highest pressure for which the meter is calibrated. A valve on the discharge side is opened slightly and the position of the pointer noted, and the quantity of steam flowing through is condensed and weighed. In like manner a series of points for a constant pressure is established through the whole capacity of the meter. The pressure is reduced and the operation is repeated. When completed and the points are connected there will be a series of concentric rings representing the different pressures and a series of converging or diverging curves representing the pounds of water passing through which is indicated by the position of the pointer when the meter is in operation.

The spring should be of steel, heavily nickel plated. The meter may be inserted in the steam pipe, either next to the boiler, in which case no separator need be used, or next to the engine, in which case a separator between the meter and boiler, as close to meter as possible, should be used, and a drum having four times the capacity of the first cylinder at its average cut off should be placed between meter and engine to get a constant flow through the meter and a practically stationary position (non-oscillating) of the pointer. By observing the position of the pointer for any interval of time the amount of horse-power or pounds of steam passing through to the engine or heating system may be determined.

The Indianapolis & Cincinnati Single-Phase Railway

REGULAR service was recently commenced on the single-phase railway of the Indianapolis & Cincinnati Traction Company. When completed this road will extend from Indianapolis through fourteen towns to Cincinnati. At present the line runs from Indianapolis to Rushville, about 41 miles, and cars are in service between the latter and Morristown, about 20 miles.

The power station is at Rushville, and is equipped with two 500-K. W., 2300-volt, 3-phase, 25-cycle Westinghouse alternators, direct-connected to cross-compound Corliss engines. Steam is furnished by three 350-H. P. Babcock & Wilcox boilers, arranged for natural gas firing, though provision is also made for coal burning. The current is led to two pairs of 250-K. W. air-blast transformers, connected on the 3-phase, 2-phase system. The secondaries deliver 2-phase current at 33,000 volts. A single-phase circuit runs to each transformer station.

TRACK LAYING ON THE INDIANAPOLIS & CINCINNATI SINGLE-PHASE RAILWAY

Two 300-K. W. oil-insulated, self-cooling transformers in the power house reduce the 33,000 volts to 550 for that portion of the trolley line in Rushville. Transformers, located in stations situated along the line at intervals of from 10 to 12 miles, also reduce the 33,000 volts to 3300. The transformer stations are of steel, brick and concrete, the doors and windows being protected by steel shutters. Each is equipped with two 300-K. W. transformers, with disconnecting switches and lightning arresters.

Within the limits of Indianapolis,—a distance of about 3 miles,—the cars will be run over existing lines, and will be operated with direct current at 550 volts. In Rushville they will be operated with alternating current at the same potential, and, on intervening sections, with single-phase, 25-cycle current at 3300 volts.

The cars are equipped with four 75-H. P. Westinghouse single-phase motors of the commutator series type,—two on each truck. The Westinghouse multiple-unit system is also provided, and, as the cars are to be operated on both direct and alternating current, the rheostatic system of control was adopted. The motors are geared 45 miles an hour maximum, with a normal speed of 30 miles an hour. "Limited" cars will be equipped with motors of 150 H. P. total capacity, to run from 50 to 60 miles an hour. Each car has two trolleys, one of the bow type for high-potential service, and the other a modified standard trolley for use on the direct-current and low-voltage section.

The high-tension transmission lines consist of a No. 4 bare copper wire, and are supported on large porcelain insulators, held by iron pins to strongly constructed cross-arms, mounted on a separate line of poles set near the edge of the right of way. Along the private right of way the trolley wire is suspended 18 feet above the track from poles set in the center of the grade, 100 feet apart, with a bracket made of angle iron looped at the end, so as to carry a large flat insulator, from the top of which is run a 7-16-inch steel strand cable or messenger wire. The trolley is formed of No. 000 copper wire, and is carried 8 inches under the messenger cable, to which it is attached every 10 feet with steel clamps. Where the tracks are in the streets the poles are set on the sides of the streets, and the trolley is suspended from span wires. Otherwise, the construction is the same as along the private right of way.

The entire system is provided with two metallic-circuit telephone lines, one of which is reserved exclusively for the train dispatcher; the other line is intended for general company business. Each car carries a telephone, so that communication can be had with the train dispatcher at intervals of 2000 feet. Telephone wires are carried on porcelain insulators on cross-arms near the tops of the trolley poles. The wires are transposed every 500 feet, in order to avoid disturbance by the current in the transmission lines.

It is estimated that the absence of rotary converters in the sub-stations will make a saving of $6 a day for each station. The three stations already in use will thus make a saving of $6570, and, when the entire road is in operation, the annual saving will be $22,000.

The electrical equipment of the road was furnished by the Westinghouse Electric & Manufacturing Company, of Pittsburg, according to plans of Messrs. Sargent & Lundy, of Chicago.

When Tyndall came to America in 1870 to deliver lectures on light and electricity, he brought with him 100 Grove cells to produce an electric light for the purposes of demonstration. His assistant was obliged to spend two hours before each lecture in arranging these cells, filling them with acids and scraping the connections, retiring from each encounter almost asphyxiated by the irritating and poisonous fumes of nitrous oxide gas. At the present time no lecturer on science in the halls where Tyndall spoke need spend a moment in providing a source of electricity. It is on tap, so to speak, and can be obtained by touching a button. Tyndall, in his highest flight of scientific imagination, did not picture a development of electricity which would light the halls in which he spoke, which would convey him to and fro with great speed through the streets which he used in going to them, and would enable him to whisper from one city to another, across 1000 miles of intervening space.

New asbestos fields are said to have been found in the country west of Lake St. John, Quebec, Can.

Two-Motor vs. Four-Motor Equipments and Track Bonding

DISCUSSED BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ON FEBRUARY 24

THE last regular monthly meeting of the American Institute of Electrical Engineers was held at New York, on February 24, 1905. Mr. J. W. Lieb, Jr., president, occupied the chair.

Two papers were presented, one by Mr. Norman McD. Crawford, on "Two-Motor Versus Four-Motor Equipments," and the other by Mr. C. W. Ricker, on "Track Bonding." The general subject of the evening was "Light Electric Traction," and Mr. Crawford's paper considered at length the respective advantages of two motors versus four motors for street car equipment for conditions met with in ordinary city travel.

For the purpose of his paper a line was selected having light grades and reasonably small line losses, a line passing through the business center of a city and reaching the residential section, thus at all hours of the day calling for a fair average number of stops, and, therefore, reasonably rapid acceleration, in order to make the time schedule. For this service four types of equipment were selected, namely, Car *A*, 20-foot body, single trucks, two 25-H. P. motors, gear ratio 1 to 4.87; Car *B*, 26-foot body, two trucks, two 35-H. P. motors, gear ratio 1 to 2.82; Car *C*, 26-foot body, two trucks, four 35-H. P. motors, gear ratio 1 to 2.82; Car *D*, 29-foot body, two trucks, four 40-H. P. motors, gear ratio 1 to 3.67.

The service required of these cars was exactly the same, 136.5 miles per day, at an average schedule of 8.45 miles per hour. Each car was equipped with a wattmeter, the readings of which at the end of each half trip were recorded, and at the end of the run the readings were checked by ammeter and voltmeter readings. The peaks of the load were noted at times of acceleration and on grades, and from these tests curves were plotted and tabulated showing the average watt-hours per ton-mile, kilowatts at peaks during day's run, and passengers and kilowatt-hours per half trip. The tabulated records point to the superiority of the light two-motor car, single-truck equipment, for service on the line and under the conditions selected. With longer trips, heavier grades, greater speed in miles per hour, and greater density of population, requiring more rapid acceleration, there is no doubt, the author thinks, that a car of the *D* type would show the greatest efficiency.

The operating manager is looking not only for a car equipment that will fulfil all the requirements of any particular service with the least cost for repairs, and the minimum demand on the power station, but also for one that will combine these advantages at the greatest speed which safety to the public and the distance to be traveled per trip will allow. If the distance is, say, 6 miles per half trip, or 12 miles per round trip, requiring four cars for 15-minute service at 12 miles an hour, and three cars for the same headway at 16 miles an hour, the platform labor per mile in the first instance will be $0.0335 \times 4 = 0.1340$, and in the second instance, $0.025 \times 3 = 0.075$, a saving in labor of 0.059 per mile, and 0.0085 per car mile. This great saving in cost of operation appeals to the operator, but not so greatly if the operating costs are increased by excessive demand on power station equipment and by added interest charges due to increased line copper and rail bonds.

The prime features to be considered in selecting motors and cars for a given run are the following:—

a. The density of population, as governing the size and seating capacity of car body, number of stops per mile, and consequently the acceleration; the frequency of service and the speed in miles per hour.

b. The number of trucks and motors, as determining the number of cars in service, the platform labor, the demand upon power-plant equipment and increased interest charge for line and power plant.

c. The gear ratio, as determining the size of motors, the acceleration, the number of stops per mile, the heating of motors and consequent repairs, and additional power station and line equipments.

The discussion of this paper was opened by Mr. A. H. Armstrong, of Schenectady, who said the contest between two and four-motor equipments is of long standing, but of late years has seemed to have settled itself rather definitely in favor of the four-motor equipment. As Mr. Crawford stated, no general rule can be formulated for predicting in all cases the use of a two or four-motor equipment.

The fundamental reason for adopting the four-motor equipment is the need of increased traction. This need is felt in many different ways, and is partly due to climatic conditions in the North, partly to the presence of excessive and continuous grades over hilly routes, and partly to an exacting schedule calling for very rapid acceleration. In the latter class may be included all city railroads. High acceleration can be obtained only by the adoption of motors on every axle, making all axles driving axles.

The two-motor equipment seems to be regulated more especially to light city traffic, to roads enjoying a fairly level profile and having a schedule that can be accommodated with a moderate amount of acceleration, and when the climatic conditions are not perhaps so severe that they will destroy the tractive effort available with two-motor equipments. There is no reason why a car should demand more energy for a given service when equipped with four motors than with two, provided the total weight of the car is the same in each case.

The common method of comparing two-motor and four-motor equipments is, he thought, unfair, and that is true in the present paper when a two-motor 35-H. P. equipment is compared with four motors of the same size. The weight of the car is greater, and the comparison is, therefore, not on an equal basis. In conclusion, Mr. Armstrong said he thought the only basis of comparison of four-motor and two-motor equipments that can be rationally made, is due entirely to local conditions. Each case must be decided by itself, but the sentiment of railway managers is growing in favor of the four motors for single car operation with every axle equipped.

Mr. S. T. Dodd, of Pittsfield, Mass., said we needed data on the cost of repairs of cars per motor, rather than on the cost of repairs per car-mile. Concerning the statement often made that two-motor equipments running upon the same schedule and with the same weight of car as four-motor equipments will heat more than the latter because the radiating surface of the smaller motors is greater, and, therefore, will carry a greater average load than the larger motors, he remarked that this, in his opinion, was not justified by facts, inasmuch as the ordinary designer provides that the large and small motor have practically the same radiating surface. It appeared to him that in some of the cases the difference in heating cited was not due to the two-motor and four-motor equipments per se, but to a difference in gearing, the increased heating being due to too high gearing.

Mr. Calvert Townley, of New York, considered that in the usual comparison of these two classes of equipment a difficulty arises when, instead of strictly comparing two motors with four motors, a lot of other factors are drawn into the discussion; for example, the question whether the car seats 42 persons or 28 persons, or the question of gear ratio. The question as to which car is the most economical to use is really a matter of local requirements, density of traffic and other conditions. Also within ordinary limits any reasonable gear ratio can be applied to either motor. He thought four motors should be excluded from consideration in cases where enough motor capacity can be obtained on the car with two motors. Obviously it is not a question which is the better arrangement, because there is only one arrangement to be made—if the necessary capacity in the cars cannot be obtained with two motors, four motors must be used.

TRACK BONDING

Mr. C. W. Ricker then read his paper on "Track Bonding." He began by noting that in the earlier days of electric railway work, with crude apparatus and light loads, track resistance was neglected. As the need became evident, auxiliary returns were run and connected to the rails at frequent intervals, but of a size which now seems absurdly small. Joint bonds were first of small iron wire, like railroad signal-system bonds. Then pieces of copper wire with the ends riveted in holes in the rail-web were used; then pieces of trolley wire with channel pins and so on, until specially designed terminals were developed. The work of Mr. F. H. Farnham regarding the electrolysis of buried metals called attention strongly to the return-circuit losses in what was then a well-equipped electric railway system. Since then the progress has been along the general direction of utilizing the track metal to best advantage for the return circuit; and except in the case of rather complex city networks and single lines fed from a power plant unfavorably situated, this course has proved more economical than the installation of copper return cables.

With the prospective use of alternating currents and the six to sevenfold increase of apparent track resistance, an increased use of copper may become necessary; but with all direct-current operation the engineering problem is to use the rails to best advantage, and this is largely a matter of the selection and installation of track bonds.

The first condition to determine the character of the bonding is the rail joint, which, in turn, is determined by the roadbed. The majority of all track, including all not buried in pavement, must have flexible joints of either bolted or wedge types, and the electrical conductivity must depend upon bonds installed for that sole purpose, that of the rail joint itself being slight.

While rail bonds are made of a wide variety of forms and materials, all in general use have some flexibility, for ease of application and for durability afterward, varying with the amount of flexure expected in the track structure.

This has led to the general adoption of a form consisting of two terminals with a connecting shank of considerable length, to which all bonds conform, except some special kinds in very limited use. Hence, it is convenient to classify bonds by the kind and form of contact with the rail. There is thus the compressed terminals in which a hole is drilled or punched in the rail, and a cylindrical terminal of the bond is upset in the same way by great pressure, applied slowly, till the bond metal fills the hole very tightly, with the two metal surfaces in intimate contact and held there by elasticity. A terminal of the same form is expanded in the hole in the rail by means of a drift driven through a hole in the terminal. Soldered terminals are those in which a flat terminal is soldered to the surface of the rail with either soft or brazier's solder. In another case the terminal of a copper bond and the surface or a hole in the rail are amalgamated and held in contact with slight pressure, depending upon a layer of tin amalgam to maintain the metallic contact. In one form a mass of tin amalgam is placed between amalgamated surfaces of the rail and joint plate and held in place by a cork washer squeezed between the same.

In case of bolted terminals copper strips or sheets are pressed against the surface of the rail by bolts designed for that purpose, or are pinched under the joint plates. There are also many sorts of makeshift bonds, used mainly where there is no money with which to get those of better designs: channel pins and cylindrical washers for round wires, and hammer riveting are the most common. They depend mostly upon the ingenuity of the man on the work, and are seldom worth consideration save when no better can be got.

To get the necessary conductivity, bonds are nearly always of copper, about the only exception being those of tin amalgam. To reduce cost and resistance, they must be as short as practicable, and the manufacturing cost must be kept low, to preserve the scrap value as near the first cost as possible. For durability they must be flexible enough so as not to break or lose contact by the allowable relative motion of the rails. They must be formed so they may be applied to the types of rails in ordinary use, in such position as to be protected from accidental damage, and from theft. They should be readily accessible for inspection and repair. The cost of application must be kept low, and to this end it is very important that the process shall be so simple and easy that no highly-skilled labor or extraordinary care is required to install them with certain and uniform results. The bond that satisfies all these conditions has not yet been devised.

The ordinary process of selection has developed a form of bond made of annealed copper and consisting of a flexible stranded or laminated shank about 8 or 12 inches long, welded to solid terminals of considerable mass, which are attached to the rail-web under the joint plates or less frequently under the base of the rail. Accessibility for inspection and repair, however, is almost wholly sacrificed, and the importance of good work in manufacture and application is thereby greatly increased.

Pure copper is a very plastic material of low strength and elastic limit, and under moderate pressures behaves almost like a liquid. The surface oxidizes slowly at ordinary atmospheric temperatures, but very readily at high temperatures, and so it is very difficult to weld. The result is that the union between the shank and terminals of a composite bond is always subject to suspicion, and not the less so that the outside of the same and all the welds that show at or near the surface may be very nice and neat to look at and the resistance moderate as the unwelded interior contacts are still bright when the bond is new. Under the smooth exterior may be defective welds that will corrode, and weakened strands that will soon be broken by the motion of the rails, either of which will materially diminish the utility of the bond.

The discussion of the ratio of contact area to cross section of bond has not lead to the adoption of any standard. In practice the largest contact area conveniently obtainable is utilized. Unfortunately, the full possible contact area is seldom realized, because of rough or dirty surfaces and insufficient compression or soldering.

Mr. Ricker then took up the question of breakage of bonds, disintegration of welds, and the importance of good contacts. Breakage may occur because of defects in manufacture, as in copper bonds with welded terminals, the strands may be weakened by overheating where they enter the terminal, and a slight, but continuous, motion of the joint will cause them to break one at a time, at this place. The surfaces at the imperfect welds in composite bonds corrode, increasing the resistance greatly and loosening and weakening the bonds so that they may be pulled apart. By far the most important cause of impaired contact is oxidation, which is greatly facilitated by moisture, so that the slightest crevice into which moisture may penetrate and lodge is dangerous. Soft-soldered contacts underground are not to be trusted. Brazed joints seem to give no trouble. Amalgamated steel surfaces are not durable and soon rust in a track exposed to dampness.

Impairment of contacts and breakage are the most common causes of the rapid deterioration and general unreliability of track bonding, and these causes may usually be traced to improper selection of material, together with cheap workmanship and poor supervision. The paper closed with some interesting data concerning the cost of bonding.

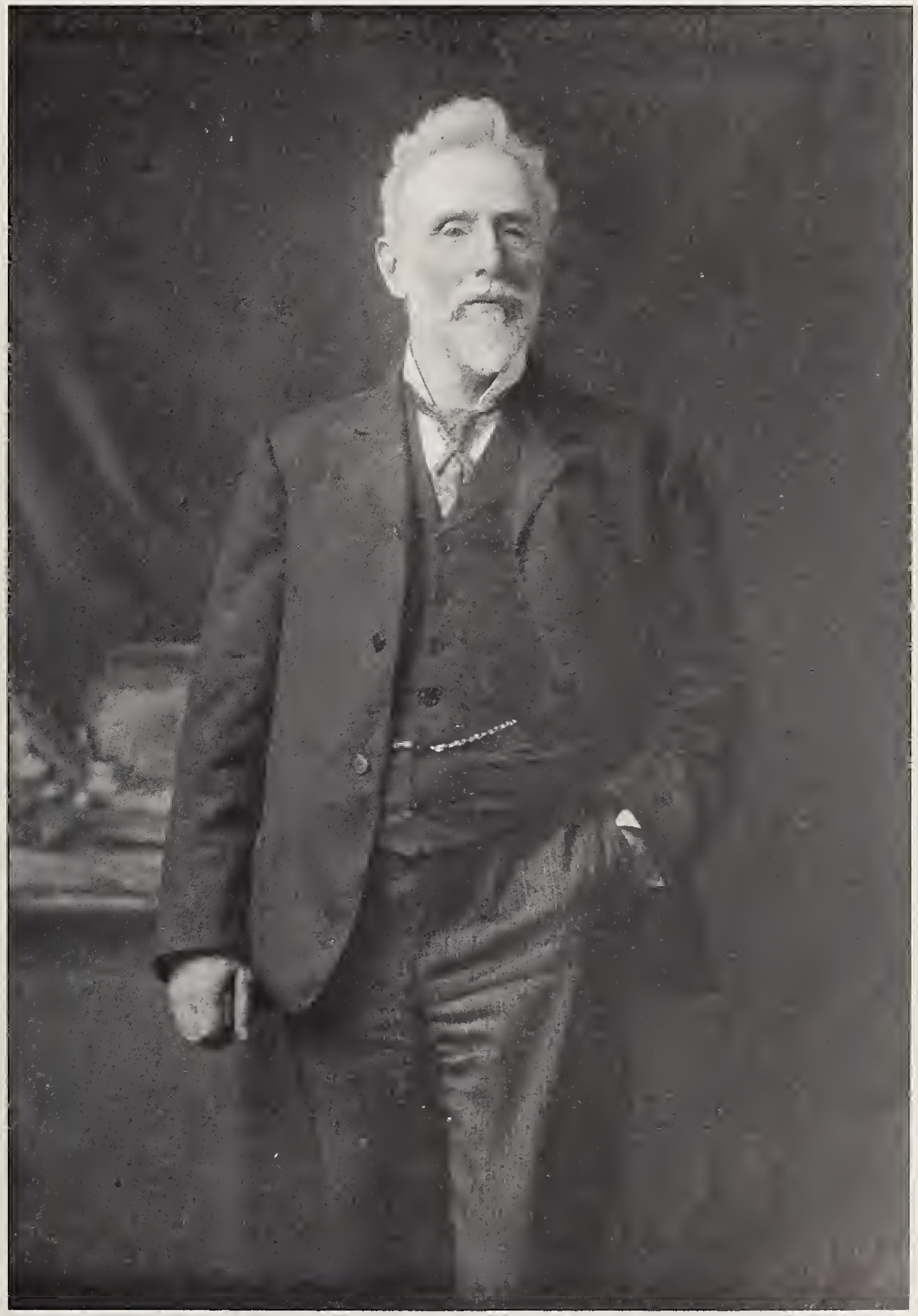
The subject was discussed by Mr. H. A. Lardner, of New York. The only regret after what Mr. Ricker has so well said, is that no bond has yet been found that meets all the difficulties of rail bonding. The difficulties are certainly very great, but Mr. Lardner thought that they were largely due to the inability to obtain a good contact between the bond terminal and the rail. He believed that some radically different methods of bonding will have to be devised. He thought it practically essential that all rail be drilled, or at least reamed on the work, and it is a question whether or not the bond terminals should not be actually machined so as to present a much more accurate fit and require less expanding than is possible with the bonds now upon the market. Mr. Lardner felt that we must look to some form of bond which may be more readily inspected than the expanded terminal bond commonly placed beneath the splice bars.

Mr. A. A. Knudson, of New York, made some remarks bearing on the subject of electrolysis, saying that he thought the danger of electrolysis was but slight on an elevated railroad steel structure, owing to the great conductivity of the structure itself as compared with the underground pipes.

Electric Traction Twenty Years Ago

IN responding to the toast, "These Twenty Years," at the recent annual banquet of the American Institute of Electrical Engineers, Leo Daft, whose early electric traction experiments are still fresh in the memory of many engineers, said, among other things:—

"To the anxious pioneer life was full of tribulation. The constant cry was for armatures when there were no armatures; break-downs were of such frequent occurrence that the very idea of rest was a mockery, a delusion and a snare. Every ring of the telephone, which was only just out of its own swaddling clothes, announced some new difficulty to be surmounted or some tale of woe, and the electric traction engineer in charge of present-day equipments, with armatures capable of encircling the globe without repair,



A RECENT PORTRAIT OF LEO DAFT

will smile to learn that the report of an armature having completed its 1200 miles without going into the repair shop enabled me to pass at least one night of blissful repose. Many of the older electrical engineers will well understand the statement that the odor of asafœtida was in those days as the balm of a thousand flowers compared to that of burning shellac.

"As illustrating some of the prevailing ideas, I happened to hear a discussion between two salesmen at the old fair of the American Institute in New York, during which one urged the superiority of the dynamo he represented on the ground that it possessed an unfailing safety device, inasmuch as whenever slightly overloaded, the brushes would promptly burn out and so open the circuit. I was mentally constrained to admit that there might be some machines near home which were similarly equipped, but considered it better to maintain a discreet silence.

"But sometimes the cloud had a silver lining, and an incident during the trials of the motor 'Ampere' on the Saratoga-Mt. McGregor steam railroad, in November, 1883, illustrates the strange so-called luck which occasionally relieves the strain of constant battle. The motor had been in nightly operation for about two weeks on the 1½ miles of main track we had equipped with the third rail, and several test runs had been made with an ordinary day-coach in tow, but though this had been towed to the beginning of a combined curve and gradient of, respectively, 125 feet radius and about 2 per cent., we had never succeeded in getting the car round against the gradient, though the straight line running had been satisfactory.

"However, it became necessary to make a daylight demonstration to the usual party of selected visitors from New York, for reasons which other pioneers will readily understand, and accordingly a not inconsiderable portion of the available cash on hand was expended in providing a special train from New York, which duly landed the party of some forty guests in the early afternoon of a dreary bitter November day. The whole track, including the third rail, was covered with a mixture of clay and slush, partly due to an early morning snowfall, which the 2000 or 3000 skeptical local spectators had been industriously increasing by walking over the rails since daylight.

"When the invited guests arrived at the station, the outlook was discouraging in the highest degree, especially to a man who had been working continuously for two nights and days, and when the writer mounted into the driver's seat of the 'Ampere,' after about sixty-eight persons had crowded into the day-coach, it may be not rash now to admit that the heaviest part of his anatomy was that which is usually alluded to as the seat of the affections. But a touch on the controller sufficed to start the train, and we sailed through the now enthusiastic crowd toward the dreaded curve, fully expecting a repetition of the previous experiences, but to the astonishment of all who were in the secret, we rounded the curve and ascended the gradient with comparative ease, and absolutely for the first time with anything in tow. If this partakes of the nature of a confession, I will ask you to respect the secrets of the confessional."

It may not be amiss to recall, in connection with these remarks, that Mr. Daft's earliest work was with the New York Electric Light Company, which was soon merged into the Daft Electric Company, with works, first in New York, then at Greenville, N. J., and later at Marion, N. J. The company was almost immediately and exclusively devoted to the development of electric power machinery, and established several electric power stations at Boston, New York and Worcester.

In 1883 Daft built an electric locomotive named the Ampere for use on the Saratoga & Mount McGregor Railroad, and in the following year installed short lines at Coney Island and elsewhere. On August 9, 1883, he put in operation what was probably the first electric elevator in the world, at the Garner Cotton Mills, Newburgh, N. Y. In January, 1884, he supplied the machinery for the New York Power Company's first power distributing station in Gold Street, New York, and in May of that year the Massachusetts Electric Power Company was incorporated and fully supplied with electric machinery by the Daft Company. This was the first instance of a complete central station for the electrical distribution of power on a commercial scale, and all the apparatus was manufactured by the Daft Company.

In the early spring of 1885 Daft was requested to furnish an electric equipment for a branch of the lines of the Baltimore Union Passenger Railway Company, and in August, 1885, the Baltimore & Hampden branch was operated with the electric machinery, and continued in uninterrupted operation for four years without change of rolling stock or station apparatus; and in the light of more recent events it is interesting to note that the four independent motors were of the single-reduction type, hauling 16-foot trailers, and the regulation was series-parallel, the four spools of each motor being so connected to the controller without the use of idle resistance in any form.

The Daft road at Baltimore was particularly successful in demonstrating, in the face of general opinion to the contrary, that several cars could be worked in parallel from the same line, and that there was ample power for running around curves and mounting heavy grades. The first motor cars were the Morse and the Faraday, and a third insulated rail was used. The Daft system was used on a number of roads, and the Daft locomotive Ben Franklin was operated for some time on the Ninth Avenue Elevated road, New York.

Regarding Mr. Daft's work in the distribution of power to stationary motors by electricity, it may be mentioned that in 1884 the "Electrical World," desiring to make an exhibit at the Philadelphia Electrical Exhibition, determined to print its issue there by electricity. It was easier, however, to form the plan than to carry it out, but the Daft Company guaranteed a successful performance, and Mr. Daft himself took a hearty interest in the project. The generator motor and press were duly set up, and within the five weeks of the exhibition 80,000 copies of the paper were printed from electrotypes, the type being set in New York. This feat, besides attracting universal attention, gave, at a critical time, a direct and lasting impulse to the electrical motor industry in this country.

As one example of the development of electric power in New York, it may be stated that in 1889 about 700 H. P. was daily distributed by the Daft system to about 200 consumers in quantities varying from one-half to 30 H. P. All the apparatus, including motors, generators, switches, meters, etc., was of Mr. Daft's design, and there was probably no other installation of the kind in that respect in the world. In other words, Mr. Daft was the only inventor, up to that time, who had taken up the problem of the distribution of power electrically and worked it out in the same manner as current for lighting, providing and perfecting necessary apparatus throughout.

The coal production of the United States is now about 1,000,000 tons per day, and of this the railroads consume about 40 per cent.

It is proposed to build a London suburb on the Sussex Coast and connect it with the city by an electric mono-rail line.

From the World's Technical Press

Wooden Poles vs. Steel Towers for Electric Transmission Lines

THE question whether wooden poles or steel towers ought to be used for a high-tension electric transmission line depends, like many other things, upon circumstances. In countries where wooden poles are plentiful and inexpensive, it is probable that every expedient will be resorted to before steel towers are used. The latter, however, are generally considered to eliminate a great many line troubles. The spans can be increased, so that as few as eight towers per mile can be used with safety. This would greatly reduce the number of insulators, which can be larger, and the means for their attachment to the towers can be quite elaborate without exceeding the cost of the other construction. The height of towers can be greater, which will decrease troubles from wires, branches and other material being thrown or blown across the circuit, and reduce the breakage of insulators from the heat of forest or grass fires. If galvanized or painted occasionally, their life would be greater than could be expected of wooden construction. Towers can be erected in places even more difficult of access, since they can be taken apart in pieces of lighter weight than a wooden pole. They would also offer a more or less good lightning path to ground, which would help to prevent the injury to connected apparatus. These points were enumerated by Messrs. J. F. Kelly and A. C. Bunker in a paper presented at the St. Louis Electrical Congress.

On the other hand, one of the principal advantages of wooden pole construction was there also mentioned to be that in case an insulator is broken, allowing the wire to come against the arm or pole, the burning which takes place almost immediately in most cases may continue for several minutes before a blaze is started which will make a short-circuit. Several times it has been observed that from 20 to 30 minutes elapse from the time trouble was first noted by the ammeters or telephone until it was necessary to shut off the circuit. In one case a 40,000-volt (grounded neutral) wire lay on a dry cross-arm for several hours before the circuit could be shut off, and at the end of the time the arm was not badly charred. With a duplicate line, ample time would in most cases be given for changing from one circuit to the other, or to cut out the affected circuit, providing the telephone line was operative or the men at both ends recognized the difficulty.

The Electric Smelting of Iron Ore

IN an age like the present, says the "Scientific American," when the electric current is being applied to such a variety of uses in the industrial arts, there is, at the first mention of it, something decidedly attractive in the proposal to use the electric current in the smelting of iron ore. The wide range of industries covered by the electrical furnace, and the vast scale upon which their operations are conducted, lead very naturally to the presumption that the electric furnace may some day displace the huge blast furnace, costly to erect, and costly to operate, because of the enormous tonnage of materials that must be handled to produce a given output of pig iron. The persistency with which the problem is attacked by men who are well qualified for the investigation, proves that the end sought after is no mere dream of the enthusiast. Indeed, electric smelting of iron ore is a perfectly feasible process, if we are willing to leave out of consideration the all-important element of cost. In the present state of art, however, it must be admitted that for the majority of cases the cost is altogether prohibitive.

The subject has recently been made the subject of investigation by an expert commission appointed by the Canadian government, whose study of the subject was directed particularly to the question as it affected the iron-ore deposits of Canada. The commission made a tour of the best-known electric iron-smelting furnaces in Europe, and its findings have been embodied in a report which has recently been issued by the Canadian Department of Mines. Its Conclusions are summed up in the statement that pig iron can be produced on a commercial scale, at a price to compete with the blast furnace, only when electric energy is very cheap and fuel very dear. It was found that on the basis assumed in the report, with electrical energy at $10 per electric horsepower year, and with coke at $7 per ton, the cost of production is the same as the cost of producing pig iron in a modern blast furnace. Under ordinary conditions, where blast furnaces are an established industry, electric smelting cannot compete; but in special cases, where ample water power is available and blast-furnace coke cannot be readily obtained, electric smelting may be commercially successsful. On the other hand, although the cost of electric ore reduction prevents it from competing with either the Bessemer or the Siemens open-hearth process in the production of the common grades of commercial steel, the process was found to be in successful commercial use in the production of high-grade crucible steel.

Now, the report of this commission, outside of having fulfilled the immediate purpose for which it was presented, should serve as a safeguard to the general public against being led into hasty and undigested schemes for the electric smelting of iron ore. The figure of $10 per electric horsepower year can only be realized under very exceptional circumstances, where water is abundant, readily available, and contiguous to large deposits of iron ore. We believe that the lowest figures obtainable at Niagara are from $15 to $20 per H. P., and here, because of the size of the plant, and the unlimited volume and great head of water available, the conditions are ideal for cheap production. It may be that some of the large plants which, during the past few years, have been hurriedly erected on a scale far beyond the immediate local demand for power, are making contracts at prices that give very little, if any, return on the investment; and great care should be exercised in using such low figures as a basis of indiscriminate estimate of the cost of electric iron-ore reduction.

Electric Dissipation of Fogs

THE dispelling of fogs by means of electric currents, says "The Iron Age," is exciting a good deal of interest among leading physicists of the world. It is possible by the use of electricity to rid the city of London or New York harbor or San Francisco harbor or any other neighborhood in the heaviest fog. The only question is the cost. It may be too great, and this is what a commission is trying to ascertain at the instance of the city of London. The report is looked forward to with much interest. Sir Oliver J. Lodge, one of the foremost of British physicists, is giving this subject profound thought, which is itself proof of the importance of the work, and of the probability of the successful solution of the problem. His latest patent, just granted, provides for a comparatively simple electrical apparatus, consisting of "a combination of high potential rectifiers arranged in quadrilateral groups of four, or multiples of four in such a way that, instead of the reverse of the alternating current supply being suppressed or non-existent as at present, they are redressed to form the positive and negative discharging streams required for deposit purposes." In other words, the alternating current is used, but the pulse is all in one direction.

The property of the electric discharge of causing the coalescent deposit of matters suspended in a gaseous medium has not come into general practical use on account of the difficulties attendant on the use of the statical electrical apparatus, this class of apparatus being too delicate and easily upset for use on an extensive scale, to again quote from Sir Oliver's patent papers. There is nothing new in the knowledge of the general principle involved in all fog-dispelling apparatus. The direct current passing through the atmosphere provides, in the form of electrons, the necessary nucleus about which the particles of moisture collect until they constitute drops of rain. To dispel the London fogs, for example, the apparatus would be stationed at different points about the city to project their currents through the atmosphere until the fog has precipitated as rain.

Electrical engineers agree that the cost of such operations would probably be great, measured in equipment and maintenance, as well as in horsepower required. It would mean the establishment of large electric power stations. Possibly such stations might dispose of their power to financial advantage during days when their services are not needed for ridding the city of fog. But the cost of alleviating this moisture and hindrance to business would be considerable, no matter how economically the electric plants might be managed. Yet in considering the cost, it must be with relation to the good accomplished in the health and comfort of the community, as well as to business. A London fog costs a good deal of money. So does a fog in such a harbor as New York. It holds up the routine of business, which is expensive. Thus while it might cost a great deal of money, yet compared with the financial saving by preventing the holding up of business, and with the general public benefit, the expense might be relatively small, as is frequently the case in the matter of large public expenditures.

Heating a Town by Electricity

THE heating of a whole town by electricity forms the subject of an article in a recent issue of "The American Electrician." According to this, the town of Davos, in the Swiss Alps, is famous for its dry, healthful climate, and in the winter season thousands of tourists and health-seekers sojourn there. It is situated at a high altitude, so that its winters are cold, but dry and invigorating, and its air so pure that two great sanitariums are occupied by people in search of health and recreation, or both. The question of heating the town of Davos and its two important sanitariums vexed the local authorities for many years. The fear of contaminating the pure, dry air of the mountain resort with smoke and ashes finally led them to adopt electricity for all purposes—heating, cooking, lighting and power. There is a fixed population of about 3000 to-day, and a visiting population in winter of nearly as many more. The question of the best form of heat for the sanitarium patients was also considered from a medical point of view. The physicians condemned gas and coal stoves on account of the unhealthy odors emitted by them, and steam heat for the houses and hotels was considered unhealthful also. Electricity was finally adopted as the best for all concerned, provided that it could be obtained at a reasonable cost. The electricity for heating the town is supplied from power houses on the two streams, Landwasser and Albula, situated nearly ten miles away, where there is a fall of nearly 1300 feet. There is sufficient water power on these two streams to heat and light the whole town, and the final completion of the plant has enabled every inhabitant to use electricity for every household necessity. The town covers a district about two miles long, and half a mile wide. In this space the large hotels and sanitariums are grouped.

The Electric Heating of Tool Steel

IN a paper on "The Development and Use of High-Speed Tool Steel," read by J. M. Gledhill at the New York meeting of the British Iron and Steel Institute, he described several methods of heating the steel by electricity. By this means, he said, very regular and rapid heating is obtained, and where electric current is available, the system of electric heating is quick, reliable and economical.

One method adopted of electrically heating the points of tools consists in using a gray-iron tank, of suitable dimensions, containing a strong solution of potassium carbonate, and a dynamo, the positive cable from which is connected to the metal clip holding the tool to be heated, while the negative cable is connected direct on the tank. The tool to be hardened is held in a suitable clip to insure good contact.

The action is as follows:—The current is first switched on, and then the tool is gently lowered into the solution to such a depth as is required to harden it. The act of dipping the tool into the alkaline solution completes the electric circuit and at once sets up intense heat on the immersed part. When it is seen that the tool is sufficiently heated the current is instantly switched off, and the solution then serves to rapidly chill and harden the point of the tool, so that no air blast is necessary.

Another method of heating the points of tools is by means of the electric arc, the heating effect of which is also very rapid in its action. The tool under treatment and the positive electrode are placed on a bed on non-conducting and non-combustible material and the arc started gradually at a low voltage and steadily increased as required, by means of the rheostat, care being taken not to obtain too great a heat and so fuse the end of the tool.

The source of power in this case is a motor-generator consisting of a continuous-current shunt-wound motor at 220 volts, coupled to a continuous-current shunt-wound dynamo of from 50 to 150 volts. Arcs from 10 to 1000 amperes are then easily produced and simply and safely controlled by means of the rheostat. The negative electrode should be kept moving over the surface of contact without approaching too near the cutting edge of the tool.

Electricity is also a very efficient and accurate means of tempering such forms of tools as milling, gear, hobbing and other similar cutters, also large hollow taps, hollow reamers, and all other hollow tools made of high-speed steel, where it is required to have the outside or cutting portion hard and the interior soft and tenacious, so as to be in the best condition to resist the great stresses put upon the tool by the resistance of the metal being cut, and which stresses tend to cause disruption of the cutter if the hardening extends too deep.

Tempering of hollow cutters and other similar tools is sometimes carried out by the insertion of a heated rod within the cutter and so drawing the temper, but this is not entirely satisfactory, and is liable to induce cracking by too sudden heat application, and further because of the difficulty of maintaining the necessary heat and temperature required, and afterward gradually lowering the heat until the proper degree of temper has been obtained.

In electrical tempering these difficulties are overcome, as the rod is placed inside the cutter quite cold, and the electric current gradually and steadily heats up the rod until the correct temperature is reached, when it can be held at such temperature as long as is necessary, and the current can be gradually reduced until the articles operated on are cold again, and consequently the risk of cracking by too sudden expansion and contraction is reduced very greatly. The apparatus used is very simple. It consists of a continuous-current, shunt-wound motor directly coupled to a single-phase alternating-current dynamo of the revolving-field type giving 100 amperes at 350 volts, 50 cycles per second, the exciting current being taken from the works supply main.

The pressure is stepped down to 2 volts, the secondary coil of the transformer consisting of a single turn of copper of heavy cross section, the extremities of which are attached to heavy copper bars carrying the connecting vises holding the mandrel upon which the cutter to be tempered is placed. The secondary current, therefore, passes through a single-turn coil, through the copper bars, vises and mandrel.

Although the resistance of the complete circuit is very low, still, owing to the comparatively high specific resistance of the iron mandrel, the thermal effect of the current is used up in heating the mandrel, which gradually attains the required temperature, slowly imparting its heat to the tool under treatment until the shade of the oxide on the tool satisfies the operator. The strength of the current, and therefore the heat, is varied by a rheostat.

Rubber-Growing in Ceylon

According to "The Electrical Review," of London, experiments in the growing of Para rubber trees in Ceylon have proved successful, the trees, when mature, giving an average yield of 1 pound per tree per year.

The trees are planted 15 feet apart, making about 200 to the acre, and the tapping process is spread over a period of about two months. It is claimed that this method yields much more rubber than the older practice of making a larger number of incisions at once. After four or six months' time the trees are again tapped, the new incisions being made between the previous rows.

The results of tapping experiments show that a tree will give about 8 ounces of rubber in its seventh year and 10 ounces in the next; trees from nine to eleven years old will, if carefully tapped, furnish 1½ pounds per tree during the year, and there is no considerable average increase on this yield from trees eleven to thirteen years old, as the latter give from 1½ to 2 pounds of rubber per tree.

The New Theory of Matter

A very interesting paper on "The Theory of Matter," has been presented before the Franklin Institute, by A. E. Outerbridge, Jr., Professor of Metallurgy at the Institute. Professor Outerbridge, in connection with the new theory that matter is composed of electricity, and of nothing else, says:

"Our present view of an atom of matter is something like the following: Picture to one's self an individualized mass of positive electricity diffused uniformly over a space as big as an atom—say a sphere of which two hundred million could lie edge to edge in an inch, or such that a million million million million could be crowded tightly together in an apothecary's grain. Then imagine, disseminated throughout this small spherical region, a number of minute specks of negative electricity, all exactly alike, and all flying about vigorously, each of them repelling every other, but all attracted and kept in their orbits by the mass of positive electricity in which they are imbedded and flying about.

"Different atoms, that is, atoms of different kinds of matter, are all believed to be composed in the same way; but if the atoms of a substance are such that each possesses twenty-three times as many electrons as hydrogen has, we call it sodium. If each atom has 200 times as many as hydrogen, we call it lead or quicksilver. If it has still more than that, it begins to be conspicuously radioactive.

"Matter then appears to be composed of positive and negative electricity, and nothing else. All its newly-discovered, as well as its long-known properties can be thus explained—even the long-standing puzzle of 'cohesion' shows signs of giving way."

The Induction Meter vs. The Commutating Meter

In a paper read before the Kansas Gas, Water and Electric Light Association, J. F. Schaefer said that the great point of difference between the induction meter and the commutating meter is that whereas the latter is a universal meter, the former is a highly specialized device operative on alternating-current systems only.

The induction meter depends for its operation upon the principle of the rotating magnetic field identical to all intents and purposes to that produced in induction motors. Unlike the commutating meter the moving element has no electrical connection with the system, and therefore brushes and commutator are eliminated in the induction type, which is in itself a great advantage in favor of the latter, although it cannot be gainsaid that since the introduction of the light-load adjustment on the commutating meter a very large part of commutator and brush troubles have been overcome. Another potent argument in favor of the induction meter is the great decrease in the weight of the moving element. In all induction meters of present-day construction the disc or drum, usually made of aluminum, serves at once the dual purpose of producing rotation and of providing the necessary drag. Comparing this with the earlier type of motor meter it is seen that the necessarily heavy, and, at the same time delicately wound armature is obviated, and as a result the average length of jewel and pivot life is very greatly increased. As a matter of fact, jewel wear in some types of induction meter is almost unknown.

The one great disadvantage of the induction meter lies in the fact of its non-interchangeability on direct and alternating currents. This means that a station operating both systems must use the commutating meter exclusively if it desires to standardize one type. When the first induction meters were introduced they could not be used upon more than one frequency without a complete recalibration, and in some makes, even at the present time, the double-lagged meter has not been devised. This, of course, works a great hardship upon the central station operating two frequencies, as it necessitates keeping two forms of meter in stock, and a complete recalibration or perhaps removal of meters of one frequency whenever the other frequency is standardized. In justice to the induction meter let it be said this difficulty has been eliminated in some makes as far as possible by the so-called double-lagged meter which provides that they may be used upon two frequencies by simply making a very slight change in the internal connections. With the commutating meter, however, no such provision is necessary.

Electric Crane Engineering

At the awakening to the inefficiency of the lifting tackle of ten or fifteen years ago, says Joseph Horner in "Cassier's Magazine," in an article on "Special Forms of Cranes," electricity was waiting to supply what was wanting to render the new requirements practicable, and has influenced the mechanical details of cranes also to a remarkable extent for the better. Indifferent fitting, bad design and poor materials are inconsistent with electric driving, in which high initial speeds are unavoidable. The modern electric traveler resembles its predecessors in little except general outlines and functions, or even the earlier electric travelers in which a single shunt-wound motor was attached to an existing crane, effecting, by means of wasteful and undesirable gears, its conversion from hand, steam or cotton rope drive to electricity. Electricity has given us new types of light hoists, perfect in all details. It has also simplified many of the movements in big cranes that were formerly effected clumsily by shafts and gears or by pitch chains. It has been the greatest help and the best tonic that crane makers have received since the distant periods when water and steam first supplanted hand power.

Nor has the reaction which has taken place on the electric details themselves been less marked. There is a great deal of difference in these by comparison with those, say, of only five years ago, besides which a new and extensive department of electrical work has been created. The present-day electrical equipments bear little resemblance to those which were made the subject of early experiments. Motors, controllers, brakes and careful co-ordination of power to duty have resulted as a consequence. Electric crane work is now becoming very much "cut and dried," more so than the steam or hydraulic applications ever were. The early motors were exposed to dust, and their high speeds involved much reduction gear. Now few are made which are not wholly encased, or nearly so, and lower speeds are employed. Casings are made of steel, instead of iron, to secure lightness with strength, and they are more compactly designed, to occupy less floor space. More important, too, is the fact that they are designed specially for the service that they have to perform,—an intermittent one,—hence the general preference for the series-wound rather than the shunt-wound type. The series motor runs faster as loads are lighter, exactly as a crane is required to work. It is made reversible also, to avoid the use of clumsy and noisy reversing clutches or gears that were formerly employed. And, further, motors are designed for either continuous or alternating currents, for varying loads, and also for voltages up to 500, to accommodate existing installations.

The shunt motor is started before the load is taken by the crane, but the series motor has to start with the load. Herein lies the first difference, a starting torque of the latter being, as required, two or three times greater than that corresponding with the output of the crane.

The fact that crane service is intermittent in character is taken advantage of in making crane motors with a special winding for giving a large starting torque and a high output for short periods, so that an overload of about 50 per cent. can be safely taken for a short period. This period is mostly taken at about five minutes, which is seldom exceeded in crane work, and is often considerably less. If the overload lasts a few seconds, it may exceed the normal by two or three times. One maker terms this high output the "crane output" of the motor, or the "crane horse-power," and this is a very practical method of rating. The value of this output depends largely on the length of the period of rest between working loads. This period must be at least double that of full load; but if it is considerably more, then the motors can be used for a much higher output than the crane rating, because they are capable of taking overloads of two or three times the rated "crane output" for some seconds.

From the point of view of overload, the method of "rating" of Messrs. Siemens Brothers & Co., Limited, enables a motor to be selected of suitable power for any class of duty. Each motor in this system is rated to give three outputs, or maximum effects, which it will exert during a run of six hours, without exceeding a rise of 80 degrees F. in temperature above the surrounding air. These outputs correspond with full or maximum load factors of one-sixth, one-fourth, or one-third, respectively, equivalent to two, three, or four minutes out of every twelve minutes.

Both continuous and three-phase currents are used for series motors. The disadvantage of the former is that the motors will race on sudden throwing off of the load, while little variation occurs when the latter kind of current is employed. To obviate risks of racing, some firms make compound-wound motors, in which the current is sent by a special form of controller through a shunt field each time the motor is shut off. The capacity for overload and the large starting torque are obtainable equally well whatever current is adopted.

The controllers and the brakes have been specialized for crane service in several ways,—to simplify the work of attendants, diminish risk of false movements, and to reduce the chances of accidents to a minimum. Controllers are designed for crane service in which the hoisting and slewing motions are operated by one lever in vertical and horizontal directions, respectively. The lever is also moved in the direction in which motion has to take place, upward for hoisting, downward for lowering, and to the right and left for slewing in those directions.

The greatest successes of electricity in hoisting work, after the electric traveler, have been scored in the wharf cranes of the gantry portal type. The application to the overhead traveler of the new power agency preceded that of the wharf cranes, because the difficulties to be surmounted were less. The mechanism of the existing power travelers driven by steam, cotton rope or square shaft seemed better adapted to the substitution of a motor for steam, cotton rope or hand, according to the ideas of the time, than did that of the gantry cranes.

The traveler lifts heavy loads slowly, the wharf crane light loads rapidly. The latter absorbs considerably more power than the traveler does, while the rapid acceleration of speed of lift, the equally rapid slowing down, and the quick reversals give rise to problems that were not at first easy of solution when the high-speed shunt motors were being employed to the exclusion of series-wound types. As these cranes operate mostly with warehouses on one side of the wharves, the steam boiler with its flying sparks has always been deemed objectionable; but in cold districts the hydraulic pressure system, otherwise generally valuable, gives trouble, due to freezing of water in the pipes. To prevent this, the expedients have been adopted of warming the water at various locations, or the cranes have been kept running while doing no work. Glycerine has also been used in considerable proportions in the water, but has added to the expense. The first successful attempt to apply electricity to gantry cranes was made at Hamburg in 1891, since which time these installations have become very numerous at the German and other ports.

Telephones in Restaurants

THE installation in a Cleveland, Ohio, restaurant of two telephones, with a row of seventy plugs along by the tables, was recently noted in these pages, and another restaurant in the Wall Street district of New York has adopted a similar plan, described in "The Telephone Magazine."

Three of the tables in the restaurant are supplied with telephones. They are very much in evidence from 12:30 to 2 o'clock, and after that they are consigned to unobstructive positions on the window sills or steam coils. They are well worth their rental. Two of them belong to prominent members of the Stock Exchange and connect directly with their offices. One broker has as many as thirty calls while he is at luncheon, but he disposes of them rapidly and with good humor.

At another table sit six of the busiest brokers on the curb. Up to the time of the suggestion that they use telephones their midday diet had consisted principally of sandwiches and a hasty gulp of coffee. Now they are able to conduct rather extensive operations while sitting comfortably before a substantial meal. The brokers with direct connection pay only $2 a month for immunity from being torn away from their luncheon, and the expense of the other telephone when divided among the six curb brokers is about the same.

An Unusual Method of Cable Laying

AN unusual method of cable laying, which has been employed in the Poplar district in London, was recently described in "The Electrical Review," of London.

The cables are laid separately in a corresponding number of light steel pipes, instead of being put down in the usual conduits. These pipes are coated upon the exterior with a special preparation in which paraffin wax predominates. They are made in 5-foot lengths, and are jointed by ends which screw into one another, leaving a flush surface, until a tube of 200 feet has been formed. This length of tubing is then laid in the trench, and covered all around with a layer of concrete, which is allowed to set.

This accomplished, the steel pipes, which only serve as a mandrel on which to form the concrete duct, are withdrawn by the application of steam, which is driven into them under pressure. The heat thus applied melts the preparation around the pipes, and as this also acts as a lubricant, the pipes can be withdrawn quickly and easily by winch and rope. As each 5-foot section of piping is withdrawn, it is unscrewed and coated again for further use.

Electric Railway Operation in a Great City

H. H. VREELAND, BEFORE THE NEW YORK ELECTRICAL SOCIETY

THE 248th meeting of the New York Electrical Society was held in the assembly rooms of the Metropolitan Street Railway Company, Seventh Avenue and Fiftieth Street, New York, on Wednesday evening, February 15, 1905.

President Frank J. Sprague presided, and before introducing the speaker of the evening, H. H. Vreeland, in a brief address outlined the growth of electric traction from its birth to the present time.

Mr. Vreeland chose for his subject, "Electric Railway Operation in a Great City." In fact, Mr. Vreeland's remarks, which were listened to with great attention by the large audience of men and women present, bore very directly upon the relation of the electrical engineer to a great electric railway, and the practical suggestions which Mr. Vreeland threw out will no doubt be of much value to many of the younger engineers. One of the main points which the speaker sought to impress upon his hearers was that however ingenious and apparently useful a device might seem to be, it could never be adopted unless the savings in operation which it effected much outweighed the cost of its installation and any slight complications that it might add to the system. Should the device contemplate the introduction of complications beyond the easy management of unskilled workmen it could not be considered. Any device further to be available in street railway work must be able to withstand not only rough handling and shaking, but also adverse weather conditions, and must be capable of quick and ready repair without leaving the track.

These facts and many more of a similar nature, said Mr. Vreeland, are fairly obvious, but it is remarkable how often some one or more of them have been overlooked by the electrical engineer. Mr. Vreeland accounted for this condition of mind on the assumption that the majority of present-day electrical engineers learned their business in some great establishment largely devoted to experiment, where the gross earnings of an ordinary street railroad are written off the books in a single month of fruitless investigation; where he is provided not only amply, but even superfluously, with the tools of his trade, and it is difficult for him to understand when he comes to street railroad work that in the running of a car there is no time for repairs, and that no device, however generally useful, can be employed which, if it falls out of gear, requires the car to be stabled for repairs. The characteristic weakness of an expert is to exaggerate the importance of his line of work to the industry with which he is connected. He overlooks that no established industry can afford to spend more than a certain fixed proportion of its earnings upon improvements and betterments. It must pay fixed charges, maintain its dividends and store up something in its surplus, and whatever it spends for betterments must be done with an eye carefully fixed upon its earning capacity. The expert, whether an electrical engineer or other specialist, is rarely willing to concede this condition of things, and the more absorbed he is in his own line of investigation the more unwilling he becomes to admit that anything else counts. No small part of the discouragement which awaits the specialist as soon as he leaves that occupation in which his specialty is the sole aim and business to employ his talents and training for the benefit of an industry in which his work is merely a feature, arises out of this circumstance, and he must quickly learn the great art of making bricks without straw. He will find his consolation in the fact that this is the only way good bricks are ever made; that the man who can produce only when the conditions of production are perfect rarely produces anything worth while (another way of saying that any Jack can work with good tools), and that the valuable things of life invariably come by easy and natural stages from one good and successful thing to another that is better and more successful. The expert's opportunity is limited, therefore, not by what has been accomplished, but only by the inevitably insufficient means with which he must work. He has accomplished his greatest triumph when he has adjusted himself to this fact.

Mr. Vreeland then commented upon the swiftness of the advancement of the electrical art, which carried with it the danger of the engineer and manufacturer getting ahead of the operator. This may be all very well for the development of the art, but in a practical sense it is not well for the engineer or the user. If you are going to make money at your profession, he said, you must help us make money in our business. You must not forever be postponing the day when income will begin to pay for investment. You must not be forever requiring one great investment on top of another until we have paid half a dozen times over for substantially the same service.

You must keep the practical plan of every subject closely harmonious with experimental conditions. The world does not want to be pushed or jarred or thrown out of gear; it resents a shock; it is pleased with an accommodation; it pays for what it wants.

After the lecture a practical illustration was given of the manner in which men are trained in the operation of a street car, relays of twelve or fifteen men being brought into the lecture hall for the purpose and put through a drill which included the handling of the controller at the strokes of a bell, and the finding and remedying of trouble due to defective fuses and the like. The meeting then adjourned.

Book News

Electricity in Everyday Life.

By Edwin J. Houston, Ph.D. Published by P. F. Collier & Son, New York. In three volumes; volume one, 584 pages and 235 illustrations; volume two, 566 pages and 326 illustrations; volume three, 609 pages and 288 illustrations. Price, complete, $3.00.

It is, as Dr. Houston very well puts it, no longer a matter of choice whether or not one shall become acquainted with the general facts or principles of electricity; it is a matter of necessity. Dr. Houston has, therefore, incorporated in the three volumes such matter as would enlighten the general public on the more important electrical phenomena, on the laws which govern them, and on the manner of operation of their more important applications. Each volume is profusely illustrated, and covers the subject in a popular manner without the use of mathematics.

In the first volume the principles of magnetism are presented, and the generation of electricity is treated of, first, with respect to electrostatics, then with respect to chemical action, and afterward with respect to magnetic induction.

In the second volume the principles of direct and alternating-current generators are taken up, as are also the fundamental principles of transformers. The remainder of the book is devoted to electric lighting and electric power. Under electric lighting, the various forms of electric pumps are considered as well as their fixtures, appurtenances, and the proper methods of wiring. There is also a chapter under this head on arc-light generators.

Under electric power, the principles, forms, and applications of continuous-current motors are taken up in the order just given, and an entire chapter is devoted to Tesla and the multiphase motor. The subjects of electric street railways, electric locomotives, and telpherage, are each covered in a separate chapter.

In the third volume there are several chapters on electro-chemistry, and about the same amount of space is devoted to the telephone. Under the head of telegraphy, line construction is taken up, and in addition to duplex, diplex, quadruplex, and multiplex telegraphy, submarine telegraphy and wireless telegraphy are also illustrated and described. The remainder of the volume is devoted to electro-magnetic annunciators and alarms, electric heating, electro-therapeutics, each treated under a separate head. Dr. Houston is well known in the electric engineering profession both as an engineer and educator, and as the author of various electrical works, among them "A Dictionary of Electric Words, Terms and Phrases;" "Electro-Technical Series;" Electric Transmission of Intelligence;" "Electricity and Magnetism;" "Electricity One Hundred Years Ago and To-day;" "Recent Types of Dynamo - Electric Machines;" and "Electricity Made Easy."

Electric Furnaces and Their Industrial Applications.

By J. Wright. Published by the Norman W. Henley Publishing Company, New York. 228 pages. 57 illustrations. Price, $3.00.

Mr. Wright is familiar to readers of The Electrical Age through his recent articles in these pages on the same subject as that treated of by him in the above volume. In this he has included furnaces of the electrolytic type, which, while not furnaces in the ordinary sense, depend for their action on a combination of thermal, electrolytic and chemical effects. He has drawn the line at those electrolytic processes into which an aqueous solution enters, those described involving the presence of a fused electrolyte. Several of the types treated of have never gone beyond the experimental stage, having been presented with the view of showing the amount of ingenuity which has been expended on electric furnace design. It is extreme elaboration of detail, according to the author, which has prevented the commercial success of several very promising electric furnace inventions.

The book opens with an historical general description of electric furnaces. Various types of arc furnaces, resistance furnaces and typical processes are also described.

In succeeding chapters individual processes are taken up, the history of the development of each being given, with illustrations and descriptions of the furnaces used in each process. Calcium carbide manufacture, iron and steel making, and the manufacture of phosphorus and of glass are thus dealt with.

Electrolytic furnaces and processes, as already mentioned, are next considered, followed by a description of some miscellaneous processes and of laboratory furnaces and experimental research. A separate chapter is devoted to terminal connections and electrodes. In the closing chapters of the book the author deals with the efficiency and theoretical considerations of the electric furnace, and the measurement of furnace temperatures.

The Art of Generating Gear-Teeth

By Howard A. Coombs. Published by the D. Van Nostrand Company, New York. 129 pages. 37 illustrations. Price, 50 cents.

A series of articles in "The American Machinist" furnished the material for this little book. It is devoted to the theory and operation of gear-cutting machines which generate the tooth curves, in contradistinction to those in which formed cutters or templets are used.

Taking up first the theory of generating epicycloidal, hypocycloidal and involute teeth, the author uses very little mathematics, elementary geometry being necessary in one case to show similarity of triangles. To prove that an involute may be generated either by rocking a tangent on a circle or by rolling the circle on the tangent, analytical geometry is used, but this is not necessary to a clear understanding of the whole, practical examples showing it as well.

After a general explanation of how the theory is put into practice, the author gives the history of the first generating machines. In another chapter, the development of the American machine is dealt with, followed by descriptions of the modern types built in the United States and elsewhere. The machines are not described in detail, the author indicating only the way in which the theory is put into practice and how the relative motions of tool and blank are obtained.

In the concluding chapter the generation of other forms of teeth is discussed. Machines for forming gears to mesh with "pin wheels"—a class of gearing employed in "chainless" bicycles—are also described.

Suction Gas

By Oswald H. Haenssgen. Published by the Gas Engine Publishing Co., Cincinnati, Ohio; 88 pages; Illustrated.

The first part—fully one-third—of this booklet is devoted to a description of a typical small suction gas plant, and of a more complete one of greater capacity. The construction of each part is described and its function in gas making explained.

After discussing briefly the governing and starting of gas engines, the author tells how to start and stop the plant and care for it properly. Several pages are devoted to the properties of suction gas, followed by results of tests made with gas engines and suction gas producers in Europe.

A peat or turf gas producer also is described, and a process for obtaining gas from sewage. Portable traction and marine gas plants are briefly touched on. The prices and weights of several simple plants are given, the book concluding with a few paragraphs of suction gas history.

Automobile Biographies

By Lyman Horace Weeks. Published by the Monograph Press. 180 pages and 13 full-page portraits. Price, $2.00.

This volume gives an account of the lives and the work of those who have been identified with the invention and development of automobiles. The contents are grouped under three headings: "Origin and Development"; "Pioneer Inventors"; and "Noted Investigators." The origin of the automobile is traced back to Egypt and China, nearly three centuries ago, when the motive power was supplied by the hand or foot of man. The various schemes for utilizing compressed air, the wind, steam, gasoline, and electricity, furnish interesting reading for any who may wish to trace the development of the automobile from its primitive forms up to its status at the beginning of the year 1905.

Biographical sketches are given of twenty-five pioneer inventors, among whom may be mentioned, Cugnot, Evans, Read, Hancock, Roberts, Russel, Lenoir, Marcus, Daimler, and Serpollet. These sketches must have necessitated considerable research in rare old books and papers that are not generally accessible, and show careful and systematic preparation.

Under the head of "Noted Investigators," are biographical sketches covering over a hundred of those who, although of less distinction than the pioneers previously mentioned, have at the same time done much commendable work in actively planning, investigating, and perfecting the horseless vehicle. Among this list are the names of Stevin, Hautsch, Watt, Fourness, Rickett, Richter, Roper, Richard, De Detrich and Darracq. Its arrangement is both neat and effective. The type is well chosen, the paper is of the heavy coated kind, and the portraits are finely executed on extra heavy India tint paper. The binding is dark blue with gilt lettering, and this combination gives a most effective background for the title.

Telephones and Telegraphs in the United States

A REPORT recently issued by the Census Bureau is devoted to the telephones and telegraphs in the United States up to and including the year 1902. Prior to 1880 there were few telephone companies operating lines, but in that year, with a national population of over 50,000,000, the number of telephones of all kinds was 54,319. In 1902 the population had increased to 78,000,000 and the number of telephones to 2,315,297. The number of miles of wire were 141 times as great as that in 1880, and the independent rural lines exceeded the entire equipment in 1880.

The revenue derived from the operation of telephone systems and other sources amounted to $86,825,536, or $37.50 per instrument. Of this, 94 per cent. was from actual operation. The total operating expenses were $56,867,062, and the net income was $21,660,765.

The commercial telegraph systems numbered 25 in 1902, as compared with 77 in 1880. The magnitude of the equipment and business has, however, shown a great increase. At the present time the telegraph business is practically controlled by two companies, yet the number of miles of wire in operation in 1902 was more than four times, the number of messages almost three times, and the receipts from messages more than twice as great as in 1880.

The average rate per message in 1902, excluding cable messages, was 31 cents, as compared with 43 cents in 1880. The total receipts of the commercial telegraph companies for 1902 amounted to $40,930,038, of which 86.2 per cent. represented the gross receipts from operation. The operating expenses amounted to $26,592,411, the net income to $9,981,004, and the net surplus for the year to $3,725,311. The commercial telegraph companies reported 1,318,350 miles of wire in operation in 1902. The commercial telegraph messages sent during 1902 numbered 91,651,287, and of these, 820,498 were cable messages.

A course in a new culinary system—cooking by electricity—is about to be opened by the School of Domestic Arts and Science in Chicago. A complete electric cooking outfit, consisting of ovens, broilers, saucepans, frying pans, vegetable kettles, portable plate warmers, etc., will be available. The ovens are provided with switches whereby three different degrees of warmth may be had. The apparatus is to be installed by the Chicago Edison Company.

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The Distribution of a Car Fare

THE analysis of industrial operations on a unit basis has grown rapidly in favor of late. In almost every discussion of annual reports we deal with gross and net earnings per ton-mile, income per mile of track, gross receipts per capita, cost per kilowatt installed, and the like. The main advantage of this method lies obviously in the ease with which commercial operations on a vast and complex scale can be dissected and made clear to the average mind, and thereby perceived in their true relations.

An interesting example of unit analysis may be drawn with reference to the recently issued Bulletin No. 3 of the United States Census Bureau, on the subject of street and electric railways. On page 11 of the Bulletin appears a statement of the total income account of the street railways of the United States for 1902, beginning with gross earnings of $247,553,999 and ending with a surplus of $14,714,867. Figures of this magnitude are useful to the specialist, but for obtaining a concrete conception of the relation between the different quantities involved in the earnings, expenses and dividends, it is profitable to reduce them to a 5-cent basis and thereby determine the distribution of the average car fare for that particular year.

Assuming the gross earnings from operation equal to 5 cents, the revised table appears as follows:—

		Cents
Gross earnings from operation		5.00
Operating expenses		2.88
Net earnings from operation		2.12
Other income		0.06
Gross earnings less operating expenses		2.18
Taxes	0.26	
Interest	0.77	
Rent	0.51	
Miscellaneous	0.03	
Deductions from income		1.57
Net income		0.61
Dividends on preferred stock	0.04	
Dividends on common stock	0.28	
Total dividends		0.32
Surplus		0.29

While it would be difficult to judge the operation of any particular street railway system from these total figures on the unit basis, it is plain that the popular impression of the excessive profits of the business is a mistaken one. Thus, out of each nickel received in 1902, less than one-third of a cent succeeded in filtering through the many barriers raised by legitimate expenses, to be finally applied as dividends. The surplus of 0.29 cent must be applied, in part at least, either as a sinking fund to extinguish bonds at their maturity, as a depreciation or profit and loss fund, or perhaps both.

No allowance for depreciation appears in the table. The operating expenses, 2.88 cents, bear a ratio of 57.6 per cent. to the gross receipts. Here is where the public is often misled by socialistic demagogues who state that the cost of carrying a passenger is less than 3 cents, more than 2 cents being profit to the street railway company. The very low percentage of other income than passenger fares is significant—scarcely 1 per cent. of the whole. It means, of course, that the street railways devote nearly 99 per cent. of their activities to the carrying of passengers.

Taxes amount to slightly over one-quarter of a cent in each car fare, or nearly the amount of dividends paid upon the common stock. Here we find suggestions for communities in which the street railways are operated with deficits at the end of the year, but which the public cannot well do without or even be willing to maintain with curtailed facilities. In some quarters it has been proposed to raise the fares to bring the balance sheets around to a profitable showing. The same kind of remedy, but one which would be found to pinch the average passenger less, lies in a reduction of taxes. If a road cannot pay expenses and the public must have the service, it would seem reasonable to allow the public the privilege of maintaining it in this way.

Following through the list of fixed charges, it will be seen that they amount to a total of over a cent and a half, exclusive of depreciation, which is not stated, leaving as net income less than two-thirds of a cent out of each nickel. When one finally disburses these fixed charges, allows from 10 to 12½ per cent. as a rough figure for depreciation fund, and sets aside something to insure the companies against unforeseen losses by strikes, floods, perhaps fires, and other casualties, there is little ground to complain that the street railways receive more than a reasonable compensation for the service which they sell.

Making the Most of an Old Plant

THE modernizing of old power plants is a familiar practice in many branches of electrical work. The progress of the designing engineer has been felt by more than one street railway which considered its equipment up to the latest standards long after radical improvements in the art had reduced its comparative efficiency. Managers have not, as a rule, been slow to take advantage of new discoveries and details embodied by the manufacturers in their apparatus, but in some cases boards of directors have failed to appreciate the need of new or revised equipment, and the only thing left for the executive officers in the meantime has been to make the most of the machinery in hand.

That even obsolete equipment can sometimes be made to perform well under commercial conditions cannot be doubted by anyone who takes the trouble to visit power plants in different localities; and if one or two thoroughly modern machines can be secured to carry the load during the daytime, using the old equipment to help out on the morning and evening peaks, the prospects are that if the plant is operated with skill, the figures of power cost, coal consumption per kilowatt-hour, etc., will give some of the later installations a hard rub.

There is room for the practice of a very high order of engineering in old plants which, for one reason or another, cannot at present be rejuvenated or abolished in favor of up-to-date outfits. In telephone work, expert operators can give better service with central office equipment somewhat behind the times than poor operators can give with the latest types of jacks, plugs and relays. A close parallel can be drawn in the power plant, although it is impossible to accomplish miracles in the items of operating expense with non-condensing simple engines, belted generators driven from line shafts, and the like.

A case in point is that of a Massachusetts plant which does a combined railway and lighting business in a city of about 25,000 people. At first sight of the equipment, one would expect to find any sort of operating economy impossible. To begin with, the plant has two separate, but adjacent, boiler rooms, and two engine rooms separated by the pair of boiler rooms. The lighting dynamos are all belt-driven, either from single-cylinder, non-condensing engines, or from line shafting. There are seven of these machines in one engine room and five in the other. Compound non-condensing engines drive the line shafting, to which are belted in one room four, and in the other, one of the old "D 62" bipolar generators, common in the dark ages of electric railway evolution.

The only thoroughly up-to-date machine in the place is a 450-K. W. direct-connected 550-volt railway generator, driven by a horizontal cross-compound condensing engine. This unit has shown a coal consumption of slightly below 3 pounds per kilowatt-hour, under test. From the standpoint of the modern manufacturer, the larger portion of the equipment constitutes a horrible example of antiquity, and yet the average coal consumption for the year 1904 was but 4.82 pounds per kilowatt-hour, or 3.6 pounds per horse-power-hour. The highest rate of fuel consumption was in January—5.47 pounds per kilowatt-hour, and the lowest in July—4.21 pounds per kilowatt-hour. During the year the railway load averaged 62.8 per cent. of the total output. The minimum coal consumption per kilowatt-hour occurred, as would be expected, during the month in which the railway output bore the highest percentage (74) of the total plant output.

The operation of the 450-K. W. unit in railway service in preference to the use of the old D·62's, was easily the main factor in the plant economy. These older outfits were each connected to a double-throw switch, by which they could be thrown upon either the railway or 550-volt power bus-bars, as desired. As the average railway load was not much in excess of 215 kilowatts, it is evident that during a large part of the time the old machinery was not required for railway service.

Figures are not at hand covering the total cost of power in the plant, but it is clear that the cost of attendance is greatly increased by the double engine-room layout, while the cost of maintenance must be excessive with the scheme of driving adopted. Nevertheless, the plant is kept remarkably clean and the operating force is constantly on the watch for trouble, the equipment being held up to as high a performance as its inherent and acquired defects allow. There is little to criticise in the operation of the plant, although one would prefer improved coal-handling facilities and a little greater economy in the use of artificial light during the daytime. The plant is a bad fire risk, having wooden floors, walls and roof trusses, and alternating switchboards of ancient frame type. It is a clear case of needed reconstruction in almost every corner, but it is interesting as an example of what may be done by intelligent operators when handicapped by antiquated machinery.

Electric Cable Insulation Resistances

IT is well known that the electrical pressure necessary to break down an air space must be progressively, although not proportionally, increased as the length of the air space is increased. Thus, roughly speaking, 2000 volts will jump across an air space of 1-64 inch, while 25,000 will be required to break down an air space of ½ inch, and in the case of lightning discharges it is calculated that millions of volts are necessary to break down the air space that separates two charged clouds or the clouds and the earth.

The resistance to electrical pressure of many insulating materials, such as rubber and certain oils and resinous compounds, is greater than that of air, so that it is feasible to employ a much thinner wall of these materials to withstand a given electrical pressure than could be done if air were the insulating medium, the ratio being at least 5 to 1 in favor of rubber compounds and oils. It has, however, been found in practice that after a certain thickness of insulating material has been reached, more especially in the case of cables in which the dielectric is of a fibrous nature, such as paper or cotton soaked in oils, the resistance to electrical pressure does not increase at all proportionately with further thickness of the insulating wall.

One explanation of this is that under the heating process to which the material is subjected to expel its natural moisture, vacuous spaces are left when the material cools, and these spaces are measurably conducting. Another explanation is that the long-continued baking necessary to expel the moisture from the inner layers of the insulating material when it exceeds a critical thickness, has a detrimental effect upon the material of the outer layers, which is manifested in a reduced resistance to electrical pressures. In this relation it is interesting to note that reports, some time ago, concerning the underground cables designed to convey current at a pressure of 25,000 volts in connection with an overhead long-distance transmission line coming into St. Paul, Minn., showed these cables to have given highly successful results. These results are the more satisfactory in view of the fact that this was at the time, and is yet, the highest pressure to which underground cables have been subjected under actual working conditions, and the most experienced cable engineers were not sanguine of a successful outcome of the experiment.

Wireless Telegraph News

BEFORE the Society of Arts, London, Captain Lionel James recently read a very interesting paper relating the details of his work and experience with wireless telegraphy as correspondent of the London "Times" in Chinese and Japanese waters during the early part of 1904. Very few technical details were supplied by Captain James, outside of the height of the masts and the length of the antennæ employed at Wei-hai-wei, and on the steamship "Haimun," the receiving and transmitting stations, respectively, which information was published in these columns very shortly after the establishment of this wireless circuit.

Cuthbert Hall, managing director of the Marconi Wireless Telegraph Company, in discussing the paper, expressed some surprise that the Society of Arts had accepted a paper of this nature, since it dealt only with the transmission of news. He also took exception to one of Captain James' reasons for having adopted the DeForest wireless system for his operations, namely, that it would operate at a speed of thirty to thirty-five words a minute, as against the twelve or fifteen words by other systems. Mr. Hall stated that the speed of his company's sound-reading instruments is limited only by the capacity of the operator to read by sound, and that if an operator were capable of reading 100 words a minute, there would be no difficulty in communicating at that speed to a distance ten times greater than that covered in the Far East.

This is high-sounding language, and no doubt served its turn, but when analyzed it will be found to possess no intrinsic merit, for assuming that one operator could be found to read 100 words a minute, where, it may be asked, is the operator or machine that could transmit 100 words, or even 30 words a minute with the ponderous keys employed in the system represented by Mr. Hall? Where, also, is the existing Marconi circuit over which commercial messages are now being transmitted at even 30 words a minute to a distance of 1450 sea miles, which is the distance that would be necessary to exceed tenfold the results detailed by Captain James?

The noticeable difference between Captain James' paper and Mr. Hall's statement is, that the former describes actual and well authenticated results, while the latter relates to things perhaps possible, but not yet accomplished. We expected that Mr. Hall would have closed his remarks, and are somewhat surprised that he did not, by adding that in any event the system which Captain James had so successfully used in the Far East was tributary to the Marconi system, etc.

By the way, another reason which Captain James gave for his selection of the DeForest system was, that he had found it much less susceptible to outside interference than other systems during the yacht races in New York waters. This experience, the captain states, was borne out in the Far East, and it was noticed that unless they were within a mile of another transmitting station there was no interference with their received signals. They also made it a point, when they heard either of the belligerents operating wireless, to wait until they had ceased, so as not to cause possible interruption to their work. These records of high-speed and accurate long-distance wireless signaling, together with the evidence of practical syntony which Captain James' paper recounts, if taken alone, were doubtless considered of sufficient merit to warrant the acceptance of Captain James' paper by the Society of Arts.

In the course of his paper Captain James also noted that his report of the battle between the fleets of Admiral Togo and the late Admiral Marakoff, consisting of 2000 words, had been transmitted without a single error from the vicinity of the Island of Choda, 145 sea miles from Wei-hai-wei. In commenting on this fact Sir W. H. Preece questioned whether there was any telegraph circuit in Europe over which 2000 words could be transmitted without an error, either in transmitting, receiving, or copying. Sir William is, of course, well qualified to speak on this question, but if his view is correct, it certainly discloses a remarkably low degree of efficiency in the telegraph service in Europe as compared with that of the United States, where, we venture to state, thousands upon thousands of words of press reports are daily transmitted and received without errors of any kind.

The accounts that reach us through various sources, of the numerous installations of the Marconi wireless apparatus on ocean-going vessels, together with the recent announcement of a provisional arrangement with the British post office department for the interchange of telegrams to and from Atlantic liners, leave no doubt as to the gratifying expansion of that company's business in different parts of the world. By this arrangement with the British post office, which is made with the Marconi International Communication Company, telegrams to or from passing Atlantic liners will be delivered to and received from the Marconi stations at Rosslare, Crookhaven and Malin Head, on the Irish coast and the Lizard, North Foreland and Niton (Isle of Wight) on the English coast.

Vessels of the American Line, en route to or from Havre, may thus be reached at North Foreland, Niton and the Lizard; those from Southampton, at Niton and the Lizard; the Allan liners can be communicated with at Malin Head; the Norddeutsche Lloyd vessels as well as those of the Holland-American line and the Hamburg-American line may be reached by way of North Foreland, Niton and the Lizard; the ships of the Compagnie Generale Trans-Atlantique from Havre may be caught at the Lizard, while the Cunarders to and from Liverpool may be communicated with at Rosslare and Crookhaven.

To facilitate this interchange of telegrams from and to passing steamships, a schedule is placed at each post office, giving the list of sailings and the hours up to which telegrams will be received for any vessel. After the stated hours, telegrams will be received entirely at the owner's risk.

The charge for this service is 6½d per word, with a minimum charge of 6s. 6d per message. The fees for telegrams to ships will be collected by the land office, and contrariwise by the ship's operator. The word "radio" is to appear in all messages transmitted by wireless, to indicate its source. It would not be astonishing if this should lead to the application of the term "radiogram" to all wireless telegrams, inasmuch as thus far no satisfactory term has been coined for this purpose. Marconigram and aerogram have not been generally adopted.

It will be understood that the service referred to covers only the time when the vessels are within signaling distance of any of the stations mentioned, say from 40 to 60 miles from the coast, on an average. It has been suggested that the service might be extended to Poldhu, which is equipped with more powerful apparatus than the ordinary stations, and could therefore be "picked up" by the steamships at greater distances than the other stations.

But, even if this were the case, whether or not the message had been received, for the reason, already pointed out in these columns, that owing to the comparatively weak transmitter and short antennæ on the vessels their answering signals would not reach Poldhu.

Some Applications of Wooden Stave Pipe

By JOHN BIRKINBINE

Steel-banded wooden stave pipe has been used extensively in the West for carrying water under heads of several hundred feet for power purposes, in connection with electric transmission. Comparatively little, however, has been printed about it, so that Mr. Birkinbine's paper, which was recently read before the Engineers' Club of Philadelphia, is particularly welcome. Not only is it generally interesting, but it gives data on strength and cost of such pipe which will prove convenient and useful to many engineers.—The Editor.

CONDUITS which have been employed to convey water and other liquids embrace the ancient aqueducts, wood logs bored, the modern masonry aqueducts, cast-iron pipe, wrought iron or steel riveted or welded pipe, either with transverse or spiral joints, wooden bored pipe banded and coated, sheet iron and steel pipe with cement core, and later wooden stave pipe and reinforced concrete conduits. Modifications of the above and departure from the cylindrical core make quite a number of styles and forms of closed conduits.

The wooden stave pipe is not a new conception; in fact, its form of construction is quite old, for every bucket used is practically an illustration of the general method of assembling the parts. It has served as conduits of considerable diameter for flumes or penstocks, feeding water-wheels, etc., but most of these were staves of wood secured by a series of flat metal bands.

The wooden stave pipe to which attention is especially directed was developed by the necessities of mining in western America. The distances to which metallic pipe would have to be transported, the difficult country in which the pipe was to be laid, and other local considerations brought about the construction of this form of conduit, and while it is not expected to displace cast iron or riveted or welded steel or iron pipe, it is admirably adapted for long conduits laid in difficult territory or for those which must be constructed at a moderate expenditure of money.

The use of wooden stave pipe, in the form which will be described, has gone beyond the experimental stage, both in the quantities and in the sizes of the pipes laid and in the length of time some of these have been in use.

It has been my privilege to be personally associated with construction in which wooden stave pipes from 28 inches to 72 inches in diameter have been features, the variety of territory covered and the local topographic conditions having given opportunity for the use of this form of conduit under numerous and diverse conditions.

While the data presented relate primarily to the construction of a line of wooden stave pipe $6\frac{1}{2}$ miles in length, along the Little Conemaugh River, near Johnstown, Pa., other installations and some difficult problems elsewhere will be referred to.

The pipe along the Little Conemaugh River was laid to control a supplementary supply pending the

ALONG THE JOHNSTOWN PIPE LINE

SETTING UP THE JOHNSTOWN PIPE LINE

construction of the permanent features of a comprehensive water supply for the industries of Johnstown. It varies from 44 inches to 36 inches in diameter, and while for most of the 6½ miles of its length the pressure is light (the pipe being on regular gradients of 1 to 2 in 1000, closely approximating the hydraulic grade), there are inverted siphons under considerable pressure. For the most of the route of the pipe there is no wagon road in the Conemaugh Valley, the creek and the Pennsylvania Railroad occupying the limited space between the steep hillsides; however, roads make it possible to reach the valley at several points; but for most of the distance the road used had to be built, and was of a temporary character.

THE U-FORMED CRADLE AND INNER SUPPORTING RING FOR SETTING UP THE PIPE ARE HERE MORE CLEARLY SHOWN. FOR DESCRIPTION, SEE OPPOSITE PAGE

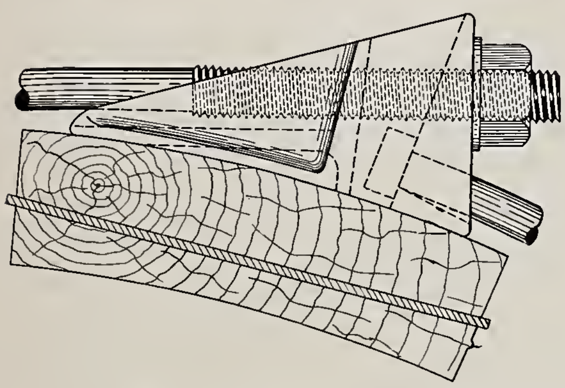
To handle cast-iron pipes weighing three to four tons each and connect them in a locality such as that indicated, would have been a costly undertaking. The use of riveted steel pipe did not show to advantage when the light head of most of the distance covered by the conduit, and the acidity of the water coming from coal mines, which might be expected when the flow of the streams was below the normal, were also taken into consideration. The water conveyed by this conduit is not for domestic purposes or for steam generation.

The total length of the wooden stave conduit along the Conemaugh River is 33,822 feet, of which 9209 feet are 44 inches in diameter, 21,458 feet are 42 inches in diameter and 3155 feet are 36 inches in diameter, the diameters and grades being such as to secure equal deliveries. The pipe is made up of staves of fir, cut and milled in the State of Washington. They are from 12 feet to 30 feet long, about $5\frac{1}{2}$ inches, or over, in width, and $1\frac{1}{2}$ to $1\frac{5}{8}$ inches thick.

In the 36-inch pipe there are 22 staves, and in the 42-inch, 25 staves. The staves are held in place by $\frac{1}{2}$-inch round steel bands having a tensile strength of not less than 60,000 pounds per square inch, the actual breaking strain of the $\frac{1}{2}$-inch bands showing 12,300 pounds. On one end of the band is a button-head 1 inch in diameter, and on the other a thread $5\frac{1}{2}$ inches long, rolled into the upset end. The head of the band fits a recess in a malleable iron shoe, the other portion of the shoe receiving the threaded end after the band has encircled the assembled staves. Each band is "cinched" by means of a brace which forces a nut against a washer, which in turn rests against the shoe. In this way the bands are adjusted to the required tension and the pipe is made tight.

The banding is spaced to suit the various pressures, the maximum spacing allowed being 12 inches, center to center. Where the pipe is under heavy pressure the spacing is reduced until, at a crossing of the Conemaugh River, with a static head of 63 feet, the 44-inch pipe bands are $4\frac{1}{4}$ inches apart, and at a creek crossing, where the static head is 176 feet, the 36-inch pipe bands are $2\frac{3}{4}$ inches apart.

The contractor for the Conemaugh pipe line, C. P. Allen, C. E., of Denver, Col., used the following formula for spacing the bands:—



ONE OF THE SHOES FOR TIGHTENING THE BANDS

$$\frac{600\,L\,P\,H\,F}{A\,B}$$

= number of bands per 100 feet,

Where D = diameter of pipe in inches;

Where B = breaking strain of band (60,000 pounds per square inch.);

Where F = factor of safety (4);

Where A = area of bands ($\frac{1}{2}$ inch round = 0.19635 square inch);

Where H = head in feet;

Where P = pressure due to 1 foot (0.44 pound).

Thus, for a 44-inch pipe, $\frac{1}{2}$-inch bands, and a 50-foot head, the number of bands per 100 feet

$$= \frac{600 \times 44 \times 0.44 \times 50 \times 4}{0.19635 \times 60{,}000} = 197.$$

Another formula for the spacing of bands in the assembling of wooden stave pipes is from a paper by James D. Schuyler, on the water-works of Denver, Col., to be found in the "Transactions of the American Society of Civil Engineers," Vol. xxxi. It is:—

$$N = \frac{1200\,D\,P}{2\,S}$$

Where N = number of bands per 100 feet,

Where D = diameter of pipe in inches,

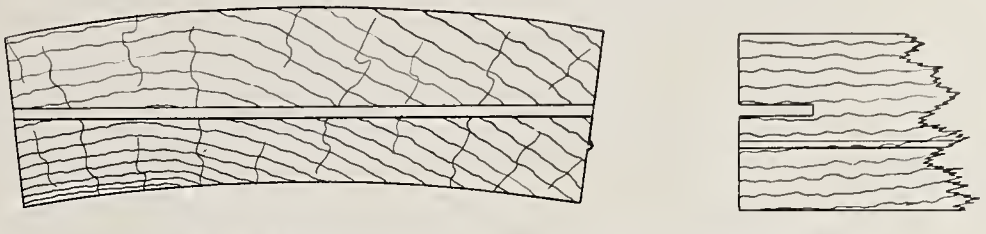
Where P = pressure in pounds per square foot,

Where S = safe working strain in pounds per square inch for bands when threaded for use, determined by regular tests at the mills where they are made.

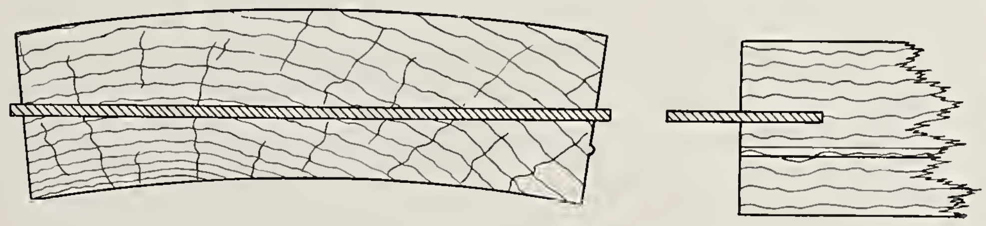
The following values of S give a factor of safety of about five in each case, or about one-fourth of the elastic limit:—

			Pounds
⅜-inch	bands,	plain	S = 1000
⅜-inch	"	upset	S = 1200
½-inch	"	plain	S = 2000
½-inch	"	upset	S = 2500
⅝-inch	"	plain	S = 3000
⅝-inch	"	upset	S = 3500

The staves are milled with inside and outside surfaces to curves representing the interior and exterior circumferences of the pipe, and the sides are cut with radial faces so that when assembled they may form a complete circle. On one of the side faces a small bead is formed by a notch in the cutting tool, and this bead is crushed under the strain of "cinching" to form a continuous water-tight joint. The butt ends of the staves are cut off square and slotted to receive clips, which in the pipe under discussion were made of sheet steel No. 12 gauge (1-10 inch thick), $1\frac{1}{2}$ inches wide, and slightly longer than the width of the stave. These clips are used in forming the end or butt joints, fitting into the slots in the ends of the abutting staves and projecting slightly into the adjacent staves. In some lines of wooden stave pipe, indurated fiber or thin strips of wood have been applied for the same purpose.



END OF STAVE SHOWING SLOT FOR CLIP AND CAULKING BEAD

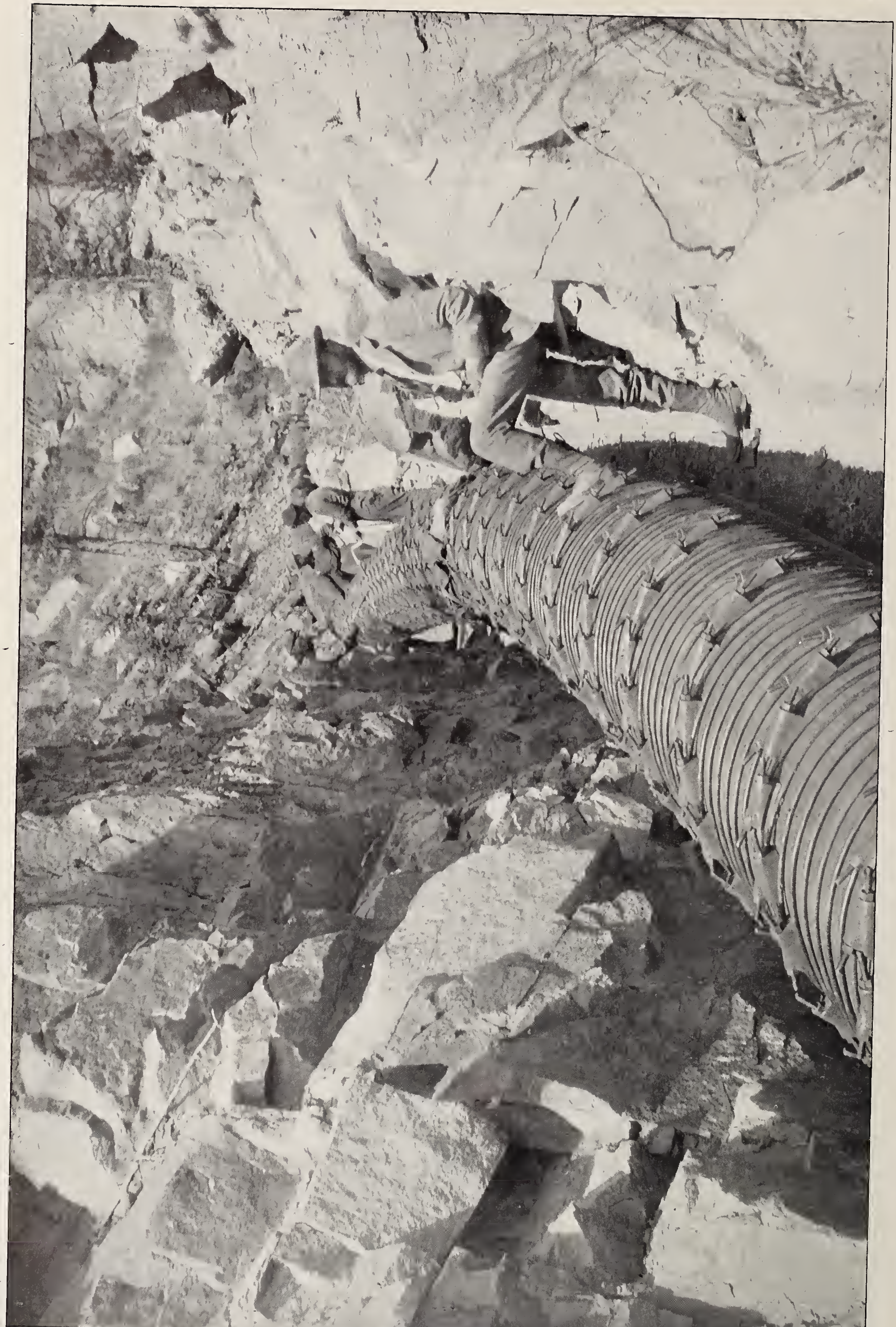


HERE THE CLIP IS SHOWN IN PLACE

In forming the pipe, cradles of steel tubing, bent in U form, are set in the ditch and the lower staves are placed in position; then upon these lower staves are placed tubes bent to the desired circles, but with ends not connected, and the form of the pipe is thus obtained. After the staves are held by sufficient bands the interior tubing is sprung together to remove it, and subsequently the necessary bands, spaced to meet the requirements of the pressure, are put in place; the pipe is then leveled to position; the cradles are removed and the necessary under-tamping is done. After this the "cinching" proceeds until the pipe is satisfactorily tightened. Each band is dipped in asphaltum, and after being placed, the bands and shoes are painted to reduce the chances or rust.

Numerous interesting installations of lines of wooden stave conduits are in Colorado, California, Oregon, Washington, and in fact in all of the Rocky Mountain and Pacific States. In some cases the pipes span streams, or cañons, and are suspended to or from the cañon walls, and traverse tortuous and nearly inaccessible routes.

A notable application of wooden stave pipe is in connection with what was designated as the Pike's Peak plant, on Beaver Creek, Pueblo, which is now operated by the Pueblo & Suburban Traction & Heating Company. This plant consists of a dam, conduit line made of wooden stave and steel riveted pipe, and a power station



A PORTION OF THE PIKE'S PEAK POWER COMPANY'S PIPE LINE. THE HALF-INCH ROUND STEEL BANDS AND TIGHTENING SHOES ARE HERE CLEARLY SEEN next, and cast-iron pipe as most expensive. As to the life of the pipe, cast iron is given first place, wooden stave second, steel riveted third, and as to the capacity, wooden stave has the largest, followed by cast iron, and steel riveted the smallest.

We know that the life of cast-iron pipe, unless the pipe is subjected to acid water or to electrolysis, is yet undetermined, and if the staves of the wooden conduit are kept continually wet, its life may also be considered as undetermined, for 60 miles of wooden stave pipe, varying in diameter from 12 inches to 48 inches, are used in connection with the water supply of Denver, Col., under heads ranging from 10 to 210 feet, some having been in place more than twenty years, and other similar instances could be mentioned.

The well-formed wooden stave pipe, laid as a continuous tube, may also be expected to present less obstruction to the flow of water than cast-iron pipe, and certainly less than steel riveted with the rivet heads projecting.

In a series of tests carried on at the Puget Sound Navy Yard in 1901, comparing Douglas fir and yellow pine for pipe staves, Frank W. Hibbs, naval constructor of the United States Navy, arrived at the following conclusions:—

"In strength Douglas fir is generally equal to yellow pine and superior to it in some essential particulars.

"Douglas fir is decidedly more elastic than yellow pine.

"Douglas fir is far superior to yellow pine as regards to toughness.

"Yellow pine is superior to Douglas fir in wearing qualities, especially when moisture is present.

"Yellow pine is superior to Douglas fir in lasting qualities, on account of the greater amount of pitch it contains.

"Douglas fir is 14 per cent. lighter than yellow pine.

"Following are the average general characteristics of strength of Douglas fir:—

"For well-seasoned, fine-grained, hard, clear stock,

	Pounds per Square Inch
Tensile strength	13,000
Tensile strength across grain	350
Tensile strength for bending	10,000
Elastic limit for bending	6,000
Modulus of elasticity for bending	1,500,000
Strength for compression across the grain without destructive deformation	1,200
Modulus of elasticity for compression across the grain	4,000
Crushing strength for compression, "end on" to grain	9,000
Modulus of elasticity for "end on" compression	70,000
Modulus of elasticity for torsion	27,000
Shearing strength with the grain	15,000
Crushing strength for columns whose proportions are such as to resist bending.	6,000
Weight per cubic foot, pounds	35

COMPARATIVE COST OF PIPE AT CHICAGO, INCLUDING LAYING, BUT OMITTING HAUL

Wooden Stave Pipe

Diameter	25-Foot Head	50-Foot Head	100-Foot Head	200-Foot Head
12 inches	$0.42	$0.49	$0.63	$0.85
18 "	0.69	0.80	1.02	1.46
24 "	0.79	0.91	1.14	1.61
30 "	0.96	1.12	1.44	2.06
36 "	1.19	1.40	1.82	2.65
42 "	1.40	1.68	2.23	3.33
48 "	1.55	1.85	2.46	3.67
54 "	2.23	2.62	3.43	5.02
60 "	2.85	3.35	4.37	6.40
66 "	3.21	3.81	5.00	7.38
72 "	3.65	4.38	5.83	8.73

Riveted Steel Pipe

Diameter	No. 14	No. 12	No. 10	No. 8	No. 6	¼ inch	5/16 inch	⅜ inch
12 inches	$0.32	$0.38	$0.44	....	....	....	....	....
18 "	....	0.57	0.65	$0.78	$0.98	....	....	....
24 "	....	....	0.85	1.04	1.28	$1.55	$1.99	....
30 "	....	....	....	1.27	1.59	1.93	2.46	$3.04
36 "	....	....	....	1.55	1.93	2.30	2.92	3.58
42 "	....	....	....	1.61	2.18	2.66	3.37	4.12
48 "	....	....	....	....	2.48	3.03	3.83	4.66
54 "	....	....	....	....	2.80	3.41	4.29	5.21
60 "	....	....	....	....	....	3.79	4.75	5.74
66 "	....	....	....	....	....	4.35	5.21	6.29
72 "	....	....	....	....	....	4.52	5.66	6.83

Cast-Iron Pipe

Diameter	25-Foot Head	50-Foot Head	100-Foot Head	200-Foot Head
12 inches	$0.73	$0.77	$0.84	$1.00
18 "	1.29	1.35	1.46	1.70
24 "	1.91	2.00	2.18	2.55
30 "	2.67	2.80	3.07	3.61
36 "	3.47	3.67	4.06	4.85
42 "	4.42	4.69	5.22	6.28
48 "	5.50	5.84	6.53	7.92
54 "	6.65	7.10	8.00	9.78
60 "	8.04	8.63	9.80	12.13
66 "	9.51	10.16	11.55	14.05
72 "	11.32	12.00	13.26	16.00

DISCUSSION

Harrison Souder.—I believe that wooden stave pipe is well adapted for use in certain localities, where, as at Johnstown, the country is mountainous and rough and where it is a most difficult and expensive matter to transport the heavy cast-iron or steel pipe through the woods and across deep ravines. For the locality mentioned and for the Western country, where the pipe is extensively used, there is nothing better. The staves can be packed on mule back and carried through regions where the cost of handling other kinds of pipes would be prohibitive. The bands are transported in the same way and the pipe is assembled in place in the ditch. Another good feature about it is that, with a sufficient length of ditch open, several pipe-laying gangs can be worked and the various sections carried on at the same time and joined as they meet, with very little trouble. Of course, in laying other pipes we can do the same thing, but with cast-iron pipe it would be difficult and rather expensive, and this objection would apply even more strongly to riveted steel pipe. From my own experience in getting large sized cast-iron pipe through the woods, a very large item of pipe-laying expense is transporting and distributing the pipe along the line.

As regards leakage from wooden pipes, I have no data convenient at this time. It is not, however, excessive after the pipe has been in service some time.

The pipe at Johnstown is giving satisfaction, though some trouble was experienced in laying it. This was largely due to the fact that the contractor left his trenches open and pipe uncovered too long. On one or two occasions the trenches were flooded by rains and the empty pipe lifted a foot or more; several landslides, too, caused much damage.

With a properly located line and the pipe well laid, wood stave pipe is satisfactory and economical.

John C. Trautwine, Jr.—Mr. Hawley tried to have wooden stave pipe adopted for the pumping main across the meadows from Pleasantville to Atlantic City, but he was overruled and steel pipe was laid. Mr. Souder has referred to the advantage of wooden stave pipe in difficult countries, such as that near Johnstown. There would hardly seem to be much difficulty in laying pipe on the Atlantic City meadows. I would ask whether wooden stave pipe would have any special advantages there. I suppose there must be some advantage which makes wooden stave pipe preferable to cast-iron pipe.

J. L. W. Birkinbine.—The advantage is that the coefficient of resistance of the wooden stave pipe is very low—the coefficient of resistance of cast-iron and riveted steel pipe increases each year, while in wooden stave pipe it decreases. A sort of slime forms and the pipe gets worn smooth by the action of the water. In Kutter's formula the factor of resistance is generally taken as 0.010 for wooden stave pipe, while for cast iron as 0.013. From actual test, I understand it has gone as low as 0.007 for wooden stave pipe, and that may be one reason why they should adopt it at a point like Atlantic City.

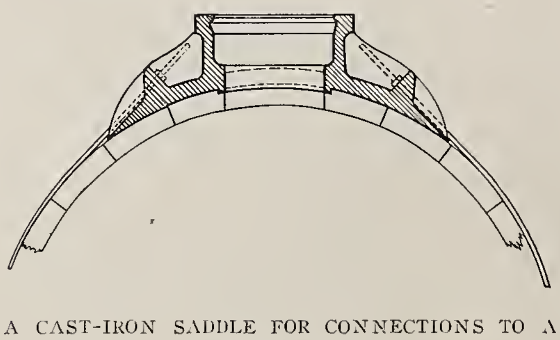
FOR SHARP CURVES A STEEL ELBOW IS SOMETIMES USED, BUT IN ORDINARY CASES THE WOODEN STAVE PIPE IS SPRUNG TO THE DESIRED DEGREE

Mr. Souder.—My impression is that it is a gravity pipe line, and under the controlling features it is probably a fact that the friction is much less. It seems to me preferable to a steel pipe on account of the salt water. There is less corrosive action upon it. The steel bands upon the pipe will, of course, corrode, but they can be renewed easily and can be made of larger section, and, moreover, when there is so little pressure on the pipe as in this case, the bands can be spaced wide apart, and the amount of metal subject to possible corrosive action is small compared with that in a steel pipe similarly placed.

The President.—This brings up the question whether the bands around those pipes have to be made strong enough to stand the original tension put on them by the tightening bolts plus the tension due to the water when the pipe is in use.

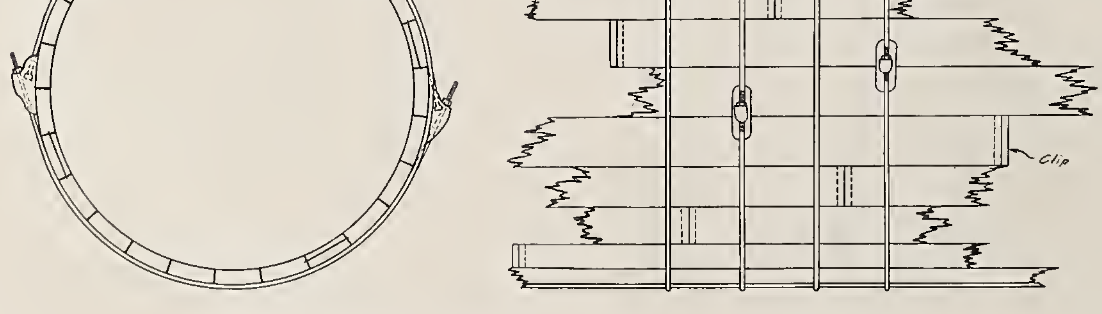
Edgar Marburg.—The initial tension in the bands produces compression in the wooden staves. The internal pressure of the water tends to relieve this compression, thereby causing an enlargement of diameter, which will produce additional tension in the bands. The final stresses in the staves and bands depend on the relative elastic behavior of the two materials, and for given data these stresses may be readily computed.

Henry H. Quimby.—The enlargement of the pipe, with its consequent increased length of band, is necessarily attended with increased stress in the band. If the materials of construction were all absolutely without elasticity, there would never be any combination of initial and load stresses; but with elastic material the initial stress produces deformation, and the deformed material—compressed or stretched—is constantly exerting force in the effort to resume its normal dimensions. Whether the load will increase the initial stress or not depends upon how it is applied—whether it acts directly or indirectly against the elasticity of both the stressed parts. There are bridge details where the load stress is not affected by the initial stress; for example, a floor beam suspended in adjustable stirrups in the old style. In the stave pipe the initial tension in the band stretches the band and compresses the staves. If all the bursting force exerted by the water pressure could be applied between the edges of the staves it would act directly and only against the elasticity of the staves and not increase the stress in the band; but as it is applied to the surface of the staves, acting to push them out and increase the diameter of the pipe, the result must be a combination of the springing elasticity of the staves and the bursting force of the water. As



A CAST-IRON SADDLE FOR CONNECTIONS TO A SMALLER PIPE

this combination increases the stress in the band, the band lengthens until the lessening force of elasticity attending the expansion of the staves restores equilibrium. The amount of increase in stress and in length of band will depend upon the moduli of elasticity of the two materials, together with the ratio between the initial stress and the applied load. Of course, if the load, or pressure, should be enough greater than the initial stress to stretch the band beyond the elastic reaction of the staves, then the maximum stress in the

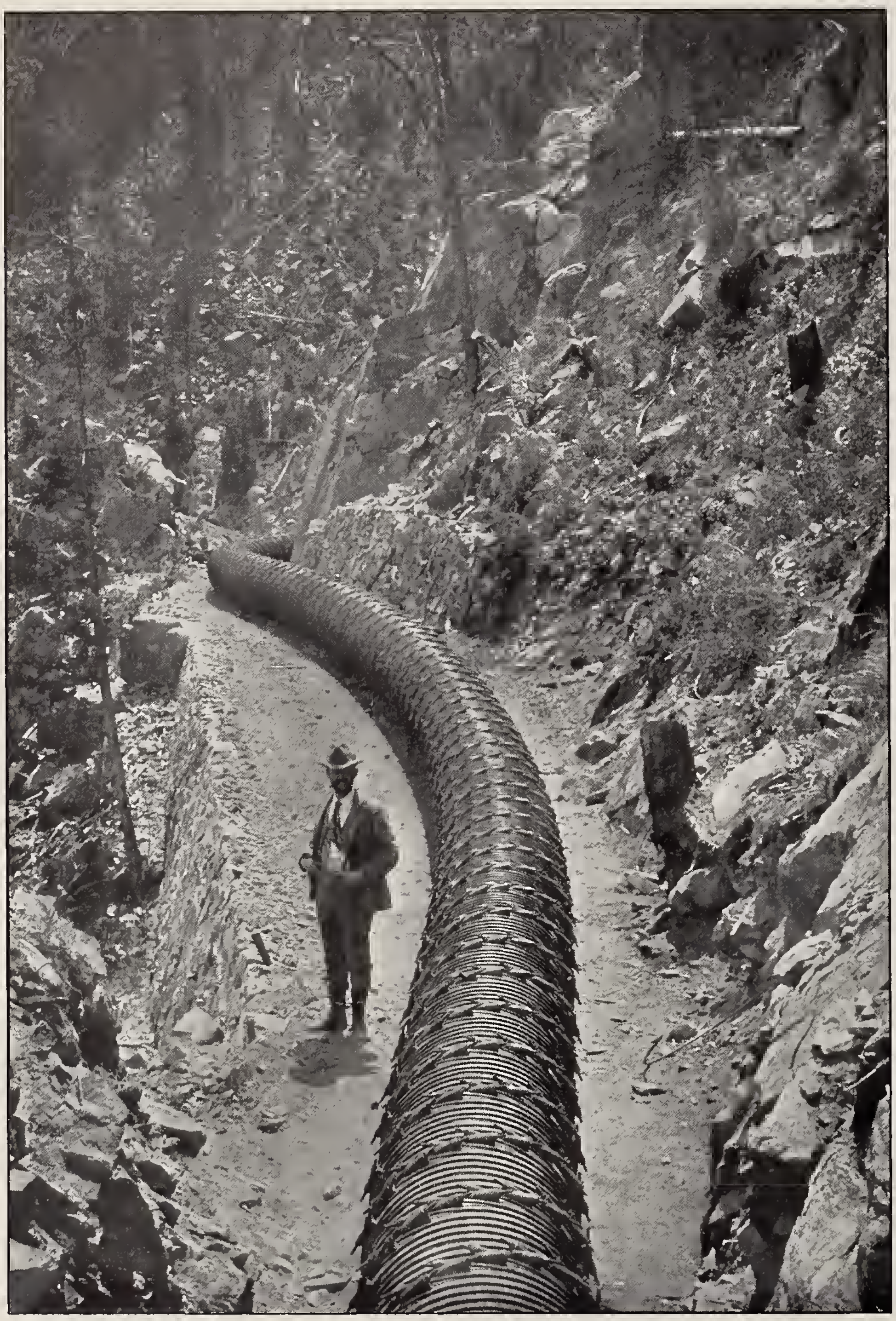


CROSS SECTION AND PARTIAL PLAN OF A 42-INCH PIPE

A TYPICAL WESTERN WOODEN STAVE PIPE LINE FOR HYDRO-ELECTRIC SERVICE band is only the pressure load, not at all increased or affected by the initial stress; but then the staves would be separated and permit water to escape. In view of this, it is clearly necessary to adjust the bands to an initial stress considerably greater than the bursting effort of the water, because, in order to prevent leakage, the staves must be actually compressed edgewise, even when the pressure is against them; therefore the band formula, which considers only the amount of the direct stress produced by the water pressure, ignoring the necessarily superior initial stress and the swelling of the wood from moisture, is scarcely complete.

J. Kay Little.—Does the thickness of the stave vary with the diameter of the pipe?

H. E. Birkinbine.—Yes, but not materially. It varies according to the size of the pipe and also according to the hydrostatic pressure. These variations in thickness, however, are slight; thus, for a 36-inch pipe the thickness of the stave is 1½ inches, while for 42-inch and 44-inch pipe it is 1⅝ inches—a difference of only ⅛ inch. Although in some cases the staves are made thicker when the hydraulic pressure is great, the strength of the pipe is generally maintained by increasing the number of bands per foot. Connections are made between different sizes or the same sizes of pipe in a way similar to that used with cast-iron pipe; that is, the wooden stave pipe is connected with cast-iron branches or breeches where the large pipes are connected, and by means of cast-iron bonnets or sleeves where a small pipe is connected with a larger one.



ANOTHER VIEW ON THE PIKE'S PEAK PIPE LINE. THE BANDING IS SPACED TO SUIT THE VARIOUS PRESSURES

J. W. Ledoux.—I understand that wooden pipe is not satisfactory for more than 200 feet head. It is always easy in the mountains to provide a standpipe, and in California and other places I have seen standpipes used quite often.

C. P. Birkinbine.—As mentioned in the paper, the upper portion of the Pike's Peak line is made of staves, until a static head of 120 feet is reached (although in some places where there are inverted siphons the pipe is subjected to a static head of 215 feet), and has on the line a water-tower 73 feet high made of wooden staves. The lower portion of the line is of riveted steel pipe of thickness varying from ¼ to ¾-inch. This is necessary, as the turbines operate under a head of over 115c feet.

Trade Journals

At a recent meeting of the American Trade Press Association, held at the Hardware Club in the city of New York, Arthur Warren, manager of the Publishing Department of the Allis-Chalmers Company, delivered an address entitled "A Plain Talk on Trade Journals." Mr. Warren discussed "special" numbers,—a misnomer, by the way, in most cases where such "special" numbers, as Mr. Warren himself pointed out, mean special pleading for special advertising, and nothing else; the differences between the problems of advertising, say, soaps or breakfast foods and steam engines, boilers and dynamos; circulation of periodicals; and finally the reading matter contained in technical papers. Bearing upon this last point he said, among other things: "There should be, and there can be a closer touch between the papers and the manufacturers. And that closer touch can be obtained without the loss of any independence on the part of the press. The papers that are not independent, the papers that are partisan and that curry favor, are the papers we don't want. The manufacturing concerns are sources of news. You want technical news and perhaps other kinds of news. But very often, especially in regard to large undertakings, you do not get the information until it has lost its news value. There are reasons for that. Perhaps they will never be entirely overcome, because the manufacturer has not only to guard his own interests, but he has to guard the interest of his customer.. When large investments are at stake the persons who are paying the money have the privilege of keeping their own counsel. You, as business men, can understand that clearly enough. And again, when the manufacturer is producing a new invention, he prefers silence until he has protected himself by patents.

Electrical and Mechanical Progress

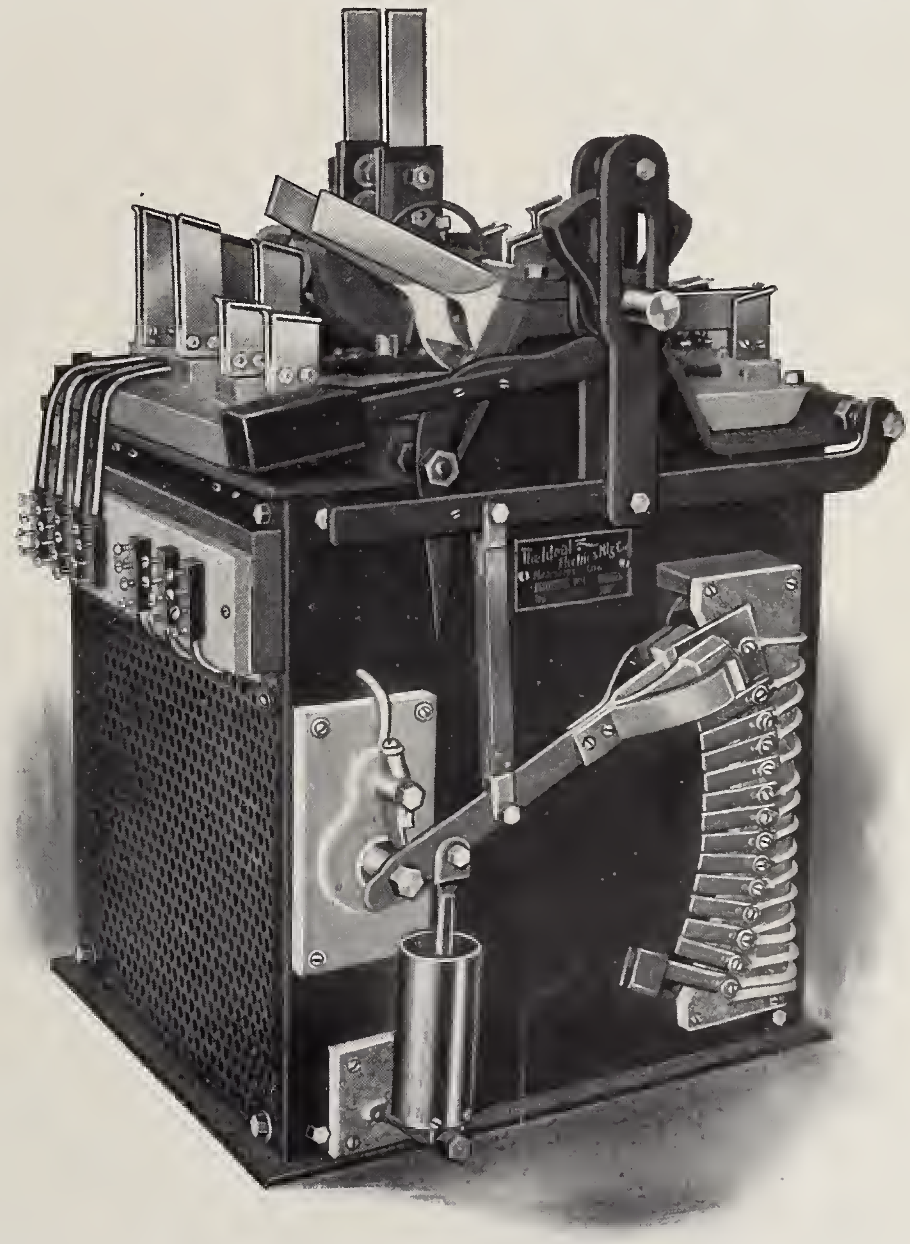
A Reversing Controller

AN automatic mechanical reversing controller made by the Ideal Electric & Manufacturing Company, of Mansfield, Ohio, is shown in the accompanying illustration. A view is also given of an elevator installation, of which this controller forms a part.

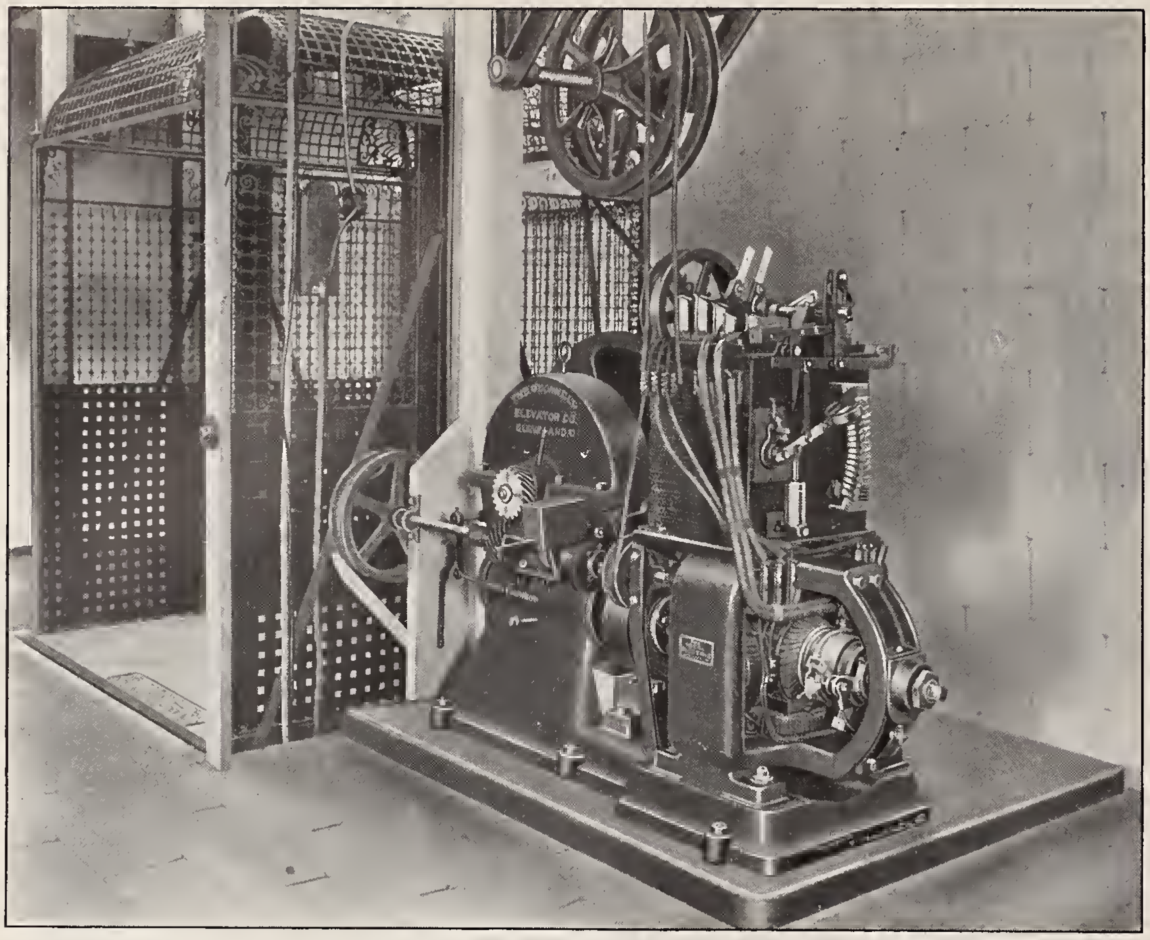
In the construction of the controller, the reversing switch, which is of the quick make and break type, is mounted on a sleeve provided with a cam. The switch is operated by means of a tension spring of steel, and its blades and contact clips are made of hard drawn brass. Hard drawn brass has been chosen in place of copper for these parts on account of its being more durable.

The armature switch is actuated by a set of cams mounted on the switch-shaft so as to close this switch ahead of the line switch, which latter is made separate and independent of the armature switch. The cams also allow the armature switch to remain closed until the line switch has been opened. The contact segments of this switch are of copper, but they are renewable. The contact lever is made of heavy brass, and is provided with two carbon brushes. By means of tension springs these brushes are made to clamp the copper segments from both sides, and thus insure good contact. The resistance is cut out by gravity, the movement being regulated by an oil dash pot. Upon reaching the last contact, the resistance arm of the armature switch automatically short-circuits the carbon brushes, and a perfect metallic connection results.

In the operation of the controller, the contact lever is not released until the main switch has made full contact; this prevents the blowing of fuses, which would result from cutting out resistance ahead of the line connections. The travel of the shaft in taking up the lost motion in the sleeve of the main switch cuts out the greater part of the resistance in circuit before breaking the main line circuit; this reduces the flow of current, and leaves but little to be cut off by the main switch, which in turn results in prac-



AN AUTOMATIC MECHANICAL REVERSING CONTROLLER MADE BY THE IDEAL ELECTRIC & MFG. CO., MANSFIELD, OHIO



AN ELEVATOR INSTALLATION EQUIPPED WITH THE CONTROLLER MADE BY THE IDEAL ELECTRIC & MFG. CO.

tically no arcing at the switch contacts and avoids the frequent necessity of repairs. The speed of the elevator car is thereby reduced so gradually as to overcome the jerky effect, and the large number of contacts employed, together with the action of the dash pot, ensure an even acceleration.

The armature switch is mounted on a heavy slate base. The frame of the controller is of heavy angle-iron construction, and is provided with a flange around the bottom to facilitate fastening the controller to the frame of the motor, as shown in the accompanying illustration.

Electric Power in a Gymnasium

AMONG the many applications that have been made of electric power to the driving of machinery there is one distinctly novel in the gymnasium outfit aboard the cruising steamship "Prinzessin Victoria Luise," of the Hamburg-American Line. In this particular instance the equipment comprises the latest forms of Dr. Zander's system of apparatus. One of the appliances affords all the varieties of horseback exercise, a conventional saddle, stirrups and other accessories being provided, and, with them, suitable adjusting mechanism, so that the whole outfit can be given more or less violent vertical and slightly horizontal reciprocating movement through a system of cams and connecting rods, simulating very closely the motions of the animal in life.

Another apparatus is a form of couch, moving back and forth over a set of rubber-tired wheels, so placed as to gently massage the back of the person reclining upon it. More violent massage of other parts of the body is obtainable in several additional machines,—one a so-called vibrator, which, on trial, is found to admirably justify the choice of name. To the engineer, however, the principally interesting feature about them all is found in the fact that the actuating mechanism of each is a small electric motor. The flexibility of the electric drive system is here almost indispensable, and has been utilized to full extent. Without it, some possibly unsightly, and certainly awkward, shafting transmission would have been compulsory, and might have been a prohibitive factor in planning the installation.

A Large Electric Sign

THE huge "Butterick" sign, installed 225 feet above the ground at the top of the seventeen-story Butterick building in New York, calls special attention to the possibilities of the incandescent lamp for advertising purposes. The sign is the largest in the world.

The initial letter is 68 feet high, the remaining eight letters are each 54 feet high, and the complete sign contains 1152 4-candle-power 120-volt Edison incandescent lamps and consumes 17.28 K. W. The letters are of a light steel box construction, secured to the wall by expansion bolts. The structure is inconspicuous as seen from the interior of the building and offers no obstruction at the windows to the entrance of sun and air. The lamps are spaced 18 inches apart and provided with individual hoods against the weather. Shields placed outside the lines of lamps obviate reflections from the buff-colored wall of the building, so that the illumination is given solely by the direct light of the lamps and all effect of blurring is avoided.

The officials of the Butterick Publishing Company consider this sign a splendid advertisement. They compute that it costs not more than $3 per day to operate the sign from dusk to nearly midnight, while the number of lamp renewals has seldom been as many as six per week.

We are indebted for these data to the New York Edison Company, which supplies the current for this sign as well as for the entire Butterick building.

A New Direct-Current Motor

A NEW direct-current motor of the Lundell type, made by the National Electric Company, of Milwaukee, Wis., is shown in the annexed illustrations.

The cast-iron frames or housings, which contain the laminated yoke rings and support the bearing brackets, consist of a rigid open casing in two parts. The rear part has four hollow extension arms bored to support the laminations. Bolts pass through the arms, holding the two parts together.

The laminated yoke is built up of

ELECTRIC SIGN CONTAINING 1152 EDISON LAMPS INSTALLED ON THE BUTTERICK BUILDING, NEW YORK CITY punched mild steel rings, and the pole-pieces are similarly made. The latter are provided with end plates, so constructed as to provide ventilating ducts to carry off the heat in the field

THE LAMINATED YOKE OF THE LUNDELL MOTOR

coils. The pole-pieces are held by bolts tapped into the end plates and passing through the frame.

In the armature of machines up to 60 H. P. ventilation is not provided for, the heat losses being very low. The coils are form wound, of standard proportions, and provide for ample room at both ends. Supporting rings, cast in one piece with the end plates of the core, serve to hold the ends of the coils firmly in place.

The commutators are built on the lines of standard street railway practice, the shells being ventilated through the center. The brushes and brush holders are of new design. One brush is placed directly in front of the other, the total bearing surface being the same as that with the brushes side

A LAMINATED POLE PIECE OF THE LUNDELL MOTOR

by side. Each brush is provided with a separate tension spring, and any irregularity in the commutator strikes only one brush of a stud at a time, so that while one may rise the other will still be in contact.

Where field control is used to obtain broad ranges in variable-speed work, or where the service calls for special commutating conditions, the brush at the leaving edge is made of high-resistance carbon to take care of the sparking conditions, and the other brush of high conductivity to carry the current.

The Tantalum Incandescent Lamp

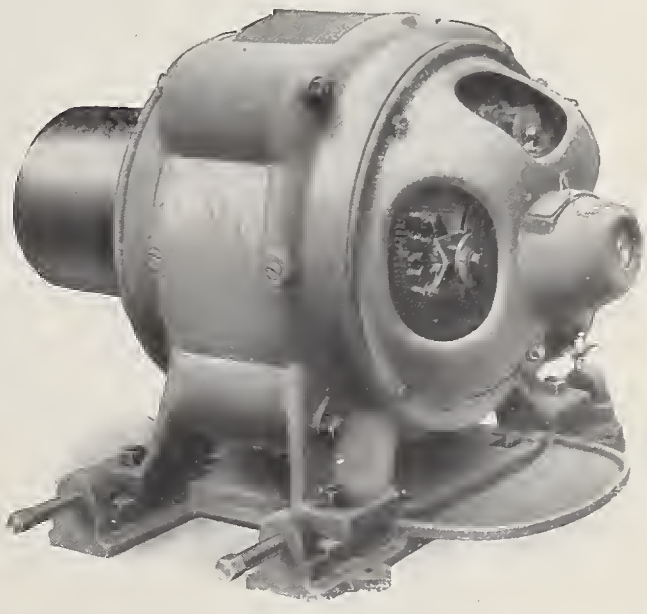
WHEN the platinum wire of the first incandescent lamps had proved a commercial failure, and had given place to the now universal carbon filament, it appeared as if any further progress were impossible as far as the use of metallic filaments was concerned.

For many years, indeed, little attempt at the improvement of incandescent lamps was made, until Nernst produced a lamp of which the incandescent substance consisted of magnesia mixed with oxides of the rare earths, and it was generally expected that development would be along some such lines. More recently, however, a reversion to the original type was shown by the introduction of a lamp the filament of which was composed of the metal osmium—one of the group to which platinum and rhodium belong, and possessing many of their peculiarities. Little has yet been published concerning the osmium lamp, and it is too soon to form an opinion concerning its practical merits, though the tendency to revert to metallic filaments in place of carbon is again shown by Messrs. Siemens & Halske, of Berlin, placing upon the market a lamp of which the filament is formed of the metal tantalum.

The evolution of the lamp was described in a paper read last week before the Elektrotechnische Verein, of Berlin, by Drs. Bolton and Feuerlein, who conducted the experimental work in connection with it. Following the fact that the visible radiation of a body increases with its temperature, it was sought to find a material for the filament which should stand the excessive temperatures proposed without melting or disintegrating. Vanadium, produced electrolytically from vanadic acid, was found to have too low a melting point, and niobium, a metal of the same group, though better than vanadium, was eventually discarded.

Tantalum, another of the group, with four times the atomic weight of vanadium and twice that of niobium, was then tried. Potassium tantalofluoride was reduced in the manner indicated by Berzelius and Rose, and the powdered metallic tantalum recovered was melted in a vacuum, and the resultant metal was found to be practically chemically pure. Its chemical and physical properties were so different from the generally accepted idea of them that it is doubtful whether the pure metal had ever been previously prepared. It resisted all alkalies and acids, with the exception of hydrofluoric acid, and as well as being of about the hardness of mild steel, has many similarities to the latter metal.

Pure tantalum wire has a specific gravity of 16.8 and a tensile strength of 95 kilogrammes per square millimeter, or about 25 per cent. greater than that of steel. It is malleable and can be drawn into very fine wire. At indoor temperature its electrical resistance is 0.165 ohm for the length of 1 meter with a cross section of 1 square millimeter; the temperature coefficient is positive and is equal to 30 per cent. between 0 degree and 100

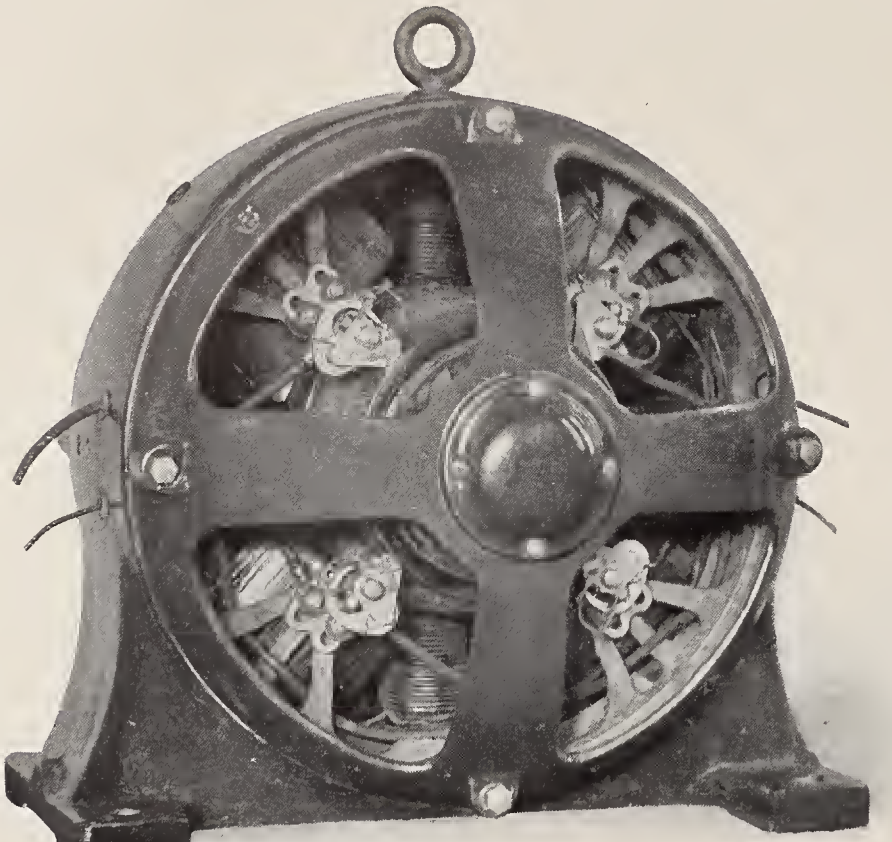


NEW LUNDELL TYPE MOTOR BUILT BY THE NATIONAL ELECTRIC CO., MILWAUKEE, WIS.

degrees C. The coefficient of linear expansion between 0 degree and 60 degrees C. is 0.0000079. Before fusion a very gradual softening takes place, extending over hundreds of degrees.

The low resistance of tantalum necessitates an extremely long filament to enable the lamp to be used on circuits of commercial voltage. The standard type of lamp for 110 volts has a filament 650 millimeters long and 0.05 millimeter in diameter, the weight of which is 0.022 gramme. It gives about 25 Hefner candle-power with a consumption of 1.5 watts per candle-power, thus taking less than half the current of the ordinary carbon lamp. The size of the bulb is about the same as that of the ordinary lamp, but rather more cylindrical to accommodate the filament. The latter is wound between two sets of radial arms, carried on a central pillar, axially on the bulb. There are about a dozen arms in each set, and these are furnished with hooks at their outward ends. The filament is wound zigzag from hook to hook between the upper and lower sets, its extremities being held by two of the lower arms, from which platinum wires are connected to the terminals of the lamp.

The life of the lamp is said to be equal to that of the ordinary lamp, the bulb blackens but little, and the deterioration is not very rapid. It is said to withstand shocks and careless handling without damage, and to have the further advantage that, should the filament by chance burn through, the broken end nearly always fuses on to an adjacent loop, and the circuit is reestablished as efficiently as before.



FRONT VIEW OF THE INTERPOLE VARIABLE-SPEED MOTOR, BUILT BY THE ELECTRO-DYNAMIC CO., BAYONNE, N. J. THE AUXILIARY POLES BETWEEN THE MAIN POLE PIECES ARE CLEARLY SHOWN

An Interpole Variable-Speed Motor

THE interpole variable-speed motor built by the Electro Dynamic Company, of Bayonne, N. J., and shown in the annexed illustrations, is of interest in that four auxiliary pole pieces are provided with the view of obtaining sparkless commutation at all loads and speeds.

The way in which this result is obtained may be best shown by considering the conditions which are encountered in the operation of the ordinary constant-speed motor. When a brush is in contact with two adjoining commutator-segments, the coil connected between them is short-circuited on itself. The resistance of the short-circuited coil, together with the connections to the commutator, being very small as compared with the contact resistance of the brush pressing on the commutator, the strength of the currents flowing toward the brush from the respective commutator-segments will, to a great extent, be dependent upon the relative value of the contact resistance, and the larger the latter the smaller will be the currents. This quality of the carbon brush tends to prevent sparking.

As the short-circuited coil passes under the brush, the current flowing in it is reversed, passing from the maximum in one direction down to zero, and then up to the maximum in the opposite direction. The current thus varying in the coil short-circuited generates in the coil an electromotive force tending to maintain the varying current. The effect, therefore, of self-induction is to produce sparking.

The current flowing through the different armature coils produces a magnetic field in the space between the pole corners—that is, in the region of the coils that are being short-circuited. These coils, in rotating, cut the lines of force in this field and an electromotive force is generated in them. This is in such a direction that it tends to maintain the current in the coil. The effect, therefore, of armature reaction is to produce sparking.

These two causes of sparking in the constant-speed motor are overcome in part by the resistance of the brush contact, and also by so placing the brushes that the short-circuited coil is in the edge of the main magnetic field. When properly placed the coil cuts lines of force in such a manner that the electromotive force generated aids in the reversal of the current—that is, the main field is used to prevent the lines of force from the armature field passing out in the region of the short-circuited coil.

While it is possible in the constant-speed motor to control the sparking by the means mentioned above, these means are entirely inadequate for the variable-speed motor. The reduction of the field strength necessary to obtain the high speeds prevents its use in overcoming the magnetic field of the armature. The armature field is, therefore, not only present, but the increased speed of the armature proportionately increases the maintaining electromotive force until it becomes so large that the carbon brush cannot overcome it. The increased speed of the armature also increases the electromotive force of self-induction. As a result it becomes impossible for the carbon brush to reverse the current in the short-circuited coil, and in consequence there is destructive sparking on the high speeds.

In order, therefore, to control these electromotive forces, it is necessary to provide a magnetic field independent of the main field of the motor. This is done in the interpole motor by auxiliary poles, which are small compared with the main poles, and are located between the latter and provided with coils connected in series with the armature, so that all of the current taken by the latter flows through the coils of the auxiliary field, which are so proportioned and arranged as to give the proper field for commutation.

THE ARMATURE OF THE INTERPOLE MOTOR WITH THE BALL-BEARING SHOWN AT ONE END

All of the coils of the auxiliary field being connected in series with the armature, weakening of the field of commutation by an increased load is prevented, and the auxiliary poles produce the required compensatory field of commutation independently of the main field, which, with increased number of revolutions of the armature, must be correspondingly weakened. Moreover, the function or effect of the auxiliary poles is independent of the direction of rotation of the armature, because if the latter is reversed the current in the auxiliary field is also reversed. The strength of the field in the shunt coils is varied independently of the series coils, whereby the armature is enabled to rotate at variable speed and variable load in either direction without sparking and without variation in the position of the brushes.

Another interesting feature of this motor is that the armature shaft runs in ball bearings, reducing the friction and necessity for oiling to a minimum.

A New Use for the Electric Fan

THE electric fan possesses possibilities additional to those of providing comfort in the hot-weather period. Mention has previously been made in these columns of the use of such fans in show-window compartments in cold weather as a means of preventing frosting of the glass, but a more recent suggestion is that of turning the air current from the fan on a steam or hot water radiator as a means of increasing their efficiency. We get, thus, a modified form of hot-blast heating apparatus of the kind with which every heating and ventilating engineer is familiar. Where, as is often the case in dwellings, the radiator is a bit too small to properly warm its apportioned space, this improvised fan service is said to have proved a most satisfactory heating auxiliary, and, indeed, there is good reason why this should be so. For the illustration on this page, which shows a fan engaged in the manner here mentioned, we are indebted to the Chicago Edison Company, who have latterly been exploiting the merits of this adaptation in their attractive little periodical "The Electric City."

In connection with the much used hot air furnace heating system, in which the warmed air is led from the furnace to the cellar through ducts to different parts of a dwelling, the electric fan likewise is recommended as an adjunct to comfort. It is not unusual for some one of the ducts to yield only a scant warm air supply, or even to reverse its action. In such a case the electric fan can be easily arranged with a cardboard hood and set in front of the duct opening in the wall so that it will help to draw air from it; when there is a floor opening, the same effect may be secured by placing a box covering over the floor register and setting the fan in one side of the box, blowing outward and away from the register. Withal, the electric fan is no longer merely a warm weather servitor.

A NEW USE FOR AN ELECTRIC FAN

Electricity in India

IN telling of the electrical development going on in India, E. C. Deepbolt, in "The Electrical Engineer," of London, says that in Calcutta the success of the new electric tramways has been marked and the extensions in progress and under consideration are numerous. The demand for electric fans, light and power has necessitated the building of two extra power stations in the city, and other places offer excellent opportunities for electric tramways, lighting and power installations.

In the Presidency of Mysore the gold fields have given increased profits since being worked electrically, the power for driving the generators being obtained from water-falls, and in Bangalose and the city of Madras extensions of the tramway and lighting systems are about to be started.

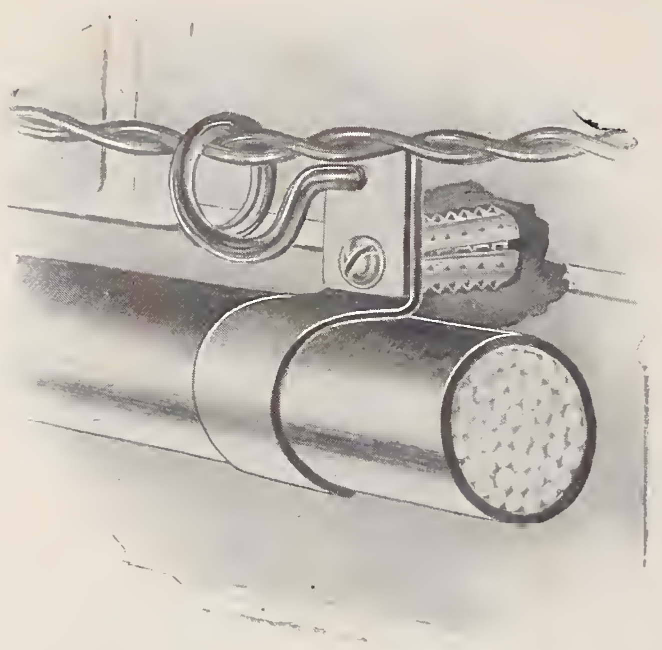
In Burmah, the electric tramway at Mandalay has been completed, and Rangoon is contemplating the electrification of the tramways there.

New Electric Locomotives for the Valtellina Railway

THE new electric locomotives for the Valtellina Railway, which were built at the Hungarian Government locomotive works and equipped electrically by Messrs. Ganz & Co., of Budapest, present some interesting features.

Each locomotive has three driving axles in the middle and a running axle at each end. Two double motors are placed between the driving axles, and each motor shaft has a crank at each end. A connecting rod couples these and the crank of the middle driving wheel on each side. From the middle bearing of this rod, two other rods extend to cranks on the end driving wheels. The cranks on one side are set 90 degrees ahead of those on the other side to prevent a dead center. As the specifications provided that no toothed gearing should be used between the motors and driving axles, this construction was adopted so that the motors might be detached bodily and replaced.

The motors are of the three-phase, 8-pole type, a high-tension and a low-tension machine being combined on one shaft. With the high-tension side working alone a synchronous speed of 225 revolutions per minute is attained, and with the two sides in cascade the



A NEW CABLE CLAMP MADE BY THE DIAMOND EXPANSION BOLT CO., NEW YORK

speed is 112.5. Current is supplied at 3000 volts and 15 cycles only to the stator on the high-tension side, the windings of the low-tension stator and rotor being for 400 volts.

The locomotives were built for a high speed of approximately 40 miles an hour, and a low speed of 20 miles an hour. It was required that they be able to start on a 20 per cent. grade with a 250-ton train and run 10 hours at both speeds without the motors heating to over 60 degrees C. They were also required to start a 400-ton train and accelerate up to 30 kilometers, or 18½ miles, on a 3 per cent. grade, thirty times without undue heating, two-minute intervals being allowed between each start and stop

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A Clamp for Supporting Electric Cables

A NEW cable clamp, made by the Diamond Expansion Bolt Company, of New York, is shown in the annexed illustration. It is intended for attaching pipe conduits and lead-covered cables to brick, stone, concrete or wood, and for supporting bridle rings to carry bridle wires.

The clamps are heavily galvanized and made in four sizes for carrying lead-covered cable from ¾ inch to 2 inches in diameter. The bridle rings are made with a machine thread for screwing into the clamp, and can be furnished galvanized, enameled or of brass. The clamps will not dent or injure the lead-covered cable in any way, as is the case with spike cable dogs.

But one expansion shield, furnished with the clamp if desired, is required for fastening the clamp to the masonry. This requires the drilling of one less hole than do spike dogs and separate bridle rings. The clamp costs less than the other articles, and the expansion bolt insures a more secure fastening than cable dogs. It is also claimed that clamps put up with these bolts can be taken down without injury to the conduit, while conduit put up with spike dogs is injured when the dogs are driven. Another advantage claimed for this clamp is that it can be used alike for attaching to wood or stone walls. Previously a strap hanger with two wood screws was used for attaching to wood, and a spike cable dog to stone, making it necessary for the linemen to carry a supply of both kinds with them; now one article will serve both purposes, as the clamp can be attached to wood with a regular wood screw. Another feature is that the expansion shields can also be used with standard bridle rings where it is desired to set the latter separate.

Russian Electrical Progress

TWO rather ambitious schemes for electric traction on a large scale were recently brought before the Electrotechnical Association of St. Petersburg.

The first is no less than the electrification of the Trans-Siberian Railway, a project considered by Count A. F. Lubienski as not only desirable, but necessary. The transportation of passengers and goods on this railway, apart from the traffic due to the war, has developed to such an extent that it will soon become necessary to increase the number of trains. Owing to several circumstances, particularly the lightness of the rails and the insufficiency of water, the existing trains are said to have reached their practical limit of speed; and though the water difficulty might be met by canalization or other means, the relaying of track would entail an enormous expenditure of money and time.

The Count maintains that the most rational and economical way of meeting the case is by the introduction of electric traction on some parts of the line at least. The existing track would be made use of, and the many sharp curves and heavy gradients would not limit the speed of a multiple-unit electric train to the same extent as in the case of a train drawn by a steam locomotive. It is proposed to make use of the rivers and waterfalls along the course of the line for the supply of electric energy, which would be generated at power stations from 100 to 200 kilometers apart, and distributed in both directions to transformer sub-stations at a pressure of 100,000 volts.

The second project was brought forward by G. O. Graftis, and is rather more modest in its scope. He proposes the electrification of the Caucasian railways on the grounds that electric traction is particularly adapted to a mountainous country, and that abundance of power is at hand in the waterfalls of the Caucasus. The large number of rivers and mountain torrents watering the district through which the railway runs constitute an ideal source of power which could be turned to account with little difficulty.

A Single-Phase Motor, Driving Machine Tools

AN interesting example of the application of a single-phase motor to driving machine tools is shown in the annexed illustrations. The motor was built by the Wagner Electric Manufacturing Company, of St. Louis, Mo., and is wound for 104 volts, 60 cycles, developing 7½ H. P. at 1200 revolutions per minute. The machine driven is a 42-inch vertical boring and turning mill, built by the Gisholt Machine Company, of Madison, Wis.

The motor being of the constant-speed type, speed variation is obtained by means of two silent chains, shown in the illustration with the casing removed, a clutch, operated by the lever shown, engaging either driven gear. The motor is connected to lighting circuits and is started by simply closing the line switch. It has an overload capacity of 50 per cent. above the full rated load, but should it be necessary for any reason to make an exceedingly heavy cut, which would otherwise overtax the motor, it is automatically able to take care of such a condition by running at slow speed, and upon the removal of the heavy load it automatically returns to the normal running speed.

These motors are built in sizes from ¼ H. P. up to 40 H. P. They may be wound for any voltage desired and built for circuits of any commercial frequency, and operate as satisfactorily on high as on low frequencies.

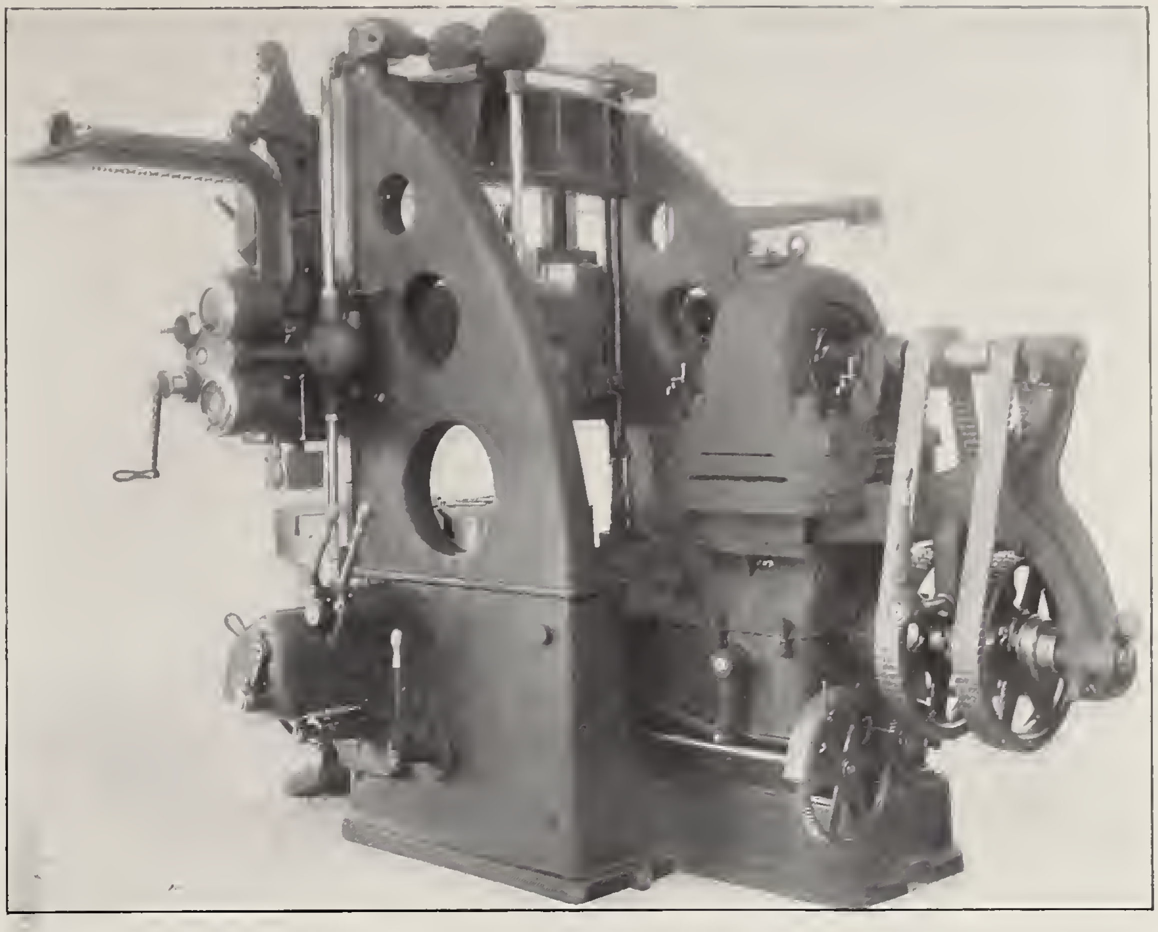
The driving mechanism of the mill consists of a powerful friction back-geared headstock, with three ratios of back gearing obtained through sliding gears. Thus six changes of table speed are obtainable for each speed of the main driving shaft. The levers for operating the friction head and the sliding gears are convenient to the operator when he stands in his usual position. The friction clutch is operated from either side of the machine.

Ten changes of speed are provided for both heads, the feed for each head being independent. A friction device prevents injury to the gearing should the heads run together. Automatic trips are provided for both the cross and up and down feeds, so that the feed may be thrown out automatically at any predetermined point. There are also micrometer dials provided for the different feeds, reducing the amount of calipering to a minimum. The wearing surfaces throughout are very large, the iron is hard and close grained, and gears throughout are encased.

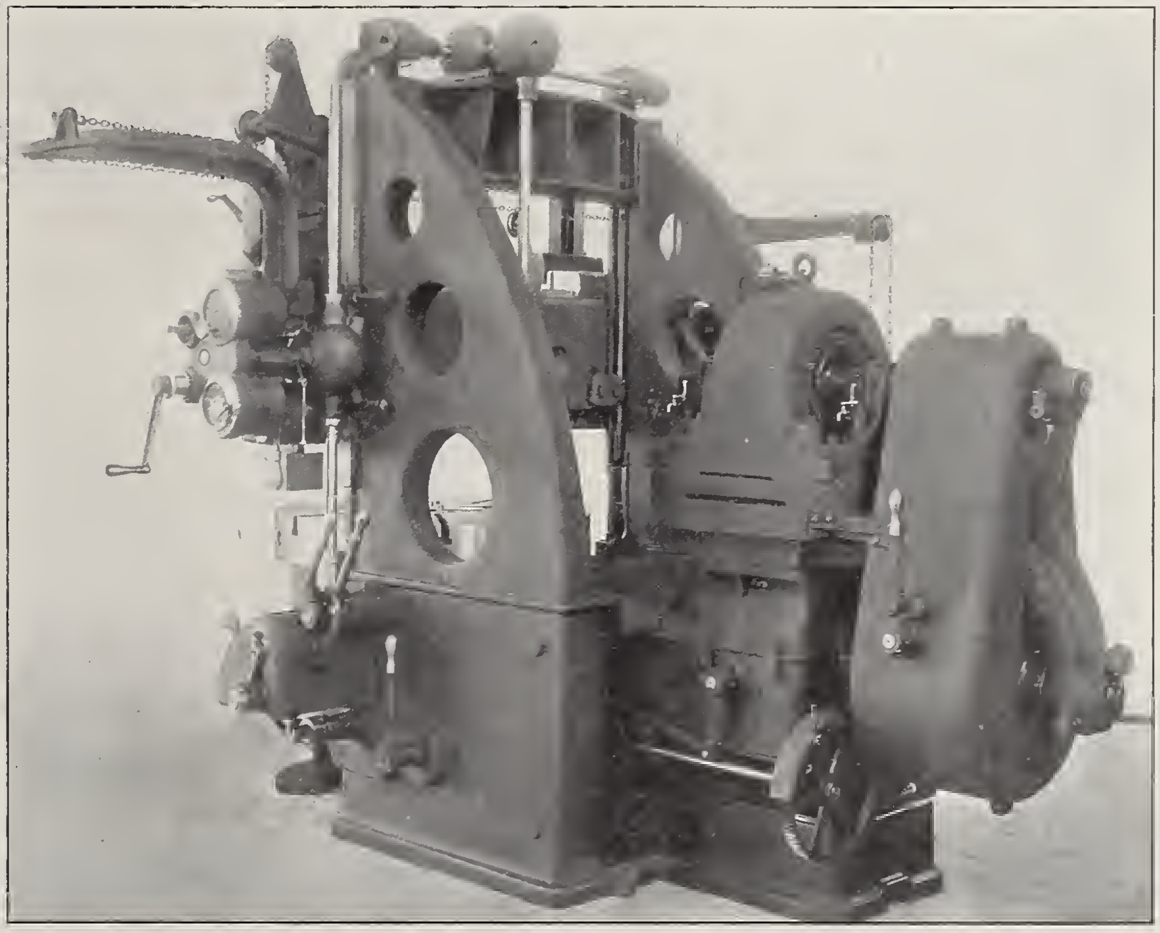
On all sizes of the machines above the 42-inch, a rapid traversing device for moving the heads in and out, and the down slides up and down by power is provided. This operates in such a way that one movement of a lever when a feed is in will throw in the rapid movement of the head, and it may be thrown out at any desired point and the original feed will be re-engaged by moving the lever to its original position. This quick operating of the heads may be also used when the table is at rest, thus guarding against any damage being done by having the heads run into the work while it is revolving.

On the 42-inch mill no rapid traverse in provided for the heads, as it adds unnecessary mechanism to the machine. The distances to be traversed by the heads are short, and the fast speed, obtained instantly by the friction clutch, allows the heads to travel as fast as necessary.

The mills are made in six sizes, ranging in swing from 34 inches to 72 inches, inclusive. The 34-inch mill, however, is not equipped with the friction back-geared headstock, but is driven by a four-step cone pulley, which is thrown in and cut by means of a positive clutch operated by a lever. The 34-inch mill, however, is equipped with all the other devices, including the micrometer index, automatic tripping device, etc., and is made in two styles, with a plain or a swivel head. A screw-cutting device may be attached to either style.



A VERTICAL BORING AND TURNING MILL, BUILT BY THE GISHOLT MACHINE CO., MADISON, WIS., AND DRIVEN BY A SINGLE-PHASE MOTOR BUILT BY THE WAGNER ELECTRIC MANUFACTURING CO., ST. LOUIS, MO. TWO DIFFERENT SPEEDS OF THE MAIN SHAFT OF THE MILL ARE OBTAINED BY MEANS OF THE TWO DRIVING CHAINS SHOWN



ANOTHER VIEW OF THE ABOVE BORING AND TURNING MILL, SHOWING HOW THE CHAIN DRIVE IS CASED IN

A 57,000-Volt Transmission Line in France

According to "The Electrical Engineer," of London, a 57,000-volt transmission line is about to be constructed between Moutiers, in Tarentaise, and Lyons, in France, a distance of about 113 miles. About 4700 H. P. will be transmitted.

The work is to be carried out for the Société Grenobloise de Force et de Lumiére by the Compagnie de l'Industrie Electrique et Mécanique de

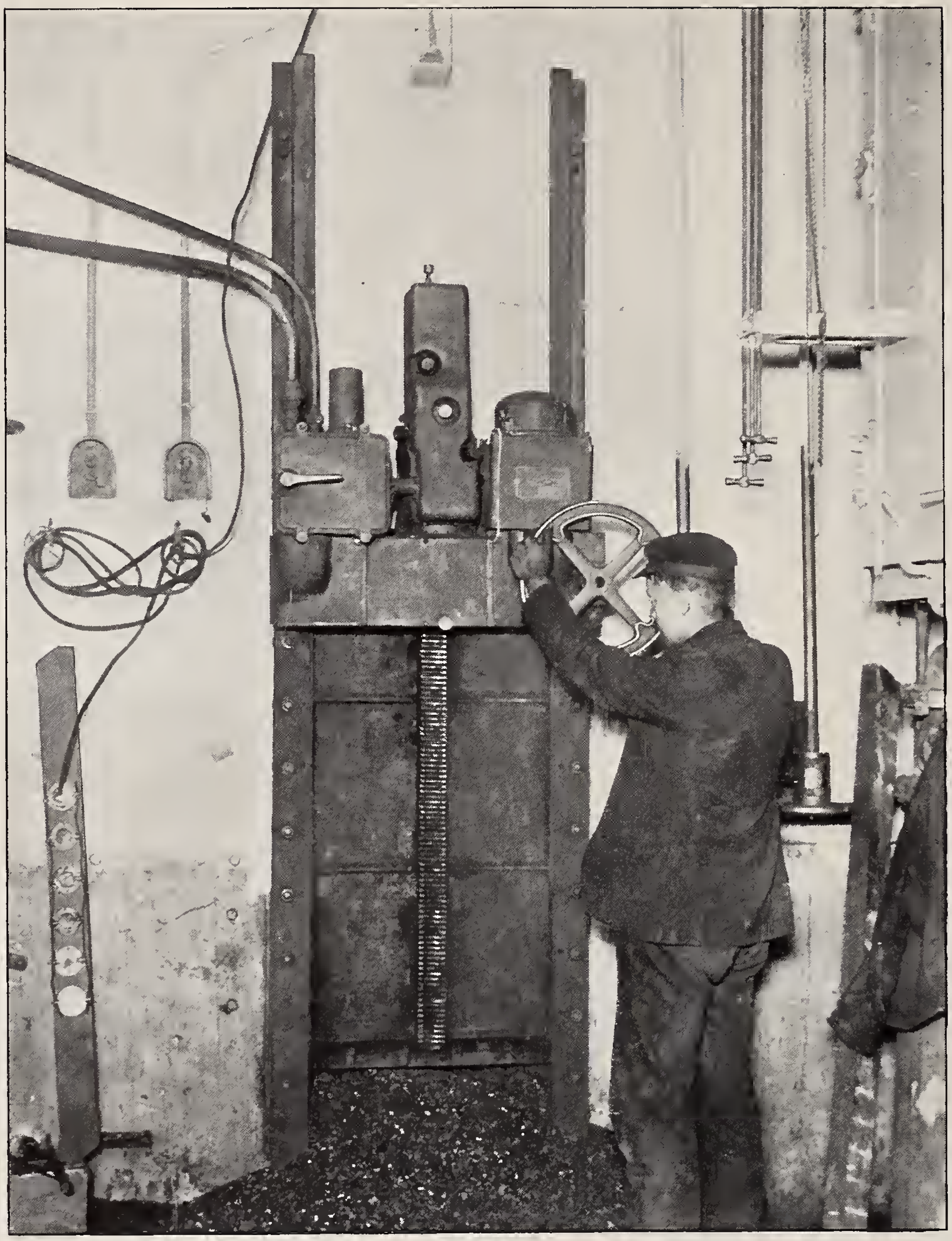
Genève. For the purpose the contractors are about to install four pairs of dynamos at the generating station at Moutiers, and there will be at the receiving end of the line five groups of double motors with all accessories.

It is an interesting fact that under the order for this equipment the plant will work on the continuous-current series system. This system has, however, been largely used in the district in question, and has worked successfully between Saint-Maurice and Lausanne, in Switzerland, a distance of 36 miles. In this case, however, the maximum voltage did not exceed 22,000, so that there will be a considerable jump in the present instance, as at full load the voltage at the generating station is calculated to be 56,960. With this voltage the horse-power above mentioned will be transmitted over the distance of 113 miles by means of two copper wires 9 mm., or about 3-8 inch in diameter.

At the point where the line enters the town of Lyons underground cables are to be used, which will be highly insulated and armored. Allowing for the loss on the line these cables will still have to stand a voltage of 50,000.

Closing Bulkhead Doors Electrically

AFTER several years of costly experimenting with pneumatic and hydraulic systems for operating bulkhead doors and armored hatches aboard warships, both systems have been abandoned by the American Navy in favor of an electrical system. The first electrical installations are now in working order on the "Colorado" and "Pennsylvania," the new 13,500-ton armored cruisers. Thirteen other cruisers and battleships now building will be similarly equipped.



POWER DOOR BETWEEN COAL BUNKERS AND ENGINE ROOM ON THE U. S. CRUISER "COLORADO." THE WHEEL IS MERELY AUXILIARY. THE MOTOR IS ON THE RIGHT. THE LEVER FOR RELEASING THE DOOR WHEN THE CURRENT IS CLOSED IS ON THE LEFT. INSTALLED BY THE LONG ARM SYSTEM CO., CLEVELAND, OHIO

The defects developed in the hydraulic and pneumatic systems—due mainly to the practical impossibility of keeping their valves and packings in working order—have been overcome in the electric system, and naval authorities, including many who have heretofore opposed, as necessarily ineffective, all power doors for bulkheads, have given the new electrical system devised by the Long Arm System Company, of Cleveland, Ohio, unqualified approval. The bad repute into which distantly controlled bulkhead doors fell at one time was brought about by the members of the crew who were likely to suffer from the operation of the power system. The first idea was to drop the heavy doors like so many guillotines, and then followed the idea of closing them slowly by air or water pressure. In both cases, however, it was found that the doors could not be depended upon to shut at the proper moment, nor to stay open when so required, because the pneumatic or hydraulic pressure could not be perfectly maintained.

The electrical system, however, is not subject to these defects. It complies in every way with the specifications of the Navy Department providing that power doors or armor hatches "must be capable of permitting operation on the spot by power or by hand from either side of the bulkhead or deck," and "be capable of being closed by power, simultaneously from an emergency station." It is further provided that when the doors are closed and the emergency action is in effect, any door may be opened by a man at the door to allow him to pass through in performing his duties, but after he has passed through and released the controller handle the door will again close by the emergency action.

The mechanism of the "Long Arm" system may be outlined as follows:—

1.—An emergency station, located usually in the pilot house or some convenient place above the deck.

2.—The power doors or hatchgears, supplied with three independent mechanisms.

a.—The switch by which a man at any door can open and close it at will from either side.

b.—The switch, operated from the emergency station, by which the door is closed upon the approach of danger. This emergency switch, although permitting absolute control, may have its operation suspended temporarily by the hand switch just mentioned. In such a case the emergency station switch will close the door as soon as the hand controller is released.

c.—The limit switch, by means of which the current supplying the motor which provides the power for closing and opening the doors is cut off when the door has closed and locked, or has encountered an obstacle to full closure. This switch has mechanical connection with the door or hatch-plate, and is so arranged that it will cut off the current from the motor, and thus prevent blowing out of the fuses. An interesting improvement of this part of the mechanism is one by which the switch is made to again close the circuit to the motor and thus start the door toward its grooves after an obstruction is removed, as, for example, when an inflow of water washes away coal obstructing a bunker opening.

The door and hatch-gear motors are designed for direct current; they are reversible, ironclad, bipolar, and of light and compact construction for intermittent service. They are entirely enclosed in water-tight cases, and are capable of carrying large overloads without heating or injury.

THE EMERGENCY STATION

The emergency station consists of two parts, one a water-tight case containing the mechanism for controlling the circuit running to each door or hatch-gear for closing the same, and the lamps to indicate the closure; the other case containing the fuse box, in which each wire is supplied with the proper fuse.

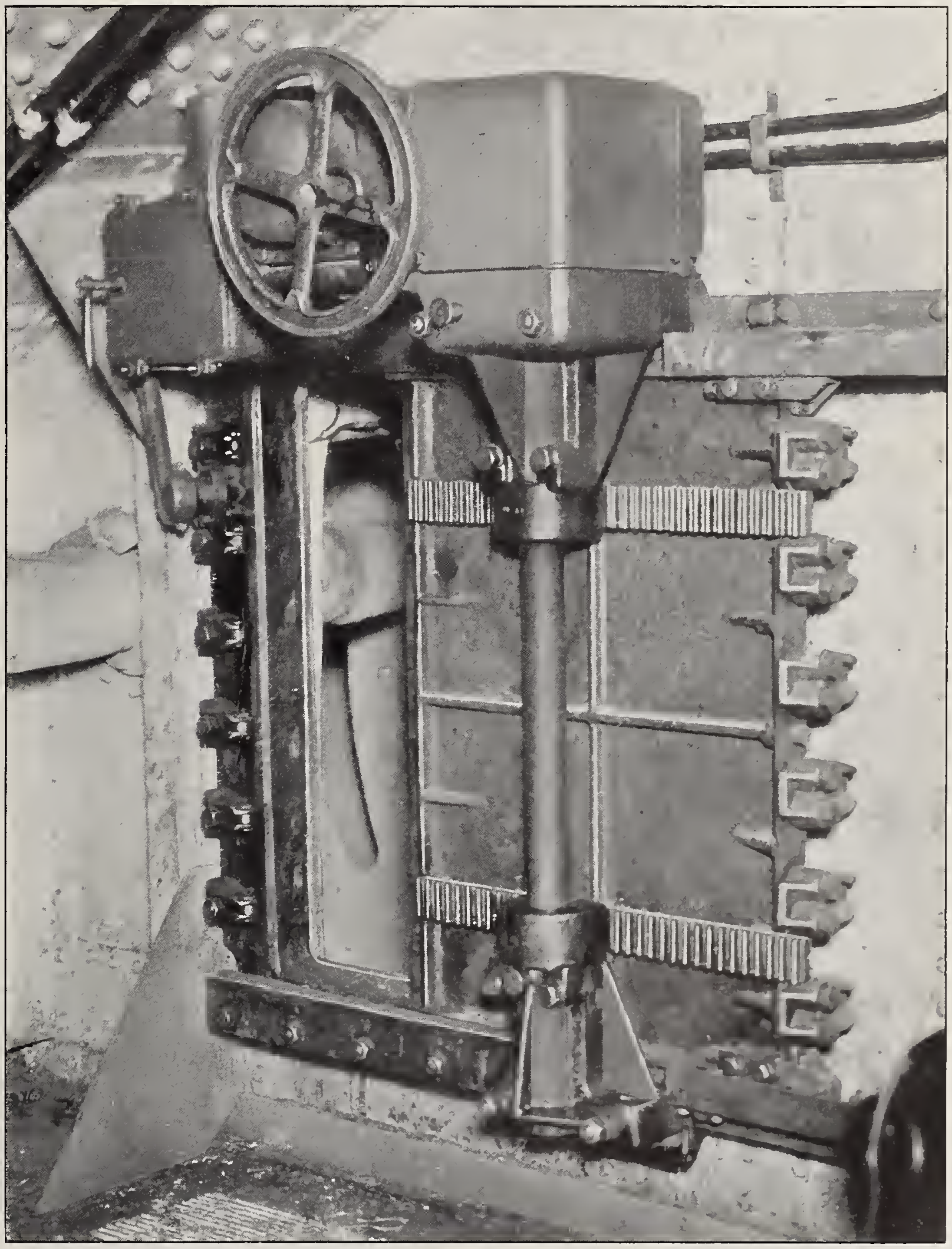
The wiring required for a complete installation of the system is very simple. It comprises one twin conductor by which the emergency station is connected with the ship's mains; one twin conductor by which the controller on each door or hatch-gear is connected with the emergency station, and one twin conductor connecting the controller on each hatch-gear or door with the ship's mains. Here, as in other parts of the system, great simplification has been worked by replacing pneumatic and hydraulic power by electricity. The former system added another set of complicated machinery to the ship's equipment, while the electric system calls for nothing more complicated than connection with the electrical mains necessary for other purposes.

THE SYSTEM IN OPERATION

To explain the operation of the "Long Arm" system, it is perhaps best to imagine an actual instance in which it would be called into play. Suppose that the "Colorado" is in danger of being rammed, or that her hull has been punctured by a torpedo. The officer of the deck, or the one first aware of the danger, will "press the button" of the emergency station, immediately releasing the gearing driven by a spring and controlled by an adequate escapement. This gearing then closes the circuit for operating the emergency switch in the controller of each door or hatch-gear. It does not start all the motors at the same time, thus avoiding the necessity for a large supply of current. It starts the doors, however, one after the other at intervals of about three seconds, so that 25 doors and hatch-gears can be closed in 75 seconds from each emergency station without more than six motors being in operation at any one time.

As each door makes a complete closure it automatically completes the circuit running to the emergency station and there connected with a small incandescent lamp, located back of each of the discs around the edge of the emergency station. Each disc is numbered to correspond to a door, so that the officer in charge can tell by a glance at the station whether or not all the doors have closed. If any one door or hatch-plate has not closed, the fact is immediately observable, and the location of the trouble is known by reference to a diagram at hand showing the location of all the power doors and hatchways. Whether the emergency is "on" or "off" is indicated by a red light shining through one of the lower discs of the station.

The Navy Department has subjected this system to the severest possible tests before approving it. The results of these tests are shown in the fact that similar equipment is called for in the specifications for all three of the men-of-war just authorized by the United States Government. The principal feature which has excited the approval of practical naval officers is that this device secures the confidence of the members of the crew stationed in the immediate vicinity of the power doors, the same men who had so little confi-



POWER DOOR ON THE CRUISER "COLORADO," COMMUNICATING WITH STEERING GEAR ROOM. THE DOOR IS JUST COMING TO A CLOSE dence in the hydraulic and pneumatic systems that they invariably tampered with the mechanism in such a way as to defeat its purpose completely. The combination of perfect local control, together with the certainty which the electrical system gives that the doors will not suddenly drop, mainly accounts for this confidence.

The question of power doors is receiving attention by the admiralty department of almost every important government in the world. The fact that H. M. S. "Victoria" might have been saved if her bulkhead doors had been closed has been ever in the minds of progressive naval constructors. Owing to the fact that nothing has been devised abroad better than clumsy imitations of the old hydraulic and pneumatic installations on American warships, now discarded by the American Navy, accounts for the fact that foreign navies have not yet seen fit to call for power doors in the equipment of their new ships. It is likely, however, that several European battleships will be equipped with the "Long Arm" apparatus within a short time.

Schuyler Skaats Wheeler

PRESIDENT OF THE CROCKER-WHEELER COMPANY

By GANO S. DUNN

SCHUYLER SKAATS WHEELER is one of the types of men that contribute to our country's greatness. Although but little over forty, he is already a captain of industry, of noteworthy career, and his course is interesting to those who recognize in the organizing of workmen and the handling of materials opportunity for character expression formerly considered limited to the old and classic professions.

A native of New York City, where he was born of Dutch descent in 1860, Dr. Wheeler was educated at Columbia College. Leaving there in 1881, he was employed as assistant electrician in the American branch of the Jablochkoff Electric Light Company, in the work of which historic corporation he took a great interest. The failure of the Jablochkoff "candle," the critical feature of their system of illumination by alternating currents, caused the dissolution of this company and the transfer of Dr. Wheeler's connection to the United States Electric Light Company, at that time coming into the field with the direct-current arc lamp.

His interest in central stations, which were then the great mystery as well as the great hope of electrical engineering, led him soon to seek a place on the staff of Edison, under whom he did his most important early work. He was present at the epoch-making opening of the Pearl Street station, in New York, and later, from the competence he displayed in its operation, was appointed in charge.

When the success of the Edison systems had proved the feasibility of central stations and of underground distributing conductors, other cities called for such equipment, and on account of his intimate knowledge of the art, Dr. Wheeler superintended many of these installations. After laying the underground system of Newburgh, N. Y., he remained there for some time as superintendent of the Edison Company.

In 1886 central station engineering had solved some of its most important problems, and the operating of a plant no longer gave opportunity for development to men of the highest abilities. Dr. Wheeler, therefore, went into other fields. He was for a time electrician of the Herzog Teleseme Company, to which he contributed important inventions, and finally, in the establishment of his connection with the C. & C. Electric Motor Company, he entered the field of manufacturing, in which he has remained and in which he has made his greatest successes.

The C. & C. Company had just been organized by two friends of Dr. Wheeler, Charles G. Curtis and Francis B. Crocker, for the manufacture of small electric motors on the same scientific principles of construction that were embodied in the dynamos of that day, but which were much further developed. It was the first concern of its kind in this country, and at the time of its organization electric motors were more scarce in the metropolis than automobiles were five years ago.

To the accurate mechanical perceptions and creative ability of Dr. Wheeler, who was electrician and factory manager, were due many of the features which brought the company's motors immediately to the front and fostered general electrical manufacture. The new factory of the company in New York, the first shop in the country to be devoted wholly to the manufacture of electric motors, was established under Dr. Wheeler's direction, and the company's early operations were very prosperous. Differences in the management arose, however, which caused a change in the whole policy of the enterprise, and in 1887 and 1888 Curtis, Crocker and Wheeler severed their connection with it, Crocker and Wheeler deciding to go into business under their own names as a firm and build electric motors of even a higher grade than they had been building in the C. & C. Company, for which kind of motors there was a rapidly increasing demand.

It was at this time that Dr. Wheeler was appointed expert of the Board of Electrical Control of New York, the onerous and exacting duties of which he performed while developing the new firm. The history of the time is full of the struggles of the great corporations, on the one hand, trying to maintain their labyrinth of overhead wires, so dense as to disfigure and make dangerous the city's streets, and on the other hand, the city ruling that the overhead structures must forthwith come down, and finally, under Dr. Wheeler's direction, actually felling the poles, amid the cheers of onlookers and the threats and actual violence of the owners of the destroyed property. This warfare brought upon Dr. Wheeler the ill-will of all the companies in conflict with the municipal authorities, but before the work of the Board of Electrical Control was over he had turned this ill-will into confidence and respect by his fairness and real protection of the electrical interests of the city.

With all that he contributed toward the putting underground of New York's wires and cables, Dr. Wheeler worked hard with his partner, now Professor Crocker, of Columbia University, pushing their manufacturing business, and they were rewarded with great success. After a time the firm of Crocker & Wheeler became the Crocker-Wheeler Electric Motor Company, after the formation of which and because Professor Crocker had been appointed to the chair of electrical engineering at Columbia. Dr. Wheeler resigned from the Board of Electrical Control and gave all his time to the new enterprise, of which he became president and general manager.

The organization finally became the Crocker-Wheeler Company, of New Jersey, one of the most important builders of electrical machinery of today. When, in less than two years, its New York factory quarters were outgrown, it sought location out of town, having in view ultimate expansion to the limits of a great industrial corporation. At the new site in East Orange, N. J., the Lackawanna Rail-

SCHUYLER SKAATS WHEELER
President of the Crocker-Wheeler Company, of Ampere, N. J.

road, through Dr. Wheeler's influence, opened a station, and in honor of the great French discoverer and investigator in electricity named it "Ampère."

In 1895, after three years of growth, the works were completely destroyed by fire; but while apparently a disaster, this was really a benefit, since the remodeled buildings that almost immediately arose were of the most modern kind, adapted to the manufacture of heavy machinery on a large scale, and fitted with perfect equipment in every respect. The promptness and energy shown in rebuilding were so remarkable as to cause universal comment, and by operating day and night in large tents and temporary sheds with electrically-driven tools the company succeeded in filling most of its orders and holding its business. Too much credit can hardly be given to Dr. Wheeler for the labors of the early days. Growth was so rapid that his company's capital was multiplied many times in the course of a few years, and with all this the great financial panic of 1893 and the fire just referred to were successfully met and passed.

While Dr. Wheeler possesses the true engineering mind, that broad judgment which seems to rise above calculations and determine intuitively the principles of an engineering problem, and while it is to this characteristic, producing valuable inventions and designs, that his early successes were due, it is not in this direction that he has done his latest and best work. It is as an organizer and an executive, as an inventor of new methods of factory operation, to win success out of latter-day competition, that he has been pre-eminently successful, and has blazed a way into a comparatively new country of manufacturing economics. Industrial organization in this country is carrying the lamp of progress far ahead into the darkness of old-fashioned and inadequate methods, and to such progress Dr. Wheeler is one of the men who have made great contributions. Poor Richard said: "Take care of little expenses; the big ones will take care of themselves." This is also true of the thousands of little elements entering into the finished products of electrical and other manufactures. It is the insignificant things that maintain high costs, delay deliveries, introduce uncertainties into financial accounting, and, in general, cause manufacture to get out of joint. They are the skeletons in the closet of the industrial manager.

As an army without captains, sergeants, corporals, ranks, and files is a mob, so a factory without organization carefully provided for the most minute elements of its product, is an uncertain quantity in the industrial warfare of to-day, and, sooner or later, must succumb. The art of war is old and its organizations are understood, but the art of manufacturing was born scarcely two centuries ago, and developed only in the latter half of the century just past. It is not hard, therefore, to find in the still but imperfectly organized industrial fields room for such generalship as would occupy a Cæsar or keep a Frederick on his mettle, and it is in these fields that Dr. Wheeler has been busy.

To give in detail the methods he has employed and the results he has accomplished is beyond the scope of this sketch, but an example of them in one direction may be of interest. The tens of thousands of items of stock and finished parts involved in electrical manufacture it is beyond the powers of one man or even a group of men, by the ordinary methods of the past, to keep properly proportioned to the product that is finally formed; hence in large factories the merchandise or stock departments have been, on the one hand, a principal cause of failure of delivery owing to unforeseen shortage of material, or, on the other hand, they have been the depositories for extravagant excesses of all kinds of supplies, locking up large amounts of capital sorely needed in other parts of the business.

The merchandise or stock departments have become thus clogged with useless materials, owing to the absence of proper correlation between stock and the finished product. The materials accumulate rapidly through undiscovered errors in ordering, the abandonment of types of product rendering their stock of parts on hand obsolete, and the over-ordering of special supplies prompted by the good old adage of being sure you have enough. The general confusion has been principally because the exact accounting for all the minute items of stock and the close relation of all materials to the orders the factory has engaged to fill has been considered too vast a labor to undertake, and an evil which it would cost more to cure than to endure.

Incident to the old system have been the additional great losses incurred by an annual or semi-annual shutdown to take inventory, of which the cost is enormous if, besides the expenses of the actual counting, there is included a proper share of the unceasing fixed charges and the loss of profit resulting from loss of output, the profit being affected by the output in a geometrical ratio.

Dr. Wheeler, after much observation and study, and guided by expert accountants, deliberately undertook to incur the expenses of a ledger account for every item of material and every finished part in his company's manufacturing and to provide such inter-dependent systems of specification writing by the draughting department, order-issuing by the production department, requisition-issuing by the purchasing department, and reporting of receipts and deliveries by the receiving and stock departments, that, once a factory order is booked and its details are completely specified, its course through the shop is almost automatic. Its execution, involving the labor of hundreds of workmen and the drawing or purchasing of perhaps thousands of items of stock, is no longer subject to the discretion of anybody, and, therefore, to his possible error, or neglect, but, through the functions of comparatively unskilled clerks, acting under careful system, it takes measures that it shall be provided with whatever it shall need at the time when it shall need it, and gives an indication that starts an investigation should its claims upon future supplies fail to be acknowledged and met.

The result of such provisions for dealing with the minute as well as with the greater elements of manufacture has proved to be a greatly increased output, a diminished cost of production, a minimum of capital locked up in inactive stock, shutdowns for inventories no longer a necessity, and a promptness and certainty of delivery that attract business. The mob, organizer into files, ranks, corporals, sergeants, captains, becomes an army, mobile and efficient. Many others have contributed to the higher industrial organization here referred to, but Dr. Wheeler has led in carrying it to some of its most successful developments.

Dr. Wheeler is a man of great force of character, expressing itself in a determined persistence in the accomplishment of his ends, well illustrated in his vigorous and successful handling of the machinists' strike of 1901, of which Ampère was one of the storm centers. He is devoted to his work, to which he applies himself most closely, and his liberality is shown by his purchase, five years ago, and presentation to the American Institute of Electrical Engineers of the Latimer Clark Library, the most complete and rare collection of early electrical books in the world.

As an author, he has contributed to a number of subjects in the magazines and in the technical journals, and his book on the "Practical Management of Dynamos and Motors," written conjointly with Professor Crocker, has gone through a number of editions and attained a large circulation. As a recognition of his work, Hobart College conferred upon him in 1888 the honorary degree of Doctor of Science. He is a member, and has been vice-president, of the American Institute of Electrical Engineers, and is also a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the University and Lotos Clubs, of New York; the Chamber of Commerce, of New York, and many other societies.

Dr. Wheeler has been one of the foremost in the movement to secure a permanent home for the American Institute of Electrical Engineers. In fact, in order to stimulate the building movement, he made his gift of the Latimer Clark Library conditional upon the provision of a suitable building within five years, and how successful the building movement has been, owing to the liberality of Mr. Andrew Carnegie, everybody knows. The million and a half dollars which the latter gave will soon be represented in dominating structures on Thirty-ninth and Fortieth Streets, in New York, for the housing jointly of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the Engineers' Club.

It was quite fitting that Dr. Wheeler should be asked to be one of the Electrical Engineers' representatives on the joint committee for the expenditure of the building fund and the management of the Engineering Building, and on this committee his work has been greatly appreciated.

Many of the prominent members of the Institute of Electrical Engineers have been suggesting Dr. Wheeler's name for the presidency of that society in the election that will be held next May.

Personal

Martin P. Rice, head of the Publication Bureau of the General Electric Company, at Schenectady, N. Y., recently sailed on a trip to Europe.

C. E. Downton, of the Westinghouse Electric & Manufacturing Company, recently gave an illustrated lecture at the Worcester Polytechnic Institute upon the use of electricity in manufacturing plants.

Wm. H. Blood, Jr., has the chairmanship of the committee on district heating for the National Electric Light Association, and expects to present a very full and important report on this branch of central-station industry, at the next meeting of the association. The other members of this committee are C. R. Maunsell, of Topeka, Kan., and R. S. Wallace, of Peoria, Ill., both of whom have had personal experience with steam and hot-water heating plants, and have given the subject extensive study and observation. A liberal appropriation has been made by the association for carrying on investigations, and the work will be very thoroughly done.

Prof. Charles P. Steinmetz, in an address before the Albany Institute, Albany, N. Y., remarked that the ultimate results of the successful experiments with electric locomotives will be an electric trolley service between Albany and New York.

It will be pleasing for Mr. Edison's many friends to know that he has practically recovered from his recent operation for mastoiditis. He celebrated his fifty-eighth birthday last month at his home at Llewellyn Park, N. J.

Frank H. Gale, of Schenectady, N. Y., one of the many capable young men on the literary staff of the General Electric Company, has succeeded to the duties of the late E. H. Mullin, and will spend half of each week in New York City, in charge of the publicity department of his company.

Charles W. Cross, M.E., E.E., formerly of the Roberts & Abbott Company, consulting engineers of Cleveland, Ohio, and later electrical engineer for the Eastern Ohio Traction Company, has entered the employ of the Crocker-Wheeler Company, of Ampere, N. J., and is attached to the Cleveland office of the company.

Prof. William L. Hooper, head of the electrical engineering department of Tufts College, has been granted leave of absence for the remainder of the year to study the protection of high-voltage transmission lines from lightning. He will examine all the available literature upon the subject, and is planning to inspect all the principal transmission lines in this country, beside some in Europe.

The international committee of the St. Louis Exposition has recognized the engineering ability of the designers of the apparatus exhibited by the General Electric Company in awarding grand prizes as follows: To Elihu Thomson, Swampscott, Mass., for various applications of electricity; also to C. P. Steinmetz, Schenectady, N. Y., for electric lighting, and to F. J. Sprague, New York City, for application of electricity to transportation. They have also awarded gold medals to C. G. Curtis, of New York City, "the originator of a successful American multi-stage steam turbine;" to W. L. R. Emmett, of Schenectady, N. Y., "designer of the vertical type of Curtis steam turbine and generator," and to W. B. Potter, Schenectady, N. Y., for applications of electricity to transportation. They have also awarded silver medals to W. S. Moody, Schenectady, N. Y., for transformers; to E. M. Hewlett, Schenectady, N. Y., for distribution of energy, switchboards, etc., to H. F. T. Erben, Schenectady, N. Y., for apparatus for generating electricity; to H. G. Reist, Schenectady, N. Y., for apparatus for generating electricity; to L. T. Robinson, Schenectady, N. Y., for scientific apparatus, measuring apparatus and laboratory standard instruments, and to F. P. Cox, Lynn, Mass., for measuring instruments, indicating, recording and integrating.

H. S. Reynolds, who for the last four years has managed the Stone & Webster interests in Columbus, Ga., consisting of all the street railway, electric light and gas properties in that city, has resigned to accept a position in the operating department of J. G. White & Company, of New York.

Plainfield, N. J., will number Dr. F. A. C. Perrine among its new residents. As president of the Stanley Electric Manufacturing Company, Dr. Perrine has been living at Pittsfield, Mass., for several years past, but his new residence will bring him nearer to the city of New York, where he has rapidly growing business interests.

E. L. Byron, who for the past twenty years has been connected with the Vulcan Iron Works Company, of Toledo, Ohio, has been promoted to the position of general manager. This does not mean that Alexander Backus will retire from that place, but that Mr. Byron will take much of the responsibility that has hitherto rested on the shoulders of Mr. Backus.

Obituary

Mr. A. P. Goddard, president of the Freeport Railway, Light & Power Company, a valued member of the National Electric Light Association, died at his home in Freeport, Ill., on February 12, at the age of seventy-two. He was born in Franklin County, N. Y., but his family removed to Freeport when he was two years old. Mr. Goddard was prominently identified with the development of Freeport, having served as alderman mayor and member of the board of supervisors. He also served in the Civil War as lieutenant in the Illinois Volunteer Infantry and was brevetted a captain for honorable service.

Trade News

The contract for the electric generators for the Carnegie Institute Building in Pittsburg has been let to the National Electric Company, of Milwaukee. It consists of five 300 K. W., 12-pole, 125-volt, direct-current, engine-type generators, running at 120 revolutions per minute. These machines will be of the latest design and best material, of massive though pleasing appearance, the heaviness in outline being relieved by the elliptical section of the frame. All visible bolts will be nickle plated and the field coils taped on the outside and finished with a wrapping of fish-net cord. The terminal boards will be of Vermont marble. The total net weight of each generator will be about 55,000 pounds, that of the armature and commutator aggregating 18,000 pounds.

The Westinghouse Companies have just secured an order for the equipment of a power house for the electrical operation of gold dredges on the Alaskan rivers. A number of Detroit capitalists recently formed the Canadian Klondike Mining Company, and plans were made to install a 400-K. W. turbo-generator in the power house, to be driven by a 600-H. P. Westinghouse-Parsons steam turbine. The dredges are being built by the Marion Steam Shovel Company, of Marion, Ohio, and on them will be installed induction motors aggregating about 500 H. P. and varying in size from 7½ to 100 H. P. The power house will be located at Dawson City, and the dredges will operate on the Yukon river and its tributaries. Lines for transmitting power will be strung from the station to the boats, wherever they may be working.

Judge Buffington, in the United States Circuit Court for the Western District of Pennsylvania, on February 24 handed down a decision dismissing the plea of estoppel interposed by the Diamond Meter Company, of Peoria, in the suit brought by the Westinghouse Electric & Manufacturing Company against the Jefferson Electric Light, Heat & Power Company, of Punxatawney, for infringement of the Tesla split-phase patents Nos. 511,559 and 511,560 in the use of Scheefer induction meters for alternating currents manufactured by the Diamond Company. An injunction was granted on the following day restraining the Jefferson Company from the further use of these meters.

Judge Seaman, in the United States Circuit Court for the Eastern District of Wisconsin, in an opinion handed down on February 24, after a preliminary hearing, granted an injunction against the National Electric Company in the suit brought by the General Electric Company alleging infringement of the Erben brushholder patent No. 705,055 in the manufacture by the defendant company of brushholders for generators and motors. The Westinghouse Electric & Manufacturing Company was interested in the suit as licensee under the Erben patents. This injunction is a sequel to the decree and injunction entered some time ago against the Christensen Engineering Company, in an action for infringement of the same patent, and restrains the National Electric Company, as successor to the Christensen Company, from the further manufacture or sale of the infringing device.

The Trumbull Electric Manufacturing Company, of Plainville, Conn., recently increased the capital stock to $100,000. A new four-story brick factory will be built during the coming year, the present quarters having become too small for the largely increasing business.

The Roberts & Abbott Company, engineers, of Cleveland, Ohio, report greatly increased activity in the interurban-electric railway field. Recently they have reported upon a number of proposed roads, and are the engineers of seven others. One of the most important of these is to be the Washington, Baltimore & Annapolis.

The Cutler-Hammer Manufacturing Company, of Milwaukee, has received an order from the Northern Electrical Manufacturing Company, of Madison, Wis., for 135 of the new type of Cutler-Hammer machine-tool controllers, equipped with fuses and switch in conformity to the U. S. Navy specifications. All of these controllers will be installed in the plant of the Winchester Repeating Arms Company. Although this controller has been on the market but a few months, its sales have far exceeded the most sanguine expectations of the Cutler-Hammer Manufacturing Company.

The Keokuk & Hamilton Water Power Company has been authorized to construct a dam across the Mississippi River at Hamilton, Ill. It is estimated that the cost of the dam, lock and electric power plant will be about $5,000,000. The promoters plan to furnish power to Keokuk and Hamilton, and to various cities within a radius of 75 to 100 miles. The company is required to build a dam and put in locks sufficient for the present commerce of the river, and to furnish the government drydock facilities. Five years are allowed for the company to begin the work, and it must be completed in ten years.

New Catalogues

The coal and ash-handling equipment in the power plant of the Scioto Valley Traction Company at Reese's Station, Ohio, is illustrated and described in an attractive pamphlet issued by the Jeffrey Manufacturing Company, of Columbus, Ohio.

A new catalogue sent out by the Penberthy Injector Company, of Detroit, Mich., illustrates and describes injectors, including one for automobiles, ejectors, steam rams, high and low water alarms, water gauges, oil pumps, oil and grease cups, and sight-feed lubricators.

The first of a series of folders comprising an electrical catechism has been sent out by the National Electric Company, of Milwaukee, Wis. It shows the time-honored analogy between the flow of water and the flow of electricity, and gives a number of questions, with the answers, in regard to the fundamental electrical units.

Lathe and drill chucks are illustrated and described in a new catalogue sent out by the Westcott Chuck Company, of Oneida, N. Y. The lathe chucks include several varieties of the independent, universal and combination types, the details of each being clearly shown. The drill chucks are of the double-grip type for attachment to lathe or drill press.

Electric heaters and other apparatus for heating railway cars are illustrated and described in a new catalogue issued by the Gold Car Heating & Lighting Company, of New York. Diagrams show the location of the heaters and their connection to the trolley circuit. A system of heating by hot-water circulation is also illustrated and described.

Direct-connected generating sets, in sizes ranging from 2½ to 75 K. W., are illustrated and described in a new bulletin issued by the General Electric Company, of Schenectady, N. Y. Several details of the engines are illustrated, as are also a number of complete units. Other bulletins issued by the company are devoted to remote control field rheostats for railway generators and rotary converters, motor-starting rheostats, with switches and fuses for shunt and compound-wound motors, subway transformers for installation under ground, and charging equipments for electric vehicles. In the last-named, a mercury arc rectifier is illustrated for changing alternating current to direct.

The Westinghouse-Parsons steam turbine is illustrated and described in a new catalogue sent out by the Westinghouse Machine Company, of East Pittsburg, Pa. The turbine is shown in detail and assembled. A number of illustrations show some of the recent installations, and tables are given of efficiency tests of a 400-K. W., a 750-1000-K. W. and 1250-K. W. turbine, respectively.

A series of three pamphlets, reprints of papers by Westinghouse engineers, have recently been sent out by the Westinghouse Electric & Manufacturing Company, of Pittsburg. The subjects are as follows: "Notes on Incandescent Street Lighting," by K. C. Randall; "Instrument Equipment of a Testing Department," by F. Conrad; "Points for Consideration When Purchasing Series A. C. Arc Lamps," by G. Brewer Griffin.

Storage batteries are illustrated and described in a new catalogue sent out by the National Battery Company, of Buffalo, N. Y. Several types of batteries are shown, a table giving the sizes, weights and prices of each.

The advantages of graphite made in the electric furnace for the preservative painting of metal structures are set forth in a new catalogue sent out by the International Acheson Graphite Company, of Niagara Falls, N. Y. Illustrations are given of some of the structures on which Acheson graphite paint was used.

The Wagner Electric Manufacturing Company, of St. Louis, is sending out a pamphlet containing answers to some central station questions about single-phase motors. These were given originally in a paper by G. P. Cole before the Kansas Gas, Water and Electric Light Association, and deal with problems of installation and operation. In the latter part of the pamphlet some of the applications of the company's single-phase motors are illustrated.

Although rock and ore breakers have primarily no connection with things electrical, the fact that they are among the products of the Allis-Chalmers Company, of Chicago, will make them of interest here. A new catalogue sent out by the company is devoted to these machines, various types being illustrated and described. A portable railroad ballast plant, which is illustrated, ought to prove of interest to electric railway men. It is shown mounted on a special platform car.

Industrial railways form the subject of a new pamphlet just issued by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y. It shows the company's standard and cast-plate track, together with different types of standard and special cars for a wide variety of industrial service. Electric locomotives are also illustrated and described. Another pamphlet is devoted to machinery for coal handling or similar work. A metric conversion table, also issued by the company, is printed on a slip for convenient insertion in a note book.

A steel factory equipment is illustrated and described in a new catalogue sent out by the Lyon Metallic Manufacturing Company, of Chicago. The equipment consists of steel stock-room racks, trays and boxes, barrels, pans, benches and tool racks for the shop, a variety of trucks for handling different material—in short, any receptacle needed in the up-to-date factory. Steel clothes lockers are also illustrated, as are cases for enclosing gears. The company also makes a specialty of ornamental and architectural iron work.

Electrical laboratory apparatus for use in experiments with direct and alternating currents is illustrated and described in a new catalogue sent out by C. H. Thordarson, of Chicago. The apparatus includes magnets and coils for a variety of induction experiments, high-potential transformers, impedance coils, spark coils, permeators, a motor-generator, an induction motor and instruments for electromagnetic measurements.

The Nernst Lamp Company, of Pittsburg, Pa., has commenced sending out a series of monthly bulletins devoted entirely to central-station lighting interests. The subject principally dealt with is, naturally, the development of electric-current sales through the medium of the Nernst lamp.

"Niagara's Power, Past, Present, Prospective," an address by Frederick Nicholls, vice-president and general manager of the Electrical Development Company, Ltd., of Ontario, has been sent out by the company in the form of an attractive booklet. It tells the history of Niagara and its utilization for power generation, and deals more particularly with the operations of the Electrical Development Company. Illustrations are given of several parts of the work, including the wheel pit, dam, main tail-race tunnel, power house and transmission tower.

A leaflet entitled "Fleming-Harrisburg Engine at the International Exposition, St. Louis, Mo.," has been recently issued by the Harrisburg Foundry & Machine Works, of Harrisburg, Pa. It contains a reprint of an article published recently in "The Engineer," of London, and describes the design, construction and performance of one of the company's latest productions of their four-valve compound type. The engine was used in connection with the Intramural Electric Railway, and was in service continually during the entire period of the Exposition. The engine was awarded a gold medal and diploma.

Multiphase induction integrating wattmeters are illustrated and described in a new bulletin sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind. Two types are shown, one with a dust-proof aluminium case and the other with a glass case for switchboard service. Tables of capacity for the various sizes are given with diagrams showing the dimensions.

The Hornsby-Akroyd oil engine is illustrated and described in a folder recently sent out by the De La Vergne Machine Company, of New York. Three air-compressing outfits are shown,—a portable, a semi-portable and a fixed horizontal. A number of separate illustrations have also been sent out of Koerting gas engines built by the same firm, of the two-cycle and four-cycle type. Some of these show the engines driving electric generators, and others show them operating blowing engines.

"Five Thousand Dollar Bills" is the attractive title of a booklet recently sent out by the Edison Electric Illuminating Company, of Brooklyn. The purpose of the booklet is to describe the lighting installations of some of the company's customers, whose annual bills for lighting and power service exceed five thousand dollars. The illustrations include the well-known towers in Dreamland and Luna Park at Coney Island, besides other places where light and power is supplied for industrial or commercial use.

A new type of car, "The Narragansett," built by the J. G. Brill Company, of Philadelphia, is illustrated and described in a new catalogue sent out by the company. The distinguishing feature of this car—one of the open type—is that two steps are provided to enable the passenger to reach the seat. This feature may also be applied to cars of the convertible type when opened for summer use. A diagram compares the two steps with the single step on ordinary cars.

Germany's Electrical Industries.

CONSIDERING the depression in Germany's electrical enterprises in recent years, it is interesting to note that last year's business of the Allgemeine Elektricitäts-Gesellschaft, of Berlin, enabled them to declare a dividend of 9 per cent. on its share capital and carry large amounts over to reserve funds and to payments to directors and to benevolent endowment funds for employees. The company has a steam turbine department which works on American designs, and has also established a department for making automobiles which has already turned out a large number of autos for passenger and freight traffic. The business outlook is said to be excellent, as the company has orders for a long time ahead at very remunerative prices. The report of this company may be accepted as an indication of a general improvement of Germany's electrical industries.

The estimated coal output of the United States for the year 1904 has been given as somewhat over 344,000,000 tons.

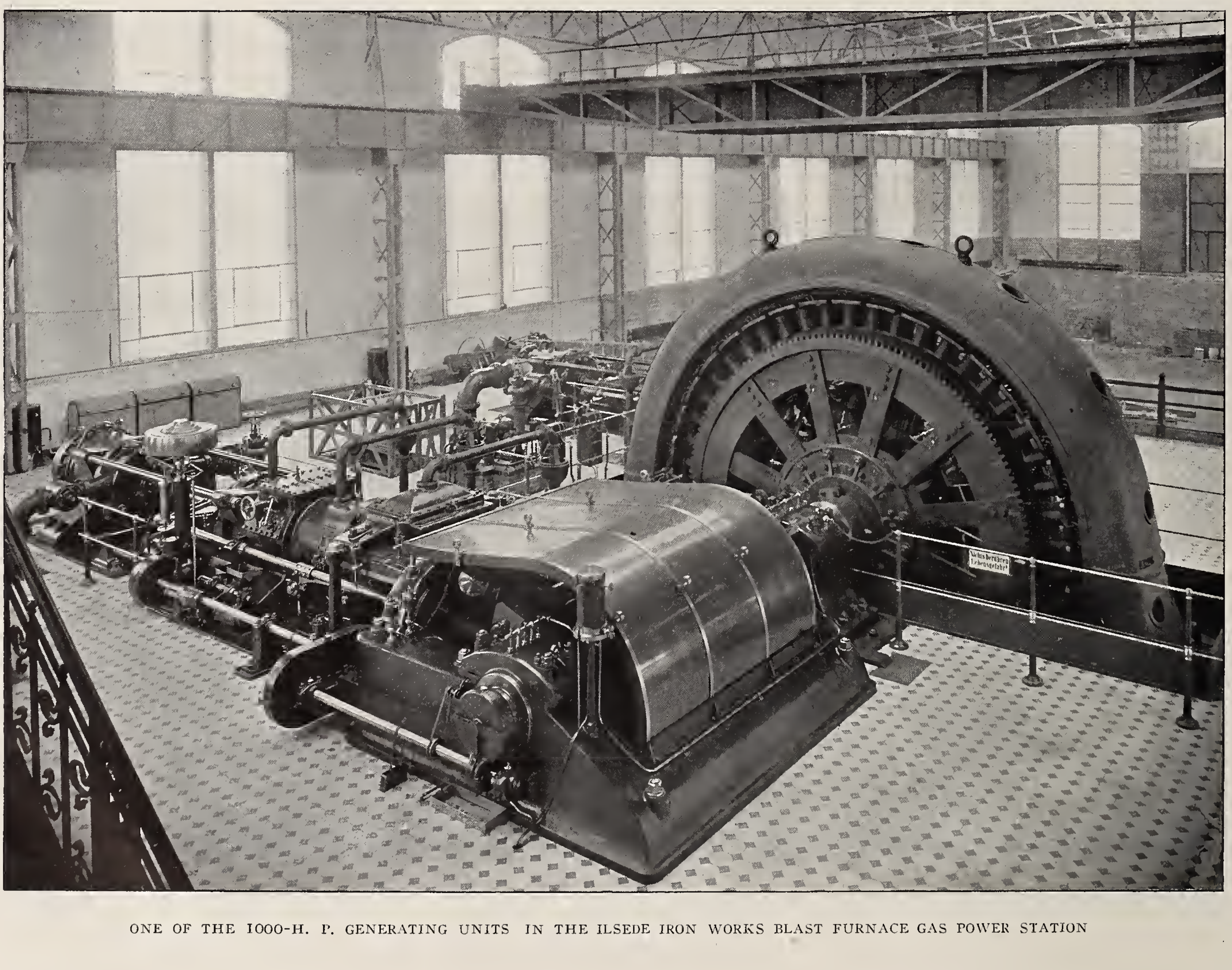
Electric Power from Blast Furnace Gas

By L. RAMAKERS

IN the Ilsede Iron Works, at Ilsede, Germany, all the waste gases from the three furnaces, averaging 225 tons of iron daily, were formerly burned under boilers for generating steam to drive the blowing engines and electric generators. When it was seen, however, that the application of electricity to lighting and power might be extended not only in the works but also in the neighboring iron mines, and in the rolling mills at Peine, 4 miles distant, it was decided to extend the electric plant and to employ gas-engine-driven generators, using the blast furnace gases directly in the engines. The steam-driven blowing engines also were discarded and gas-engine-driven ones substituted.

Plans were made for the installation of six generating units, each of 1000-H. P. capacity. A gas power station was built, consisting of two bays, each provided with a 26-ton traveling crane. The plant was installed by the German Power Gas Company, of Berlin, organized jointly by Siemens & Halske and the Union Elektricitäts Gesellschaft, to acquire the patent rights to the Oechelhaeuser gas engine.

The generating set consists of a three-phase alternator of the revolving-field type, direct connected to an Oechelhaeuser engine on each side. The latter are of the 2-cycle type, each having two pistons working in one cylinder and moving in opposite directions at the same time. These pistons are so arranged with regard to the positions of the admission and exhaust ports, which they uncover at the end of their outward stroke, that no other valves are necessary. A pump is driven by an extension of the piston rod of the back piston, and forces the gas and air respectively into the admission ports at a pressure of a few pounds per square inch; compression takes place when the pistons approach each other on the inward stroke. Regulation of speed is effected by varying quality of the mixture of gas and air.



ONE OF THE 1000-H. P. GENERATING UNITS IN THE ILSEDE IRON WORKS BLAST FURNACE GAS POWER STATION

THE GAS FROM THE BLAST FURNACE ARRIVES THROUGH THE LARGE MAINS HERE SHOWN

The alternator is driven at 125 revolutions per minute, and generates current at 10,000 volts and 50 cycles per second. It is connected with the two crank shafts by couplings, so that either engine may be used to drive while the other is lying idle. The alternator runs perfectly in parallel with the existing steam-driven generators, even when only one of the gas engines is used. The governors of the engine are electrically controlled from the switchboard, to facilitate paralleling.

The furnace gas is cleaned by two centrifugal washers, each of which is designed to free from dust 25,000 cubic feet of gas per minute. The power required to drive these is 110 H. P., and the water consumed is 440 gallons per minute. The main switchboard is placed on a gallery, and only the measuring instruments and the handles of the switches are mounted on it. All the high-tension apparatus is securely housed in a locked room.

A prize of 6000 francs ($1140) is offered by the "Association des Industriels de France contre les Accidents du-Travail," a society now organizing to hold a congress in June, 1905, for the purpose of examining whatever appliances there are that will protect those working on high voltage circuits. This prize is open to the inhabitants of all countries, and will be awarded for the best apparatus submitted that will indicate safely and clearly whether an electrical conductor is alive or not. The apparatus submitted for this prize must be adapted for use on both direct and alternating-current circuits of all voltages; it must be reliable under all conditions, and also incapable of doing damage to itself, the workmen, or the system to which it may be applied.

Freight Business on Electric Roads

THE report of the New York Railroad Commission for the year ending June 30, 1904, shows that with 1995 miles of electric lines included in the returns, 633,674 tons of freight were carried last year, as against 516,460 tons in 1903, 394,641 tons in 1902, and 287,311 tons in 1901. Earnings from freight and express traffic increased during the same period from $175,931 to $517,780. In brief, while earnings from the main source of income, passenger traffic, increased 19 per cent. in four years, earnings from the by-product of the lines furnished by freight and express traffic, increased 194 per cent.

A Pioneer Electric Furnace

ACCORDING to "The Electrical Engineer," of London, an electric resistance furnace was used by Pepys in 1815 for the cementation of iron. He took a piece of pure, soft iron and cut a slit along its length. The slit was filled with diamond dust, which was prevented from falling out by fine iron wire. The portion of the wire containing the dust was wrapped in mica. The wire, thus charged, was heated quickly to redness by the current from a battery. On opening the wire Pepys found that the diamond dust had disappeared, and that around where it had been the wire had been converted into steel.

It is reported that a bill will be shortly introduced in Canada for the governmental control of wireless telegraphy, the military authorities urging the expediency of such control in time of war.

Tesla Patents in Synchronous Motor Suit.

IN pursuance of a decision handed down on February 20 in the United States Circuit Court for the Eastern District of Wisconsin, sustaining the contention of the Westinghouse Electric & Manufacturing Company that the synchronous motors of the National Electric Company were an infringement of the broad rights covered in Tesla patents Nos. 381,968, 381,969, 382,280 and 382,281, Judge Seaman, in Wilwaukee, on February 24, enjoined the National Company from the further sale of such motors. The decision in the suit is the first that has been obtained in the litigation begun some time ago by the Westinghouse Company to prevent the sale of synchronous motors and rotary converters by American manufacturers not enjoying a license under the Tesla polyphase motor patents.

The hearing in the suit against the National Electric Company was conducted before Judge Seaman on February 6 and 7, Thomas B. Kerr and Parker W. Page appearing for the Westinghouse Company. A decision is now pending in the United States Circuit Court for the Southern District of Ohio in the suit brought by the Westinghouse Company against the Bullock Electric Manufacturing Company, alleging similar infringement of the same patent rights in the sale of Bullock synchronous motors and rotary converters. The final hearing in the latter suit was conducted before Judge Thompson, in Cincinnati, on February 7 and 8, Frederic H. Betts and Mr. Page appearing for the complainant.

The Tesla patents involved in these suits have been the subject of considerable litigation in the past few years. The action instituted by the Westinghouse Company a number of years ago against the Thomson-Houston Company, for alleged infringement of the Tesla patents, was discontinued upon the execution of a patent agreement under which the General Electric Company has for several years manufactured and sold induction and synchronous motors and rotary converters. A number of manufacturers have been enjoined from manufacturing induction motors, but the decision in the suit against the National Electric Company is the first court ruling that the synchronous motor is within the generic Tesla invention. Judge Seaman's decision makes interesting reading and is, in part, as follows:—

"With the excellent and thorough review of the earlier patents and prior art, and the well-considered concurrent view of the novelty and scope of the

Tesla invention covered by the patents (thus appearing in several of these opinions), I am relieved of any need to attempt an analysis of the general showing in the present case, which departs from the prior cases only in respect of the application of the invention to the synchronous-motor type. Although the inquiry thus presented is not free from difficulty—involving abstruse discussion and distinctions in the electrical art which are perplexing to the non-expert understanding, and are not clarified by the many pages of conflicting expert testimony—the arguments at the bar were clear and well directed, and I am convinced that the issue as now presented is within narrow compass and governed by tests for its solution which are not complicated.

"The defendant's contentions are, in substance, that the Tesla invention, embodied in each of the patents, is the rotating field mode of operation, which is 'the production of the conjoint effect of out-of-phase currents of a progressive shifting by the polarity,' and thus 'identical in its effect with that of a rotating physical magnet'; that it is limited to a self-starting motor so operated, and both by the terms of the patents and the state of the art, the defendant's synchronous motor with direct-current excitation is not within the invention; that the defendant's synchronous motor is simply a reversed 'two-phase alternating-current dynamo of the prior art used as a generator,' adapted to alternative use; and that the claims of patents 381,969 and 382,281, which bring in 'direct-current excitation producing synchronous operation,' must be limited to such use 'after the motor is started by the Tesla means and method and brought up to speed.' If the invention is so limited by the prior art, it is plain that the defendant escapes infringement. On the other hand, if not so restricted, it is equally clear that the claims of the patents are broad enough to reach the defendant's means and method of operation.

"The Tesla discovery for which these patents were granted revolutionized the art of electrical power transmission, as well demonstrated in the record from both judicial and scientific standpoints. Judge Townsend's definition in reference to the generic patents in the New England Granite case, repeatedly approved by other courts, is adopted for this consideration, namely:—'Tesla's invention, considered in its essence, was the production of a continuously rotating or whirling field of magnetic forces for power purposes by generating two or more displaced or different phases of the alternating current, transmitting such phases, with their independence preserved, to the motor, and utilizing the displaced phases as such in the motor.'

"So viewed, the patent monopoly was rightly granted for its brief term to the use of the means and methods thus discovered. While it could not exclude the known uses of the prior art, it is surely entitled to be protected against like motor structure and mode of operation, not clearly disclosed in the prior art, and the patent claims to that end must be fairly construed in conformity with the rule applicable to such inventions. I am of the opinion, therefore, that the several contentions for the defendant are either without force or untenable, for the following reasons:—

"Whether the effect of the Tesla invention in its production of the 'whirling field of magnetic force' is identical with that of a rotating physical magnet, as argued by experts and counsel, does not impress me as material to this issue. Nor does it seem material that in the one form of motor 'the rotation is produced by the unaided effect of alternating out-of-phase currents,' as described by counsel, and that so applied a self-starting motor is obtained. The discovery was of means and method in the polyphase rotating field motor to produce the whirling field of force, and employment thereof was patentable with or without direct-current excitation of the armature or secondary element. So the fact that its use produced a self-starting motor without the aid of such excitation, cannot alone serve to limit the invention to that effect, and I find no such limitation in the terms of the patent.

"The quotations from arguments of counsel and experts for the complainant in prior cases, urging the distinction of this self-starting effect in reference to the application of the generic patents to non-synchronous motors, are without force in the present controversy, and it is unnecessary to ascertain their consistency or inconsistency with the interpretation sought on this hearing. Unless limitation to self-starting motors arises out of the prior art none can be imposed upon the claims in suit.

"The further propositions urged by way of defense—aside from the defense founded upon prior inventions of the synchronous type to be considered—are these (1) that the synchronous motor of the defendant is the old generator of the art, simply reversed; and (2) that the Tesla invention is not present therein, because (as asserted) 'the preponderating magnetization of the direct current' displaced and obliterates the 'shifting alternating-current magnetization,' or Tesla 'whirling field of force.' However specious both propositions appear on their face and in the argument, neither of them impresses me as controlling.

"I believe that no proposition in the able and extended arguments on the part of the defense have been overlooked in my consideration of this case, although it has not seemed needful to discuss all of them for the purposes of this opinion. My conclusions are that the defendant's synchronous motor structure and operation are within the generic invention as patented, and expressly covered by the claims of Nos. 381,969 and 382,281; that the invention is utilized in the defendant's motor operation, notwithstanding the introduction of direct-current excitation to make it synchronous, in lieu of the full realization of the revolving field effect for self-starting; that such supplemental aid does not escape infringement, with or without advantage in such associations; and that, in any view, the combination patents referred to are not limited to after-effect of the direct-current excitation, but apply to the defendant's combination. Decree will be entered accordingly as prayed in the bill."

Insulator Tests.

THE fact that insulators are successfully tested for high voltage before they are put up does not necessarily prove that they will not cause any trouble when on the line. According to Messrs. J. F. Kelly and A. C. Bunker, insulators which were tested for 120,000 volts, water test, for one minute, have given trouble in less than a month after being placed on a 40,000-volt line. Other types, which had stood 40,000 volts, water test, for five minutes, have been known to be unsatisfactory for 13,000-volt city (overhead) service, though this would not hold in every city. The greatest value of electrical test for insulators before being used is to determine whether the various parts are homogeneous, and whether they have been properly cemented together.

The first bulletin, recently issued, of the United States Bureau of Standards contains the results of investigations on the temperature of the electric arc. Three photo-metric pyrometers were used, the Le Chatelier, the Wanner and the Halborn and Kurlbaum. With the first, a mean absolute temperature of 3720 degrees C. was obtained, with the second 3680 degrees, and with the third, 3690 degrees.

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The Electro-Metallurgical Industries

By JOHN B. C. KERSHAW, F. I. C.

THE STEEL WORKS AT LIVET, FRANCE, OF THE THERMO-ELECTRIC COMPANY, OF PARIS. WATER POWER DEVELOPS THE ELECTRIC CURRENT HERE USED

TWENTY years ago, industrial electro-metallurgy was represented by only one slow-growing and comparatively unimportant industry,—that of copper refining by an electrolytic process. This was started by Messrs. Elkington Brothers, at Pembrey, in South Wales, in the year 1869.

To-day, electricity is being employed on a large scale in the production for commercial purposes of aluminium, calcium carbide, ferro-chrome, ferro-nickel, ferro-silicon, glass, graphite, iron and steel, lead, silver and gold, tin and zinc,—and in addition to these, of a large number of electro-furnace products like siloxicon and carborundum, formerly unknown as commercial products, while the small electrolytic copper refining industry of 1884 has grown to immense magnitude and now covers more than one-half of the copper output of the world.

In view of the important position which electrical methods are thus assuming in the reduction of metals from their ore, in refining crude metals, and in the production of new furnace compounds and alloys, it is well that those interested in these developments should pause at times, and survey the general conditions of these new industries and their progress over some definite period of time.

The present article is intended to provide the material for such a survey. The growth and development of each industry and the progress made during last year will be dealt with in detail so far as facts and figures are available for this purpose.

The past year was not marked by any striking discovery or development of new methods in the domain of electro-metallurgy; in certain directions, however, considerable progress was made since January 1, 1904,—and in the sections of this article devoted to iron and steel and to zinc, particulars of these noteworthy advances will be given.

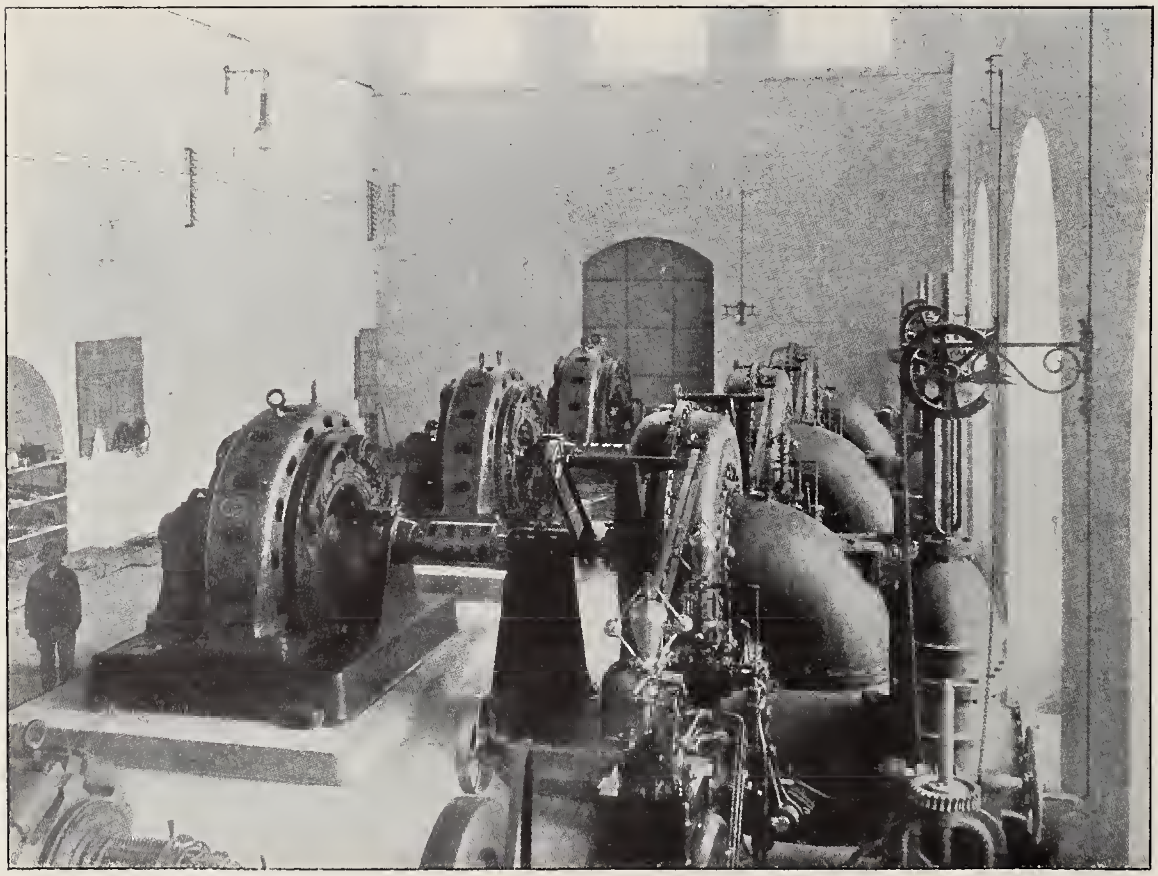
ALUMINIUM

The world's aluminium industry is represented by 11 works and an available horse-power of between 60,000 and 70,000. Of these works there are 4 in America, 2 in France, 2 in Germany, 2 in Austria, and 1 each in Great Britain and in Italy, the last named being projected only. The Pittsburgh Reduction Company, controlling the Hall patents and process in America, and the Neuhausen Aluminium Company, controlling the Heroult patent and process in Germany, Switzerland and Austria, are the two largest producers. Each of these companies controls 4 works, and has available over 24,000 horse-power for the manufacture. Were the whole of the available power in these 11 works devoted to aluminium production, the annual output would be over 17,000 tons per annum. At present it is doubtful if one-half of this total is produced. No official figures are published by means of which the aggregate output can be ascertained, and since many of these works are producing other electro-furnace products, the aggregate horse-power available is no guide to the present actual production of aluminium.

During the past year, many of the companies have been extending their plants. The British Aluminium Company, which works the Heroult process at Foyers, N. B., has been completing its arrangements for devoting the whole of the power at this works to aluminium production and for de-

PIG IRON AND STEEL INGOTS FROM THE LIVET WORKS

veloping a new water power centre on Loch Leven. Both the Pittsburgh Reduction Company and the Neuhausen Company have also been adding to their plants at the lower Niagara works and at Rheinfelden, respectively, so that the producers evidently believe they are to experience a greatly increased demand for aluminium in the near future.



THE INTERIOR OF THE POWER HOUSE AT LIVET, SHOWING SOME OF THE DIRECT-CONNECTED TURBINES AND GENERATORS

As regards its utilization, the application to overhead electric transmission lines continues in America, and many of the newer lines are of stranded aluminium wire. The most important of these are:—

	Miles
Electra to San Francisco	154
Colgate to Oakland	144
Shawinigan Falls to Montreal	35

In Great Britain and on the Continent such use of the metal as a substitute for copper has not been looked upon with favour by electrical engineers, and there are very few installations of this kind to be found outside the producing works. On the Continent, the larger portion of the aluminium produced is consumed for metallurgical work in the foundry and for special castings in which lightness is an indispensable factor.

Its use, in the form of powder for the manufacture of thermit, and for printing purposes as a substitute for stone, is also growing rapidly, while small fancy articles of aluminium continue to have a large sale owing to the beautiful effects which can be obtained by workers in this metal. The use of aluminium for cooking utensils seems stationary, owing to the difficulty of keeping the metal bright and clean without the use of soda or its salts.

BULLION REFINING

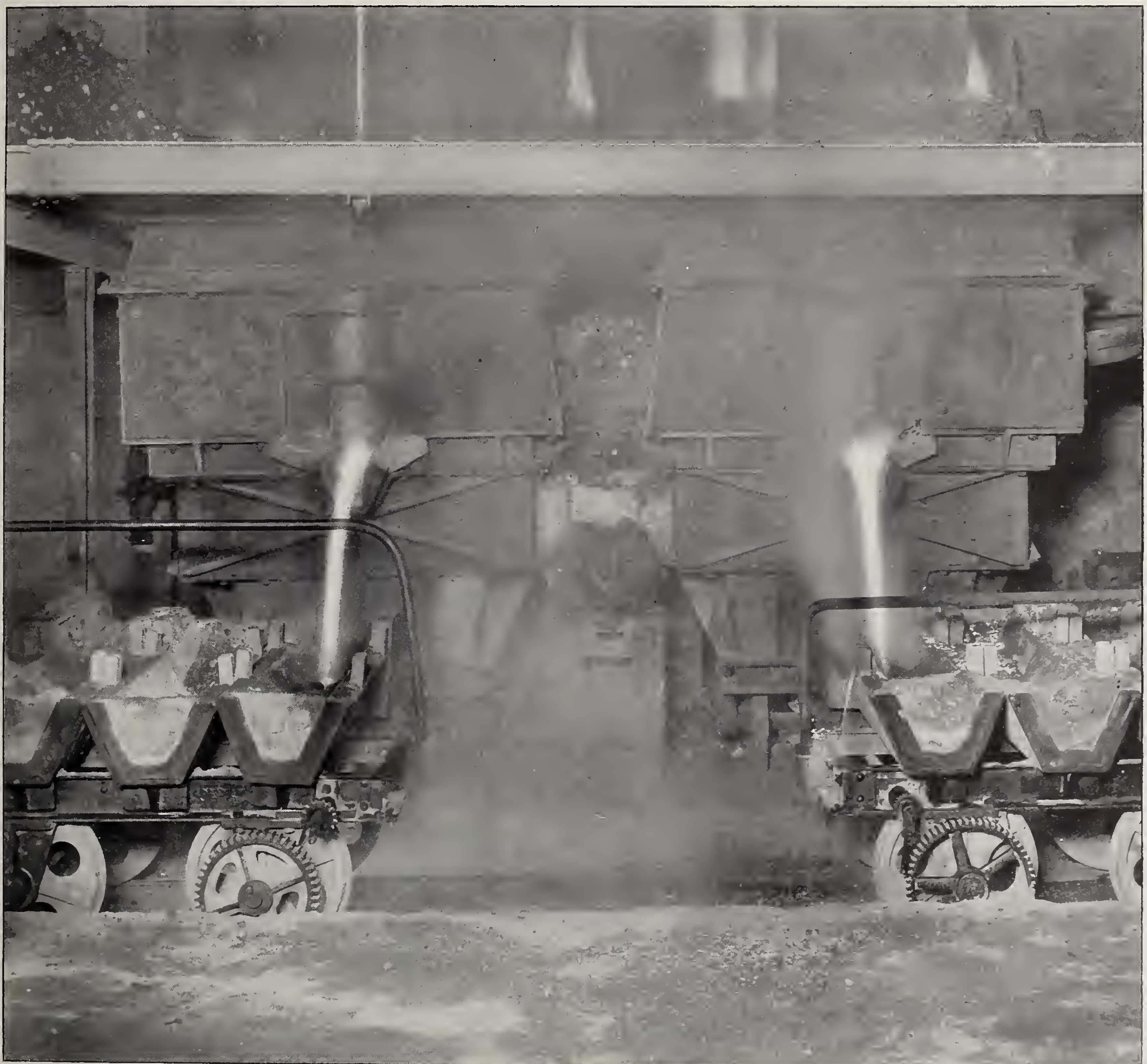
Electrolytic methods of refining gold and silver bullion are now in operation at the following places:—London, Hamburg, Frankfort, Freiburg, Pforzheim, Perth Amboy and Philadelphia; also at one place in France. The Moebuis, Rossler and Dietzel processes are in use for silver bullion, while gold bullion is refined by the method worked out by Dr. Wohlwill, of the Hamburg refinery.

This process depends upon the use of a solution of gold chloride as electrolyte, and it leads to the recovery of the whole of the platinum and palladium present as impurities in the gold bullion in the sludge from the vats. As an example of the value of the annual production of gold and silver by these refineries, it may be stated that in 1903 the Frankfort refinery of the Deutsche Gold und Silber Scheide Anstalt was reported to have produced 261,312 ounces of gold and 7,186,080 ounces of silver, while the combined output of precious metals by the Frankfort and Hamburg refineries in the same year was valued at £2,500,000. No production figures for a later year have been published, but the electrolytic methods of bullion refining are certainly progressing, owing to their cleanliness and adaptation for close scientific control.

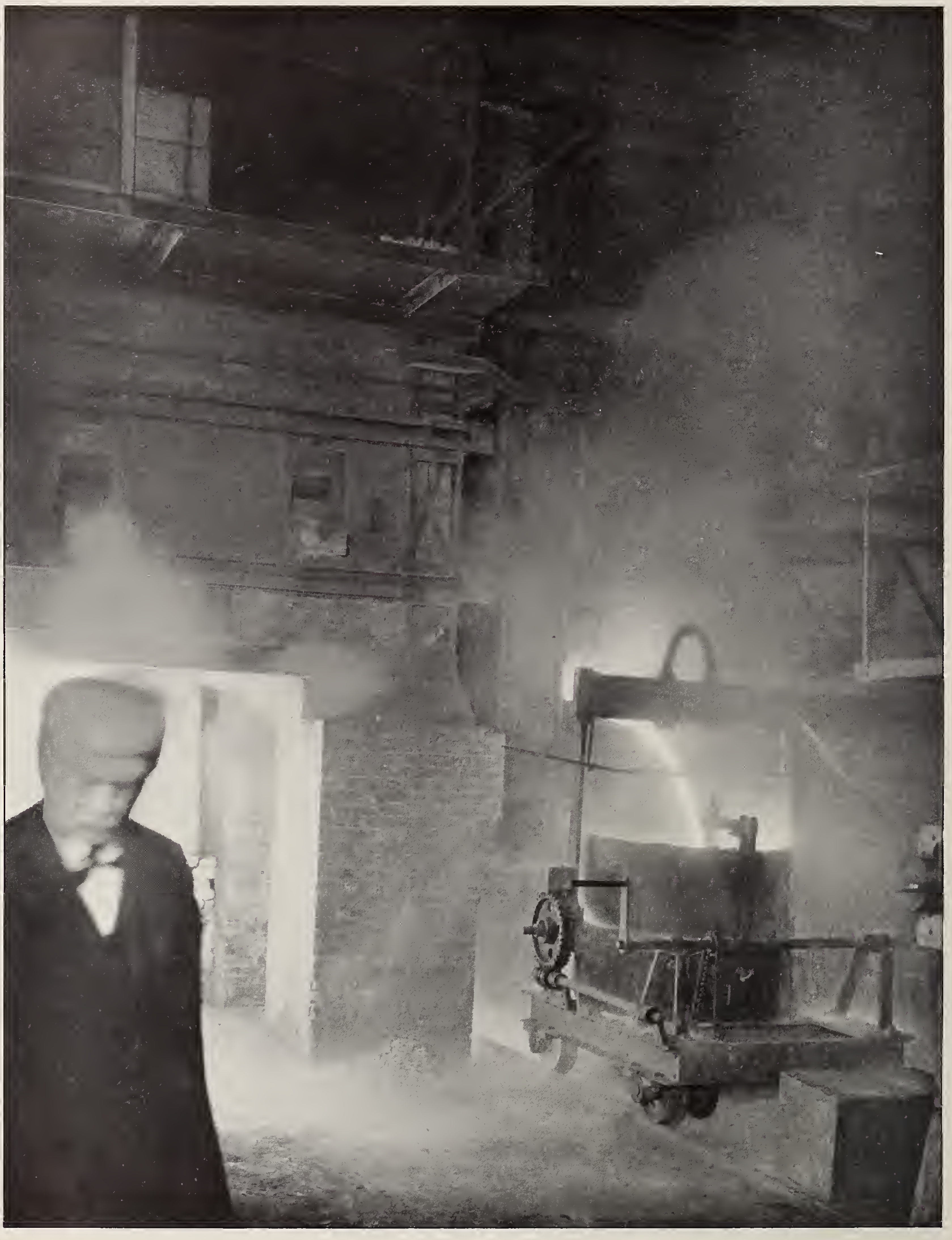
CALCIUM CARBIDE

The calcium carbide industry is still one of the largest of the electro-metallurgical industries, although the expectations of the earlier days have not been realized, and many of the works originally planned and erected for its manufacture have been closed or devoted to other purposes.

Four years ago, the writer published a list of 93 places in Europe and America where calcium carbide



EACH OF THE SMELTING FURNACES AT LIVET HAS TWO ELECTRIC FINING FURNACES ARRANGED IN FRONT, ALTERNATELY RECEIVING AND REFINING THE METAL

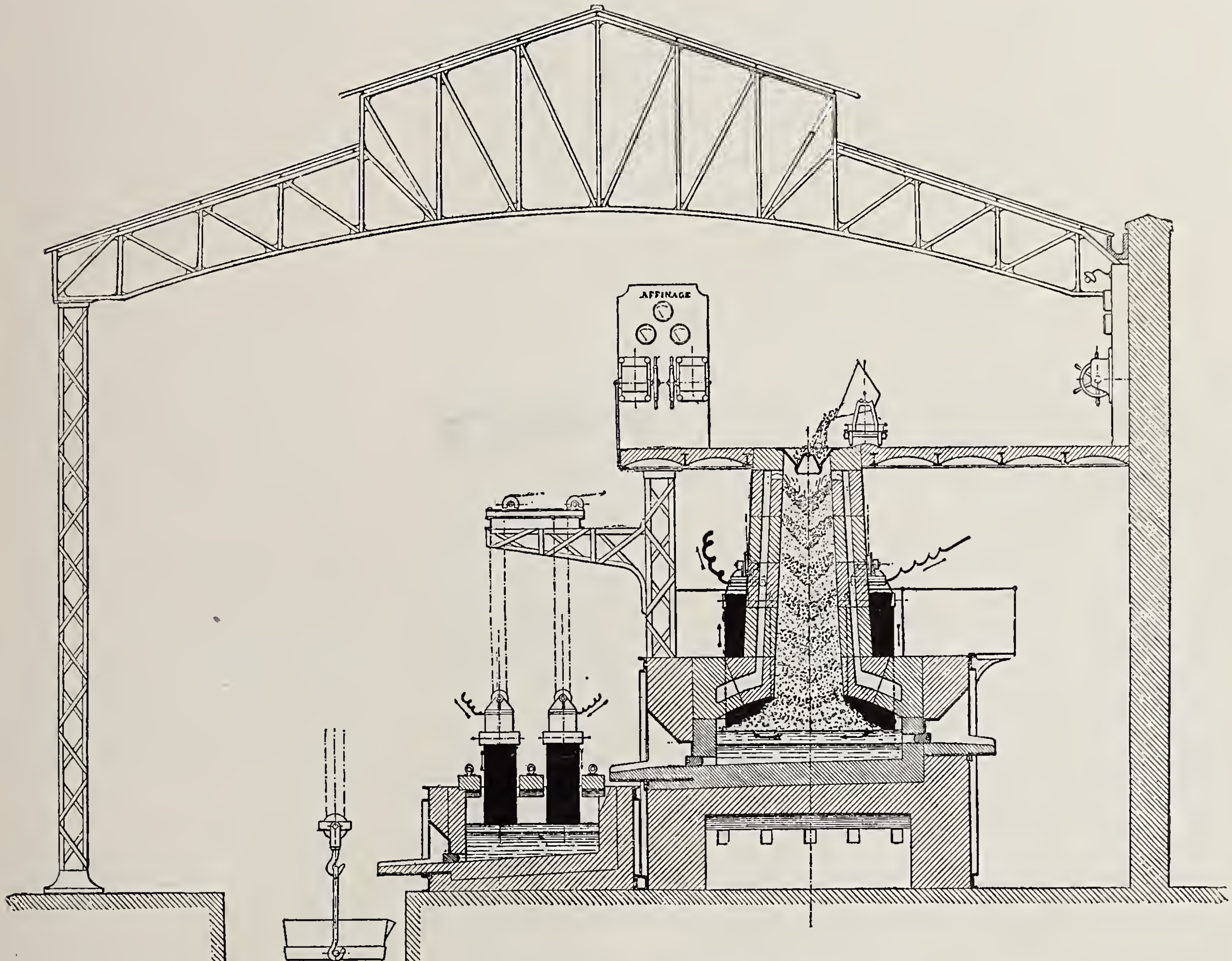


TAPPING ONE OF THE 12-TON ELECTRIC STEEL FURNACES AT LIVET works had been erected or were in course of erection, and it is probable that more than one-half of these are still producing carbide, and that between 50,000 and 100,000 horsepower are employed in the manufacture. Owing to the large number of failures that have occurred in recent years in this industry, and the consequent changes, no very reliable figures are available which relate to the number of works now in operation and the horse-power utilized in carbide production.

Several new works were planned and partly erected during 1904, of which those at Kerka, in Dalmatia, and at Serpsfos, in Norway, are the most important. A small carbide works operated by water power was also erected in Ireland, at Askeston, County Limerick, but the manufacture of carbide at Foyers has been suspended and the demand for carbide in Great Britain is now chiefly met by imports from Norway and Sweden. The failure of the English company to uphold the reliability of the Willson carbide patents under which it operated, no doubt had some influence upon the cessation of manufacture at Foyers, the final House of Lords' decision in the appeal case being against the Acetylene Illuminating Company, the owners of the Willson patents.

As regards utilization, Italy is reported to have the largest number of central acetylene installations for lighting purposes, and in 1902 is said to have consumed 12,500 tons of carbide. A large number of similar lighting installations is also to be found both in France and in Germany, the total number having recently been estimated at 250. The estimated consumption of carbide in Germany in 1904 was 20,700 tons, while the estimated production was only 13,300 tons, leaving 7400 tons to be imported. Central acetylene installations for village lighting are also becoming more common in Great Britain, and a list of 16 places where such installations exist was recently published.

A new use for acetylene, which may develop, is in the manufacture of alcohol, while calcium carbide is being employed to manufacture arc light carbons of special illuminating power. The latter application is the more promising of the two.



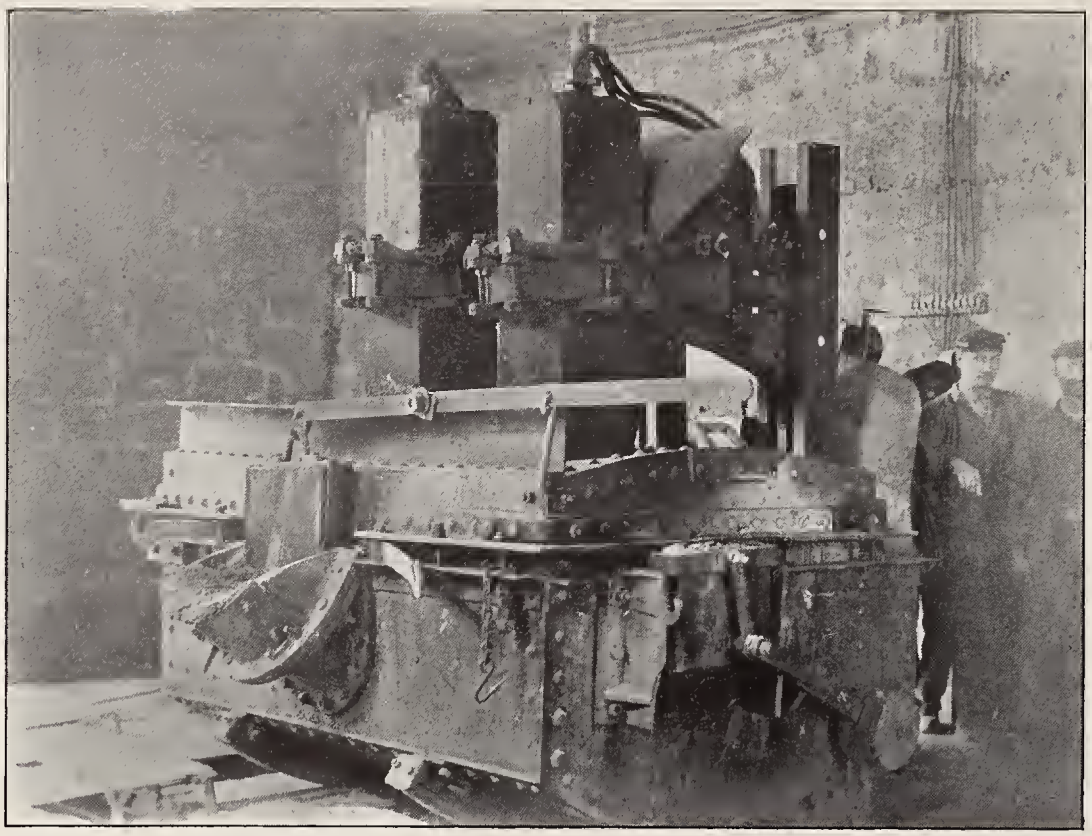
SECTIONAL VIEW OF ELECTRIC BLAST AND FINING FURNACES AS USED AT LIVET

CARBORUNDUM

Carborundum is the name given to a carbide of silicon discovered by E. Y. Acheson in the year 1891, and now manufactured on an extensive scale in electric furnaces at Niagara Falls. This product is harder than natural corundum, and is used as an abrasive material in place of corundum and emery, while as a refractory furnace lining and cement for clay retorts it is also finding profitable employment.

The Niagara factory of the International Carborundum Company has gradually increased in size until it now utilizes 5000 horse-power, and possesses one furnace which absorbs 2000 horse-power in the production of one charge of this compound. The production of carborundum in the year 1903 amounted to 4,760,000 pounds and was valued at $472,000.

One of the latest applications of carborundum is as a refractory lining for



A HEROULT ELECTRIC STEEL FURNACE

the interior of furnaces or for retorts exposed to very high temperatures, the carborundum being used in a finely divided state and being mixed with fire-clay or with water-glass and water, for this purpose. It has also been used successfully for repairing cracked retorts in gas works.

COPPER

Electricity in the copper industry finds use in two directions. As previously stated, more than one-half of the copper output of the world is now refined by the electrolytic process, and 32 electrolytic refineries are in operation at the present time. Also, in spite of early failures, electrical methods of extracting copper from its ore received attention during 1904, and both wet and dry processes for dealing with copper ores have been worked experimentally upon an industrial scale in America and in France during the past year. Within the limits imposed by this article, it is of course impossible to deal adequately with this, the oldest and most important electro-metallurgical industry, and only the barest outline of its present position and past years' progress can be given here.

Titus Ulke, who acts as statistician of the copper industry, states that the 32 refineries are situated as follows, and share in the world's output of refined copper according to the proportions here given:—

	Per Cent. of Total
United States, nine refineries	86.50
Germany, nine refineries	2.75
Great Britain, six refineries	8.80
France, four refineries	1.60
Russia, two refineries } Austria-Hungary, two refineries }	.35

That Great Britain, in which the electrolytic process of refining copper was first developed industrially, should have sunk to such a humble position as regards proportionate output, is due to many causes, chief of which is the fact that the bulk of the raw copper worth refining electrolytically is obtained from American ores, and this raw copper is now refined in the country where it is smelted. The world's output of electrolytic copper is now about 320,000 tons per annum, and is still increasing.

As regards extraction processes, one method, based upon the use of dilute sulphuric acid as a bleaching solution, is in use at Dorchester, in Canada, and is reported to have given good results with poor ores, containing from 2 to 4 per cent. copper. An electric furnace process for concentrating copper ores has also been tried experimentally in France, and as these trials were successful, it is to be employed upon a larger scale in trials with native ores in Chili. In this case a copper matte is obtained,—not pure copper. The Hoepfner extraction process is also in operation at Sapenburg, in Germany; this process is based upon the use of a cupric chloride solution for bleaching the roasted ore.

FERRO-CHROME, FERRO-SILICON AND FERRO-TITANIUM

These alloys of iron are manufactured on a large scale in the electric furnace for use in the iron and steel industries, it being found that the simplest and most effective method of introducing small quantities of chromium, silicon, titanium, or other metals into the molten iron and steel, is to add the desired metal in the form of an alloy.

The manufacture of ferro-silicon is the largest of these branch electro-metallurgical industries; between fifteen and twenty works in Europe, chiefly old carbide works, have taken up the manufacture of this product. The method of production is simple. Scrap iron or scrap steel is heated with pure quartz in a resistance type of furnace until a combination has occurred between the two. The product contains up to 25 per cent. of silicon and a 4000 horse-power plant can turn out 20 tons of it per day. Over-production has occurred in this industry in

France, and a sales bureau has been organised in Pau to regulate the output and price of the alloy.

Ferro-chrome is being produced in the electric furnace at Holcombe Rock in America, at Forges La Praz and Albertville in France, at Essen in Germany, and at Courtepin in Switzerland. The first-named works has a capacity of 1800 tons per annum, and sells most of its product to the Carnegie and Bethlehem steel companies for use in the manufacture of armour plate steel. Chromium in small amounts greatly increases the hardness of steel; hence its use in the manufacture of tool steel for armour plates.

Ferro-titanium is manufactured by Rossi at Niagara Falls by heating together scrap iron, titaniferous iron ore and aluminium, in the electric furnace, —also from titaniferous slags by a modification of this process. Pure titanium is produced in France by the Société Néo-metallurgie at Lavel, but no great demand exists for either of these products.

Ferro-manganese, ferro-molybdenum and ferro-vanadium are other alloys which are being produced by electrical methods, either by direct reduction in the electric furnace or indirectly by means of aluminium powder and the Goldschmidt process.

GLASS

Attempts have recently been made to apply the electric furnace to glass manufacture, and at Plettenburg in Germany, and in the Tyrol, industrial trials of the Becker and Voelcker electric glass furnaces are now being made.

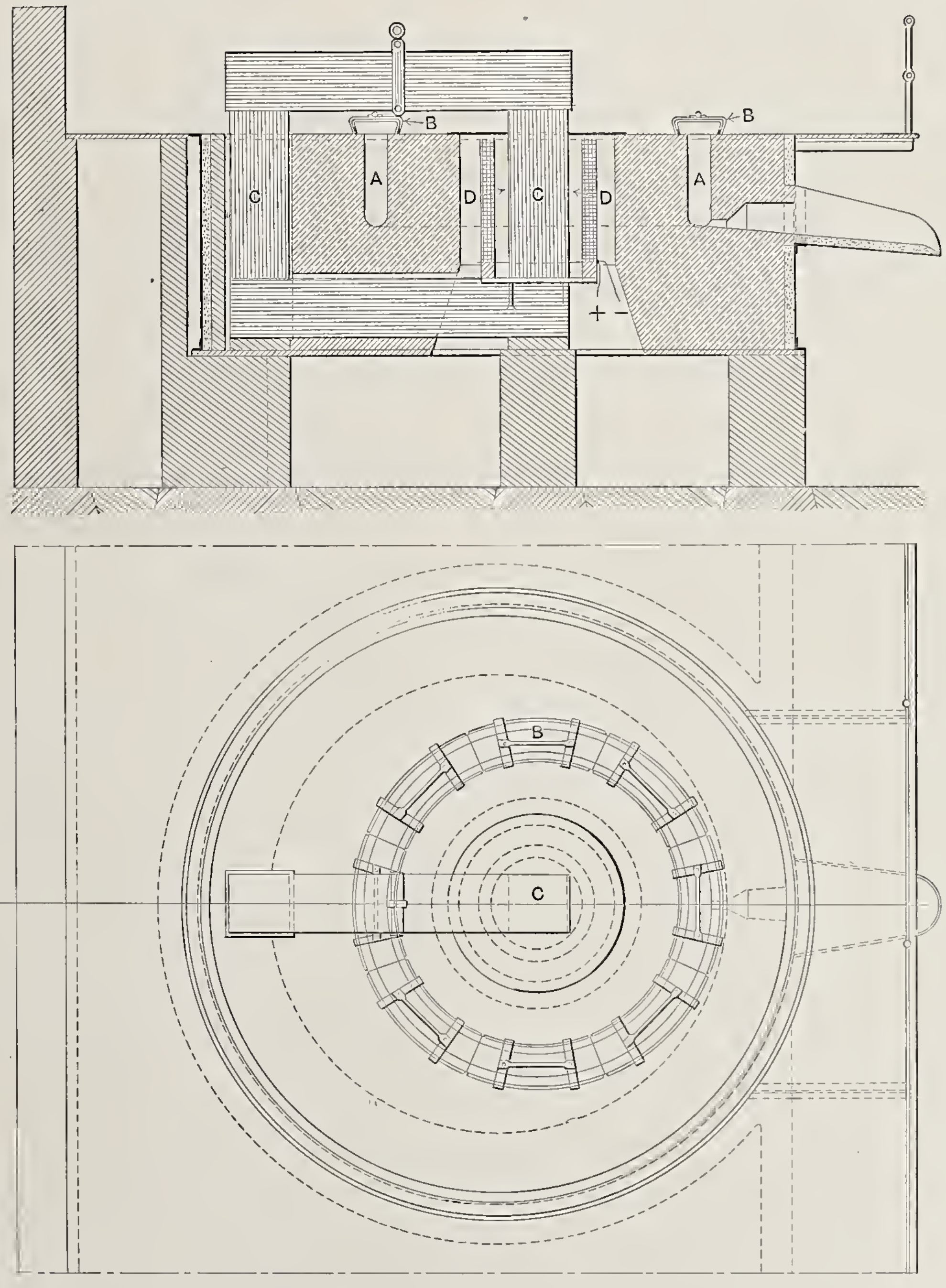
It would seem improbable that the electric furnace can compete with the Siemens regenerative gas furnace for glass reproduction, except in localities where water power can be developed at very low cost and where sand and lime exist in the neighbourhood. But for special varieties of glass, particularly for the manufacture of glass of high melting point, the electric furnace is likely to have a future.

Vessels of quartz glass for chemical purposes are in fact now being made in this manner in Germany. Quartz glass, in addition to its very high melting point, possesses great resisting power to sudden changes of temperature, and a heated vessel of quartz may be placed under a stream from a cold water tap without risk of fracture.

GRAPHITE

The manufacture of artificial graphite is based upon a discovery made by E. G. Acheson in 1891, at Niagara Falls, while experimenting with the electric furnace and the formation of

THE KJELLIN INDUCTION FURNACE AT GYSINGE, SWEDEN



VERTICAL SECTION AND PLAN OF THE KJELLIN STEEL FURNACE carbides. It was found that all carbides decomposed at a higher temperature than that required for their formation, and that the carbon separated in the form of graphite. Acheson also discovered that only a small amount of iron or silicon was required to convert a large mass of coke or carbon into graphite, and that the process worked well with the natural impurities present in certain types of coal, anthracite with high ash contents being best for this purpose.

The process of manufacture thus worked out by Acheson is now the basis of a flourishing industry at Niagara Falls, the great International Acheson Graphite Company having a large works there in which 1000 horse-power are utilized. The process is also worked at one or two small plants in Europe to protect the patent rights. The output in 1903 was 2,082,000 pounds, and the capacity of the Niagara works is being greatly enlarged, furnaces equal to 3000 horse-power being now in course of erection.

IRON AND STEEL

The electric processes for iron and steel production have now passed beyond the initial stages of their development, and this branch of electro-metallurgy promises in time to become of very considerable importance. The early attempts to use electrically generated heat for the actual reduction of the iron ore, have not, it is true, attained any marked success. It seems to be the generally held opinion among those qualified to judge, that the electric furnace cannot enter into competition with the ordinary blast furnace for production of pig iron, except in very unusual cases. But in the production of high-class steels from pig iron, and of special steel alloys from scrap of all descriptions, the electric furnace is likely to occupy an increasingly prominent position in the iron and steel industry, since all of the most successful furnaces and processes now being operated upon an industrial scale are of this description.

The writer more than a year ago stated in a previous article on this industry that the electric furnace would become, in time, an adjunct of the blast furnace, the waste gases from the latter being utilized in large gas engines to generate electrical energy, and this being then utilized in electric steel-refining furnaces to convert the pig iron into high quality steel. The correctness of this prophesy is proved by the fact that more than one such plant is already planned, and in the course of the present year both Germany and France may be able to show such a combination of the old and new processes in actual operation.

The advantages of this arrangement are that the electrical energy is obtained with no cost for fuel or water power, that the initial heat of the pig iron is preserved, and that the thermal work of the refining furnace is thus reduced to a minimum.

France is leading in the application of electric methods to iron and steel production, a result partly due to the large numbers of carbide plants in that country, with surplus power for other manufactures. The most successful of the French furnaces is that designed by Heroult and operated at Le Praz in Savoy. This is shown in the illustrations on page 246. Electric arc heating is employed, and the impurities of the iron are removed by a species of washing-out, with different slags. The daily output of the Le Praz plant is between 6 and 7 tons of steel, and the cost of the electrical energy is stated to be 6.5 per ton of pig iron. Up to the end of 1903 about 2500 tons of steel had been produced by the Heroult furnaces at Le Praz and elsewhere.

Keller, another French engineer, has designed and patented a furnace for iron and steel production, which type is being operated industrially at Kerousee and at Livet. At the latter place, pig iron is being produced from hematite ore at a cost of 44.2 per ton, of which total 9.5 represent the cost of electrical energy. Both arc and resistance heating are employed in the Keller furnace.

Gin and Girod are other French engineers who have patented electric steel furnaces now undergoing trial.

In Italy the Stessam electric furnace and process for steel production have been under trial for the past three years, and the experiments are now being continued at the Royal Arsenal, Turin, at the cost and under the control of the Italian Government. The Stessam furnace employs arc heating and makes use of ore in briquette form as raw material. It is said to be yielding iron and steel of high quality in the latest trials.

The electric iron and steel processes have not yet received industrial trial in Germany, and German engineers have not been so keen as their neighbors in France in aiding the developments of this branch of electro-metallurgy. Industrial trials of these processes in Germany may, however, be expected during this year, for the Neuhausen Aluminium Company have purchased the German rights of the Heroult process and furnace, and M. Gin has also arranged for his furnace to receive trials upon an industrial scale at Plettenberg, in Westphalia.

In Sweden the Kjellin furnace and process have been operated for two years at Gysinge with entirely satisfactory results, producing 4 tons of high-class steel per day. The heating occurs by the resistance of the mass of charged material to induced electric currents. The Heroult furnace is also being operated at Kortfors, and is producing from 6 to 7 tons of steel per day. The diagram of the Kjellin furnace on page 247 illustrates its principle. An annular groove, *AA*, forms the furnace room, the sides and bottom of which consist of refractory bricks. The covers, *BB*, close the furnace. In the center of the circle formed by the furnace room is a triangular core or cone, *C*, formed of thin, insulated copper wire, which continues outside the furnace and forms with the furnace room the two links of a chain. The coil, *DD*, is connected with the poles of an alternating-current generator.

When passing through the coil the current excites a varying magnetic flux in the core or cone, and the intensity of current in the steel is then almost the same as the primary current multiplied by the turns of wire in the primary coil. The tension of the current is naturally reduced in almost the same ratio as the intensity is increased. In this way it is possible to use an alternating-current generator of high tension, and yet obtain a current of low voltage and great intensity in the furnace,, without using transformers with copper cables of large sections and powers and costly electrodes.

In America the Ruthenberg process is being operated experimentally at Niagara Falls. This is an ore concentrating process, the crushed ore being passed between a pair of magnetic rolls and agglomerated or half melted by an electric current, for which the particles of ore form the bridge or connecting link. No industrial development of this process has yet occurred.

The Cinley furnace and process is another American patent for iron and steel production, but no details relating to the projected trial of this process upon a large scale at Messena have come into the writer's hands.

The Heroult and Keller furnaces and processes are likely to receive industrial trial in Canada at an early date, since an expert commission appointed by the Canadian Government has visited Europe during the past year, and after witnessing trials of the processes at Le Praz and Livet, has reported favorably concerning them. This commission also visited Sweden to witness the operation of the Kjellin furnace at Gysinge, and their report which was recently published contains much valuable information relating to all three processes.

The limits of space available here make it impossible to give any details of the lead, nickel, tin and zinc industries as regards electro-metallurgical processes of extraction or refining, or of the application of the electric furnace to the manufacture of new products like silicon-copper and siloxicon. In all these industries, however, with but one exception, the electrical current is being employed with increasing success.

Electric Railway Problems

THE report of the Massachusetts Railroad Commissioners contains quite startling statements as to the financial condition of the electric railways of the State. It shows, says "The Iron Age," that of 74 operating companies, 30 failed to earn expenses and fixed charges, and that of the 25 that paid dividends only 14 earned them during the year. Dividends paid decreased $371,000 as compared to the previous year, and gross liabilities increased by $2,928,000, while gross assets increased only $1,980,000. Very few companies besides keeping their railways in good order reserved for depreciation what prudent management would require. Generally present necessities only have been met, the future, with its inevitable expense for replacement and reconstruction, being allowed to look out for itself.

This falling-off in earnings is the more perplexing because much of the mileage referred to is within a 50-mile radius of the City of Boston, which territory, it is claimed, contains a greater population than any similar territory in the country, excepting New York, but not excepting Chicago and Philadelphia and their suburbs. Yet it is quite what might be expected, and the remedy is quite as apparent, to wait a little while the suburban population continues to grow, as it has been growing of recent years in ever increasing ratio.

History repeats itself. It was much the same during the corresponding period of steam railroad development. Many roads were built that did not pay for years. Some were built that have never paid. Others, the rare exceptions, were abandoned. Population and industrial business did not warrant many of the lines as investments for the time being. But the presence of the railroads developed the country until they made a population which did pay dividends by its patronage. The same is true with electric railways. Where the builders used ordinarily good judgment in selecting the country to be traversed the electric lines are building up a population, generally suburban, that will pay dividends sooner or later. Another parallel between steam and electric railway development is in the great sums of money that had to be expended in re-equipment and rebuilding the roadbed, as means and methods were improved in wonderfully rapid strides during the earlier years of, in the one instance, steam traction, in the other, electric traction. It is probably no exaggeration to assert that, other things being equal, the railroad that kept up its equipment from year to year was more economically managed and was more consistent in paying dividends than those that paid dividends first and let the matter of maintenance and improvement take care of itself.

In Massachusetts, and doubtless the same condition exists elsewhere through the Northern States, the excuse for the falling behind in earnings is the severity of last winter and the coolness of last summer. Doubtless the business depression had something to do with it. The Railroad Commissioners think this is only a part of the story. They assert:—The evil is more radical. In the early days of the change from horse to electric railway, promotion ran wild with the idea that immense profits were to be realized in the extension of the old and in the construction of new railways as electric roads in any and every direction; that where no business was in sight it would appear under the creative magic of the electric car. The test of this opinion, necessarily a test of years in which novelty disappears, is now practically complete. Experience has shown that with the more expensive roadbed and equipment, the heavier rail and larger cars, there has not been the corresponding and expected development of permanent business. Operating cost, too, in heating cars and in repair and renewal of plant has proved larger than was expected. With the new accommodation and the nearer approach to railroad conditions has come the increased demand of the public for expenditures in the interest of safety and comfort which had not been counted upon, as, for example, in construction of double track, installment of signal systems and establishment of waiting rooms. In such cases the future promises as possible events the acceptance of an unsatisfactory service as better than nothing, an increase in fares or the abandonment of the railway.

The alternative of increased fares or abandonment of the property may hit the case of electric railways situated in isolated regions, where they never should have been built. But it is poor advice to suggest letting equipment fall behind. If a railway is worth operating, it should be maintained at a reasonably high standard as far as maintenance of equipment and roadbed is concerned. Progressive street railway managers believe that more money is earned, net, where the equipment is good than where it is in poor shape, no matter where the line is located. In Massachusetts the laws and the powers given to the Railroad Commission are responsible for much of the falling off in net earnings. They are excellent laws, because they tend to increase the safety and comfort of both passengers and employees. Vestibules and air brakes, the entire avoidance of grade crossings, serviceable signal systems and other compulsory provisions rigidly enforced, cost a great deal of money. But much of this comes under the initial investment. The money has been paid. Maintenance of equipment is all essential in these companies that have fallen off in earnings, and they control the greater part of the total mileage, for they are competitors, each trying to build up its country with suburban homes and industries, each seeking the patronage that will earn dividends later on. The company that fails to realize this, or, realizing it, prefers to pay dividends to-day rather than to make necessary improvements and provide for sufficient maintenance, will in the next decade find its stock worth less money than that of its more businesslike competitor.

A lawyer for the defense in a case of speed-ordinance violation by an automobilist in England, on hearing of an electrical timing device made by Lord Kelvin, remarked:—"Oh, never mind Lord Kelvin! He is very good on taps and deep sea soundings, but I have not heard of him coming out on electricity before."

The Orpheum Theatre, in Brooklyn, N. Y., recently tried the experiment of providing a home vaudeville entertainment by means of the telephone. A specially constructed receiver was placed in front of the stage and transmitted music, songs and the like to a number of homes in the borough.

Light as a Commodity

By DR. LOUIS BELL

FEW people realize the amount of light sold yearly by the electric lighting stations in this and other countries. The gross business really rises to an amount that should command instant attention. In the United States alone, the sales at the present time run up to about $75,000,000 per year and are steadily and rapidly increasing. They correspond roughly to a consumption of 750,000,000-K. W. hours annually.

We customarily measure light in candle power, and at the usual power and efficiency of electric light the above figures mean that one would have to burn something like 2,000,000 tons of candles annually to obtain the same nominal light. Or if one prefers a linear measure for comparison, the equivalent candle would have to be 3,000,000 miles long. The consumption of gas being somewhat nearly of similar dimensions, and that of kerosene much larger, it is obvious that the country pays a tremendous aggregate price for its encroachment on the natural hours of darkness.

As there is small prospect of our countrymen taking to the simple life and doing without artificial light, this expenditure will steadily increase. It is therefore pertinent to look into some of the singular features of the trade in light and the economic peculiarities which it possesses. At the outset one must recognize the very wasteful fashion in which light is customarily used. The distant view of any city gives striking evidence of this fact. A dull glow suffuses the sky above a city visible for miles around and implying an amount of useless work that is startling in its magnitude.

When one stops to think about it, there is no real darkness about a modern city anywhere. Even at midnight there is a strongly diffused light visible. When night settles down in the country it is, save for the stars, like a pall of black velvet, and on a moonless night the darkness is impenetrable. Under city conditions one would be far from wishing darkness in this superfine sense, but on the other hand what is the use in trying to illuminate all out-door? So, too, with indoor illumination. The light furnished is usually far greater than is advantageous, and much of it does more harm than good. Broadly, then, it is well within the mark to say that there is an annual waste of many millions of dollars due to unskillful use of the illuminants purchased.

Another curious thing about light is that it is almost the only commodity in wide use of which the amount and quality bought cannot readily be measured by the consumer. If one gets short weight, or sand in his sugar, the fraud is readily detected and is subject to summary punishment. If, on the contrary, he gets less light than he is entitled to, or if it is of bad quality, the fact is exceedingly difficult to prove, and from a practical standpoint there is no recourse. One can boycott his grocer, but the supply of modern illuminants like gas and electricity is an actual or virtual monopoly nearly everywhere, and as such one cannot escape from it or bring it to account except with extreme difficulty. To the credit of the dealers let it be said that upon the whole they compare well in honesty with those in other branches of trade. The comic papers joke about the busy little gas meter as a pattern of untiring industry, but as a matter of fact it, and likewise the electric meter, is usually quite accurate, and the latter at least is likely as not to err in the consumer's favor.

The difficulty of the situation lies in the fact that the meter does not register the light-producing power of the goods delivered through it, even supposing that they are intelligently used. There is no mechanical equivalent of light in the same sense that there is a mechanical equivalent of heat, for light can be measured only in terms of what it does for the human eye, and even in this limited physiological sense, it cannot be measured with a high degree of precision. Even supposing light could be measured as exactly as one can weigh on a good balance, there is no definite standard with which to compare it.

The legal standard in English-speaking countries is the so-called standard candle, itself a rather uncertain quantity and difficult to use at that. It is much as if the sealer of weights and measures had a legal pound that varied irregularly between 15½ and 16½ ounces, and a yard that might be 35 or 37 inches according to circumstances. Add to this the hypothesis that all the weights might vary three or four ounces according as they might be balanced against pork or butter, and one can get some conception of the asperities of photometric measurements.

A definite legal and international standard of light is very much needed,—one that means the same thing everywhere and always. Such a standard is very difficult to obtain even from a rigorous scientific standpoint, being hedged about with all sorts of delicate conditions, and from a practical standpoint nothing yet proposed is anywhere nearly satisfactory. Nearly every international scientific conference has a try at the problem, but thus far the results have been far from satisfactory. Granting that a suitable standard can be found, there still remains the practical difficulty of estimating correctly in terms of it, commercial lights which vary widely in color. Until the introduction of electric lights and incandescent gas burners the color question was in abeyance, for all practical illuminants were nearly enough alike in color to be readily compared. At the present time with lights varying all the way from sickly green to purplish blue, there is trouble enough ahead to suit the most litigious temperament. Not only the amount, but the usefulness of the goods comes into question, and there is not yet available an equitable basis of settlement.

The first step, then, toward getting the trade in light upon the same basis as the sale of other commodities is to devise and legalize a suitable process for measuring it. Perhaps this will be one of the tasks for the recently organized Bureau of Standards. True enough, it is not light as such that is bought and sold, only the material for producing light, but the sale is made with an expressed or implied guarantee of quality, the fulfilment of which ought to be determinable with reasonable accuracy.

The next step must be taken by the consumer. The thing which one actually wants when he installs a gas or electric meter is not gas or electricity as such. Nor in the last resort is it merely a certain number of candle-power in light that he desires, but the power of seeing things,—that is, a certain amount of illumination at the point where it is needed. Now illumination is expressed practically in candle-feet, i. e., in terms of the illumination produced by a standard candle one foot away from the thing illuminated. As a concrete quantity it is about sufficient to enable one to read coarse print easily.

Given a 16-candle-power lamp, and bad or good illumination can be obtained from it according as it is properly or improperly used. This part of the business is strictly the consumer's; the duty of the seller of light terminates when he has delivered the goods as specified.

As a rule the consumer is none too skillful in using the light he buys. It would not be far from correct to state that at least a quarter, and often a third, of the light actually furnished is practically wasted by the user. In other words, the available light falls short by a third of furnishing the illumination that it should. Looking at the business in the aggregate, this implies a real waste of many millions of dollars per year.

As matter of practice the costly blunders made by consumers fall into two categories,—first the choice of improper lights, and second, injudicious placing of the lights chosen. The commonest mistake of the former sort is the not unnatural one of thinking that when a light looks very bright it is giving first-class illumination. But the apparent brightness of a light does not even depend on the amount of light it is giving, let alone the effective illumination. A light looks bright when its intrinsic brilliancy is high,—that is, when it is giving many candle-power per square inch of radiating surface. For example, an electric arc always looks "brighter" than a flame of equal or even greater total power, simply because the light is sent out with great intensity from a very small area. The effect of an arc in dazzling the eye is all out of proportion to the light it actually gives. In its presence the iris promptly shuts up about as far as it can, for speaking in general terms the iris adjusts itself for the brightest light in the field of vision. Thus stopped down, as one would say of a photographic lens, the eye is unable to see well the less brilliant parts of the field, which is the reason why it is so difficult to see across an arc light in the roadway. As one's ability to see things measures the visual usefulness of the illumination, it often happens that extreme "brightness" in the light hinders rather than helps.

Hence perhaps the most important single rule in planning good illumination is to keep very bright lights out of the field of view either by hiding them so that they will act by diffusion of their light from surrounding surfaces, or by shading them with the same purpose of diffusion in mind.

A well shaded arc with opal globe will really do more useful work of illumination than the same arc unshaded, although the globe may cut off a third of the total light. The same fact is true to a somewhat less degree of incandescent electric lamps, incandescent gas burners, and even bright flames. Color also plays an important part in determining the usefulness of illuminants, not only in actually judging colors, but in general use. No conspicuously colored light is as useful in enabling one to see as is a nearly white light of the same real intensity.

As regards placing lights, the usual mistake is in putting them too far from the things to be illuminated, especially in interiors finished in dark colors. In your living room, for instance, a well shaded drop light is worth two or three lights in the chandelier, and two or three lights well distributed will do much better work than a single light of their aggregate candle-power. It is astonishing to see how this principle is neglected in arranging the outlets for gas or electricity, obvious as it is. The extra cost of more outlets would generally be saved in the first year's lighting bills.

For lighting particular objects the importance of a near-by light, often fitted with a reflector, is well known, but it should be backed up by some general illumination or the light will look patchy and will hurt the eyes much as they are hurt by coming suddenly into a bright room. Sometimes excellent work can be done with very bright and efficient lights deliberately put far enough off to be out of the field of view, but this works well only in rather large spaces. On the whole, one is likely to err in the direction of needless brightness. A very moderate amount of light carefully distributed will do more good than the usual lavish methods.

From an economic standpoint the average arrangement of lighting is bad because it is relatively ineffective, and the study of methods of illumination would pay the consumer handsomely. If one-quarter of every barrel of flour purchased were, on the average, eaten by rats, the "Pied Piper" would be years behind his orders, yet the average well-to-do man pays annually more for light than for flour, and the waste does not even make a rat the sleeker. It is uncompensated loss.

Another electrical device which has been added to the equipment of automobiles is an indicator which, by the pressing of contact buttons, directs the chaffeur to the right, left, home, and the like.

New York Telephone Statistics

FROM particulars kindly supplied by the New York Telephone Company, it appears that the number of telephones in service and under contract in the city of New York, in the boroughs of Manhattan and the Bronx, on February 15, 1905, was 155,991. Ten years ago the number of telephones in the same territory was 14,975. These figures show that the average yearly increase since 1895 has been over 100 per cent.

Although, apparently, this great telephone system has been only a matter of orderly growth from year to year, it has been, nevertheless, an extremely difficult problem to render an efficient service to the vast army of ever-growing telephone users.

The expense of maintaining an efficient telephone service in New York City is greater than that of any other city in the world. It is an acknowledged fact that the cost per telephone for rendering service increases as the number of telephones in the system increases, and it is also generally recognized that the cost of labor, supplies, and almost everything in fact, is higher in New York City than elsewhere.

Still another feature which has been most expensive for the company has been the fact that telephone equipment has not been on a settled basis. The art has been continually changing, and each year has seen new and improved equipment put on the market. This equipment the company has been obliged to buy and install, discarding the old equipment which the new supplanted. It is stated that within the last few years the entire plant of the local company has been renewed three times in order that the equipment and resulting service might be brought up to the highest standard.

That portion of the plant which is located in the boroughs of Manhattan and the Bronx is almost entirely of underground construction, and as it is operated on the common battery basis, the service is quick and efficient.

The force is most carefully trained, and although the number of exchanges on Manhattan Island alone is seventeen, yet the local service, due to the high development of the operating methods, is as rapid and as satisfactory as though all the subscribers were connected with one central office.

The management of the telephone business in New York City has been most consistent and businesslike. Highly efficient service brought within easy reach by a rate system based on a reasonable charge per message has been the cause of the tremendous development evidenced by the number of telephones in service to-day.

The Progress in Wireless Telegraphy

By WILLIAM MAVER, JR.

THE possibility of telegraphing without wires by means of electric waves in free space was demonstrated when Dr. H. Hertz, in 1887 and 1888, holding a so-called "electric-eye," consisting of a ring of copper wire about 16 inches in diameter and broken at one point, a few feet from the spark gap of an induction coil, or oscillator, was able to detect minute sparks jumping across the break in the copper ring.

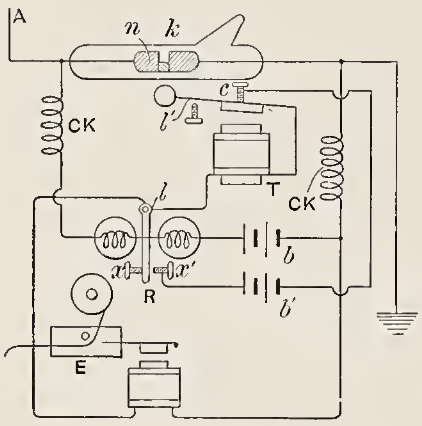


FIG. 1.—MARCONI FILINGS COHERER AND TAPPER. A, VERTICAL WIRE; *k*, COHERER; T, TAPPER; R, SENSITIVE RELAY; *bb'*, BATTERIES; E, MORSE RECORDER; CK, CHOKE COILS

In 1889 Dr. Branly discovered that metal filings, which, when made part of an electric circuit, had normally a very high electrical resistance, but became good conductors of electricity when electric oscillations were set up in the circuit, and that they retained their conducting qualities until shaken.

The art of wireless telegraphy took a long forward step when, in 1894, Dr., now Sir. Oliver Lodge made his notable experiments before the Royal Institution, in which he used, as a transmitter of electric waves, the Hertz or Righi oscillator, and as a detector of those waves, the Branly coherer, consisting of a tube filled with metal filings, in an electric circuit containing an electric bell. To insure that the filings would resume their non-conducting state upon the cessation of the electric oscillations, Dr. Lodge caused a "tapper," operated by clock-work, to strike the tube continuously. A bell or relay in the coherer circuit could thus be kept in vibration during the continuance of electric oscillations and would become passive when the oscillations ceased, and in this way signals could be transmitted. Lodge believed that the limit of sensitiveness of this apparatus would be half a mile, but even this distance advanced the signaling distance four hundredfold beyond the point at which Dr. Hertz had left it.

The art, however, received its most powerful impetus when Marconi, in 1898, using vertical wires, 80 to 100 feet high at each station, a 10-inch spark induction coil, and an improved Branly-Lodge coherer, succeeded in transmitting wireless signals a distance of about 40 miles, which distance within another twelve months, by using still higher vertical wires and more improved apparatus, he increased to 280 miles over water. See Fig. 1.

The writer on other occasions has remarked that had the progress of wireless telegraphy rested with Hertz's discovery of the copper ring detector, its utility for commercial purposes would have been very limited, in fact, nil, since the utmost distance at which signals can be detected by that device is about 8 or 10 feet.

Improvements in the construction of the filings coherer, together with an increase in the number, height and arrangement of the vertical wires, render it possible to receive signals by this form of detector a distance of 200 or 300 miles in favorable circumstances. Still, had there been no other receiving instrument forthcoming than the filings coherer, it is probable that the advance of the art would be more or less hampered, for not only would the signaling distance be limited, but the rate of signaling would more than likely have been kept at from ten to twelve words per minute, for the action of the filings coherer, it may be said, is inherently sluggish in the production of perfect signals, the cohering and "tapping back," combined with the inertia of the moving parts of the tapper, the relays, etc., all tending to that result. Possibly the limitation to the signaling distance due to the lack of sensitiveness of the filings coherer could be somewhat compensated for by the use of higher masts and greater electrical energy at the transmitting station; but this would be at additional expense, and probably would also be accompanied by a further reduction in the rate of signaling. The difficulty of adjusting the coherer and its tendency to get out of adjustment are also drawbacks to its use.

It was, therefore, very obvious to all concerned in the art of wireless telegraphy that a thing much to be desired was the invention or discovery of a coherer or detector which would, so to speak, "close" automatically on the occurrence of electric oscillations, and "open" automatically when the oscillations ceased, or vice versa. As frequently happens in such cases, this desideratum was not very long in forthcoming.

One of the first devices that bore promise of fulfilling the foregoing requirement is known as Schaefer's "anti-coherer." This consists of a silver film deposited on glass. Across this film slits are traced, this being covered by a thin layer of celluloid. When the silver film is made part of an electric circuit it is found that the resistance of the circuit rises when electric oscillations are set up therein, and when the oscillations cease, the resistance automatically falls. This action, it will be observed, is the reverse of what occurs in the Branly filings coherer; hence the name of anti-coherer. It has been surmised that the effect of the film of celluloid which does not penetrate into the interior of the slits is to prevent the dissipation of the particles of silver in the slits, and whose motion under the influence of electric oscillations probably accounts for the variations in the resistance of the circuit. Carbon filings were also found to decohere automatically; but these devices were not extensively used in practice, if at all.

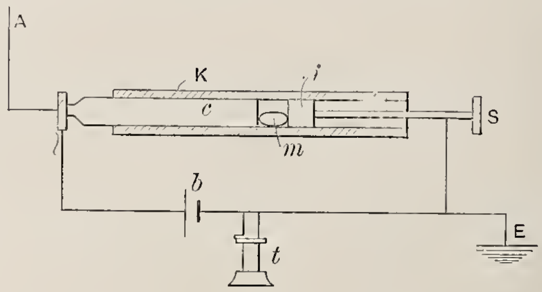


FIG. 2.—THE CASTELLI AUTO-COHERER. A, VERTICAL WIRE; K, COHERER; *m*, DROP OF MERCURY; *c*, CARBON PLUG; *i*, IRON PLUG; S, ADJUSTING SCREW; *b*, DRY CELL; *t*, TELEPHONE RECEIVER.

Perhaps the next most important auto-coherer was that due to Castelli, known for a time as the Solari coherer. also as the Italian Navy coherer, Fig. 2. This auto-coherer was used by Marconi in his first experiments in transatlantic wireless telegraphy. It consists of a tube similar to the filings coherer, but instead of metal filings between the ends of the iron or carbon rods within the tube, a drop of mercury is employed. In the circuit with the coherer there are a small battery and a telephone receiver. On the arrival of electric oscillations the mercury coheres to the carbon or iron, with the result that the resistance decreases, and vice versa, the variations in the resistance of the circuit setting up noises in the telephone, which can be read as dots and dashes when messages are transmitted.

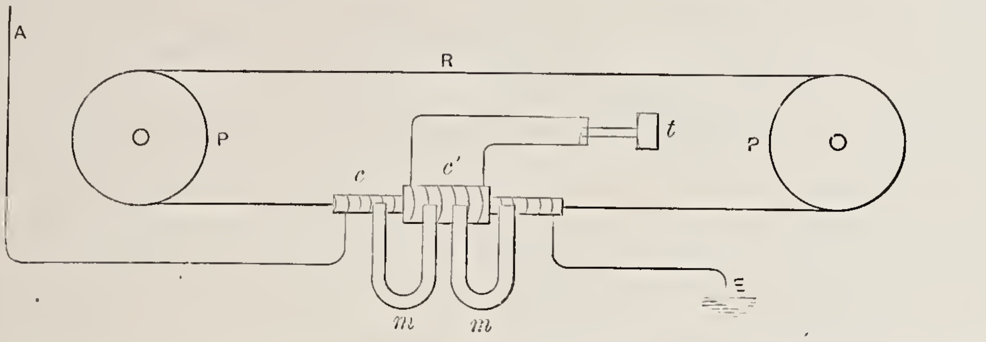


FIG. 3.—MARCONI MAGNETIC DETECTOR. A, VERTICAL WIRE; E, GROUND; *c*, INNER COIL OF WIRE; *c'*, OUTER COIL OF WIRE; *mm*, PERMANENT MAGNETS; PP, PULLEYS OPERATED BY CLOCK WORK; *t*, TELEPHONE RECEIVER

Subsequently Marconi devised an auto-coherer, known as a magnetic detector, Fig. 3, which has been used in his transatlantic and other long-distance experiments. This coherer consists of a primary and secondary wire, the inner wire of which is connected to the vertical wire in a manner practically similar to that in which the filings coherer is connected. The outer wire contains in its circuit a telephone receiver, but no battery. A rope of iron wires is caused to pass through the inner coil of wire longitudinally, by means of clock-work operated pulleys. Two horseshoe magnets are in proximity to the coils, as indicated in the figure, with their like poles adjoining. This detector of electric waves is based on the observed fact that when a magnet, such as the moving iron core, is caused to undergo slow changes of magnetism, electric oscillations in the inner wire bring about rapid changes in the magnetism of the core, which, in turn, set up currents in the outer coil, and these are heard as sounds in the telephone receiver. De Forest and Shoemaker have also devised and operated magnetic detectors.

In the United States, De Forest and Fessenden have also devised auto-detectors. The De Forest auto-detector, termed a "responder," comprises a tube, with the usual rods or plugs running into the bore. Between the inner ends of the plugs is placed a viscous substance, such as glycerine, in which some lead oxide is suspended as a depolarizer. In series with the tube are a small battery and a telephone. Normally, the battery sets up an electrolytic action which tears off particles of tin from the positive electrode that "bridge" over the space between the ends of the plugs, with the result that the resistance of the circuit is much decreased. Incoming electric waves, however, establish electric oscillations in the responder circuit which disrupt the threads or bridges, whereupon the resistance is at once greatly increased.

These variations in the resistance of the circuit are readily indicated in the telephone, and thus when the train of electric waves is broken into dots and dashes of the Morse code, messages are easily received. This instrument, it will be observed, is of the anti-coherer type.

The Fessenden detector, termed the hot-wire barretter, employs a different principle from either of the foregoing. Fessenden takes advantage of the facts that an electric current increases the temperature of a conductor through which it passes, and that an increase of temperature of the conductor increases the electrical resistance of the conductor, and contrariwise. He, therefore, employs a very thin loop of platinum wire, contained in a small glass bulb, the whole so disposed that heat will be quickly conducted from the platinum wire. In the circuit of this loop he includes a small battery and a telephone receiver, suitably connected with the vertical wire. When oscillatory currents are set up in the circuits, rapid variations of the temperature of the platinum loop, and corresponding variations in the resistance of the circuit, are produced, these, in turn, affecting the telephone receiver practically as in the instances already given.

More recently, both De Forest and Fessenden have employed a device as receiver which is termed by De Forest an electrolytic detector and by Fessenden a liquid barretter, upon the ownership of which the courts are now deliberating. This device consists of an exceedingly fine platinum wire immersed in a dilute acid or alkaline solution, Fig. 4. According to Fessenden, the operation of this device is due to the fact that a minute wall of high resistance surrounds the fine wire in the liquid, and this develops heat which increases the resistance. Electric oscillations momentarily decrease this resistance. Hence it is a heat-operated detector. De Forest contends that its operation depends on polarization effects, a counter electromotive force being set up normally by the small battery *b*, which is momentarily dissipated by electric oscillations. Slaby-Arco also use a practically similar detector, credited to Schloemilch, the action of which is ascribed to polarization effects.

This detector was employed last year by De Forest in the operations in the war zone in the Far East, where its great sensitiveness, its reliability and practicability were thoroughly and successfully tested.

Lodge-Muirhead employ in their wireless system an auto-detector termed the oil-film coherer, Fig. 5. It consists of a steel disc whose lower edge rotates by clock-work in a vessel containing mercury. Normally, the disc is prevented from making contact with the mercury by a film of oil.

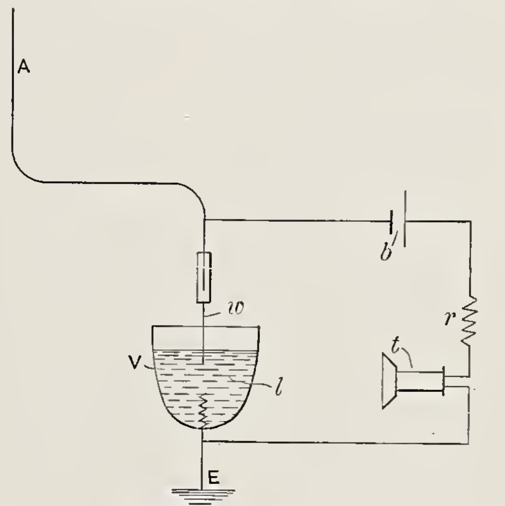


FIG. 4.—A, VERTICAL WIRE; E, GROUND; *w*, FINE WIRE; V, VESSEL CONTAINING SOLUTION *l*; *b*, DRY CELL; *r*, VARIABLE RESISTANCE; *t*, TELEPHONE RECEIVER

When electric oscillations arrive, the disc and mercury cohere with the well-known result.

By reason of the sensitiveness of the telephone receiver, utilized in connection with auto-detectors, changes of current that would not affect a relay are observable in the former instrument. Hence, by the use of the auto-detector much weaker electric waves are detected than would be the case with the filings coherer. Furthermore, the auto-coherer responds instantaneously, so that a higher rate of signaling is obtainable by its means, a speed of forty words a minute having already been obtained by De Forest.

Important improvements have also been made in the matter of syntonic, or tuned, wireless telegraphy, by means of which it is hoped to eventually transmit two or more different messages at the same time to and from the same stations. Thus far, however, it does not appear that this desirable result has been satisfactorily accomplished. But by means of tuned circuits the principle of sympathetic resonance is brought into play, and thus, with a given amount of electrical energy at the transmitter and a detector of given sensitiveness, it is feasible to transmit messages to a greater distance than would be the case with untuned circuits. By means of tuning also it is found feasible to cut out the interference from neighboring transmitting stations to a considerable extent.

For long-distance transmission Marconi, De Forest and others have successfully resorted to the use of dynamo machines for the production of electric oscillations of much greater energy than are obtainable by the most powerful induction coils. The height and number of vertical wires used in long-distance transmission have also been augmented, towers 250 feet high, with fifty or more vertical wires, being employed by the Marconi Company at some of its stations.

Considerable progress has also been made in telegraphing overland without wires, by means of portable outfits. for military purposes, the bulk of the work of this kind having been done by Siemens & Halske, of Berlin, Germany, using the Braun system. The apparatus is transported on carts, and the vertical wire is elevated by means of a captive balloon, or, in fair weather, by kites. The distance to which signals can be transmitted by this apparatus is said to be 60 miles, and it is anticipated that within a short time all the important armies of the world will be supplied with apparatus of this general type.

Lodge and Muirhead have also devised apparatus for military wireless signaling, using in connection with their system comparatively short masts and wire netting for the antenna. In the United States long-distance experiments overland are now in progress by the De Forest Wireless Telegraph Company. Messages were recently exchanged between Chicago and Key West, Fla., a distance of over 1000 miles. The masts at their stations are over 200 feet in height, and the power of the transmitting apparatus is about 30 K. W. The Marconi Company and the Slaby-Arco Company, in Europe, have also conducted successful long-distance overland tests in Europe.

The most important practical use to which this art has yet been put, however, is that of making possible communication between vessels at sea and between vessels and the mainland, which would still appear to be its greatest sphere of usefulness, and every week sees a larger number of vessels equipped with wireless telegraph outfits.

On the Atlantic Coast the United States Navy Department already has in operation fifteen wireless telegraph stations, extending from Portsmouth, N. H., to Key West, Fla. It also has stations in Cuba, Porto Rico, Panama, at San Francisco, Cal., and in the Philippine Islands, and when the plans are completed there will be under the jurisdiction of the Navy Department about seventy-five or eighty coastwise wireless stations, in addition to which there will be many more similar stations under control of the Signal Corps of the United States Army. All the United States warships and torpedo boats will ultimately be equipped with wireless outfits, a large number being already thus equipped, principally with the Slaby-Arco system. The coastwise naval stations will receive messages for and from passing private vessels without charge, under certain conditions which have been laid down in rules formulated by the United States Navy Department. The principal navies of the rest of the world are also being equipped with wireless telegraph systems, the British and Italian warships using the Marconi apparatus, the German and some other navies the Slaby-Arco, while the French Navy uses mainly the Rochefort system.

On the Gulf of St. Lawrence and on the river of that name there is now a series of Marconi wireless stations reaching from the Straits of Belle Isle to the city of Quebec. The De Forest Company has stations on the Great Lakes, at Buffalo, Cleveland and Chicago, while the Fessenden Company is beginning the installation of a line of twelve stations extending from Para, at the mouth of the Amazon River, to Manaos, 1000 miles up that river.

Many of the steamships plying between New York and Southern United States ports, as well as those sailing to West Indian and South American ports, are now equipped with wireless telegraph systems, by means of which their progress is signaled from various points. Even the inland steamboat lines, such as the Fall River line, are now equipped with wireless outfits, and numerous harbor tugs have also fallen into line.

In Great Britain and Europe the utilization of this new art has even been greater than on this side of the Atlantic. The British Government has recently completed arrangements whereby telegrams to and from Atlantic liners will be handled by the Post-

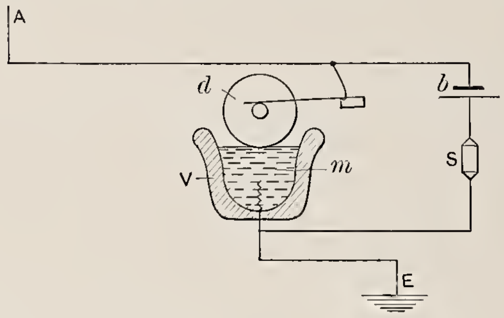


FIG. 5.—LODGE-MUIRHEAD DETECTOR. A, VERTICAL WIRE; E, GROUND; *d*, ROTATING DISC; V, VESSEL CONTAINING MERCURY *m*; *b*, DRY CELL; S, SIPHON RECORDER

office Department, with six Marconi wireless stations on the coast of England and Ireland. An arrangement of this kind has been for some time in operation in Germany, Italy and also in Canada, by which an interchange of business between vessels and the shore and to distant points via land lines has been successfully carried on.

The absolute control of wireless telegraphy is now vested in the governments of Europe and Great Britain.

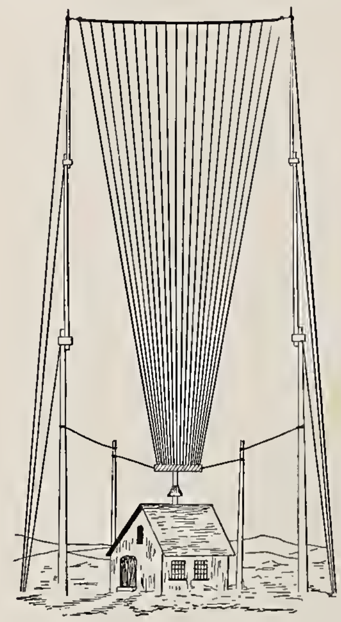


FIG. 6.—DE FOREST 2-MAST ARRANGEMENT FOR 20 WIRES AT A LAND STATION

and in the latter country the control extends to ships flying its flag wherever they may be. Thus far the United States Congress has not moved in this matter, although the board appointed by the President to report upon the wireless situation has recommended that legislation be enacted placing the control of private stations under full Government supervision, in order that they may be regulated for their own best interests, for the public welfare and for consideration of national defense.

Transition to Electric Power

The Increase of Short-Distance Transmissions

By ALTON D. ADAMS

SEVERAL years ago there was in the United States an extensive movement of manufacturers to the natural gas fields. The main object of this migration was the advantages of cheap power and fuel in industrial operation, and it afforded simply one of many illustrations of the general tendency for production to advance along the most effective lines. In the long run industries surely tend toward the most advantageous locations and methods.

Water-powers have long been attractive to manufacturers, and many have come to be great centers of industry. This has been especially true as to large works, or those in which the cost of power is a very important factor. In few cases have a large number of small industries, each deriving its energy from an independent water-wheel, been grouped about a water-power. In spite of some apparent advantages of water-powers, their development proceeded but slowly prior to the introduction of electrical machinery, owing largely to the heavy investment necessary to fit them for use and the smallness of the number of manufacturers for whom they could be made available.

Though the use of electrical machinery on an extensive scale to distribute the energy of falling water dates back little more than a decade, it is safe to say that the greater part of the work done by water-power is now delivered by dynamo equipments. In quite a number of cases the special conditions necessary to warrant very long transmissions seem to exist and they are being carried out. There is little to indicate, however, that these long-distance transmissions will ever be of more than comparatively trifling importance to the manufacturing industries. While long-distance electrical transmissions, in a few instances, have caught the public eye, short-distance transmissions, in a great number of cases, have quietly exerted a wide influence as to centers and methods of production.

Transmission of electric power has seemed advisable to some distant places where fuel is high; transition to electric power has proved economical from many points where fuel is low. In the former case, scattered industries are supplied with power at a comparatively high price; in the latter, large groups of factories receive power at a comparatively low price. Transmission of electric power is seen in the power supply to mining plants in the western districts of the United States, for example, while transition to electric power is illustrated at Niagara Falls. The concentration of manufactures about Niagara is being duplicated on a smaller scale at many other points where the energy of falling water is distributed through electrical equipment.

It seems hardly possible that a just appreciation of the value of water-powers has been lacking until the last decade, and some other reason must be sought for their present rapid development. The obviously new factor that has been introduced in connection with water-powers is electrical equipment, and it is pertinent to inquire, therefore, in what way it tends to increase their advantages. The development of a great water-power usually involves a heavy investment, and the amount grows larger as the number of, and the distance between, points at which wheels are located increases. If a long canal must be built to carry the water to numerous users, and if a large number of small wheels and pits must be provided, the outlay is obviously much more considerable than that for several large wheels grouped together. To make a great water-power available for a number of manufactures and its total use possible, without the aid of electrical equipment, usually involves a much larger first cost than is necessary with such equipment.

With dynamo machinery to distribute the energy, the question to be decided in the selection of each generating unit is not what power each industry will require, but the best size of unit, considering the total amount of water and the probable demands for electric energy. A natural result is the smallest possible first cost for generating machinery. In short, the delivery of all water-power electrically makes the compact and economical arrangement of all hydraulic works and apparatus easy, however widely the users of the energy may be scattered.

With any practicable extension of a purely hydraulic power system the locations for manufactures are very limited in extent. This fact works to the disadvantage of the power enterprise and its patrons in two ways. It may well happen that the mill sites are all occupied by industries that do not consume the entire, or even a large part of the available power, which must thus remain unsold. Even though enough factories can be located on the mill sites to make use of the entire water-power, the limited extent of these sites is sure to give them a rental value that largely offsets any advantage of cheap power rates.

A further disadvantage resulting from the restricted areas of mill sites, in connection with hydraulic plants, is the barrier that exists to the sale of power among various consumers at different hours of the day. As is well known, the energy at many water-powers is available twenty-four hours per day. Most manufacturing plants, however, require power only ten hours per day, so that water during the night goes to waste. Where all of the hydraulic mill sites have been taken, more than one-half of the total energy may be unavailable, though it would be worth large sums to chemical or other industries that use power during the entire day.

Large water-power systems must usually be entirely devoted to the purposes of manufactures on an extensive scale, as it is not considered desirable or practicable to divide water privileges into very small units. A consequence is that manufacturers who require power in only moderate quantities have derived little advantage from the development of purely hydraulic works. In view of the limitations just considered, it is not remarkable that many important water-powers remained unimproved so long, as canals and pipes were the only means for distribution. Whatever the form of energy desired by the patron of a hydraulic power system, be it mechanical work, heat, or electricity, a water-wheel must first be erected and the power thus developed changed to the required form.

With electrical distribution only a small space is necessary for the few large wheels and dynamos that absorb the entire energy of the water. Mill sites, instead of being confined to a little land along the banks of a river or canal, at once expand to include the territory within five, ten or a greater number of miles from the generating plant. This expansion of service area affects the number and character of power users. The number of industries is limited only by the water available, and the capacity of each may be either great or small. Since mill sites have come to include all the land within a long radius that is not required for other purposes, the opportunity to buy cheap power has only a slight influence on rents. Almost the entire saving in the cost of power is thus free to be divided between the water company and its patrons.

A distinct feature of electrically distributed water-power is the advantages it offers to manufacturers of small and medium capacity. The consumer of 100 horse-power will probably have to pay somewhat more per unit than the consumer of 1000 horse-power, but the difference in rates will represent only a small fraction of that in cost which would result were a separate water-wheel installed for each case.

One of the most obvious results of electric water-power distribution is the rapid growth in the vicinity of such powers of distinctly manufacturing concerns, whose very existence depends on the cheap rates at which energy is distributed. With free competition, the advantages of cheap power are sure to have an effect in a reduced price for the products. These reduced prices react through a larger demand to hasten the development of industry at the centers of cheap power. Society at large is benefited by the increased rate of return on labor and capital in each particular line, and consumers are benefited by the satisfaction of their desires at lower prices. As in most advances of industry, some have to suffer. In this case manufacturers of similar goods, using more expensive power, are at a disadvantage. Such disadvantage may reduce profits, cause a movement to the cheap power, or drive some out of the business, according to the extent to which manufacturing power enters the price of any particular product.

It is interesting to note that the results with electrically distributed water-power are different from what some have expected. Electric energy, it was claimed, for example, would go great distances to the factories; as a fact, however, the factories have gone greater distances to the electric power. Location and other advantages being equal, it is found more economical to move an industry once than to move a large amount of energy to it over a great distance daily. Increase of transmission voltages may reduce, but it cannot eliminate, the costs and losses of electric conductors. For very long transmissions the fixed capital in conductors, pole lines, and the extra machinery necessary for the several transformations bears interest, per delivered unit of energy, that might well cover the entire price for such unit near the generating plant. In the future, as at present, long-distance transmission of electric power must be the exception for special cases, and transition, to within a few miles at most of cheap sources of energy, the rule for the great majority of industries served.

Electrolysis of Bridge Members

By A. A. KNUDSON

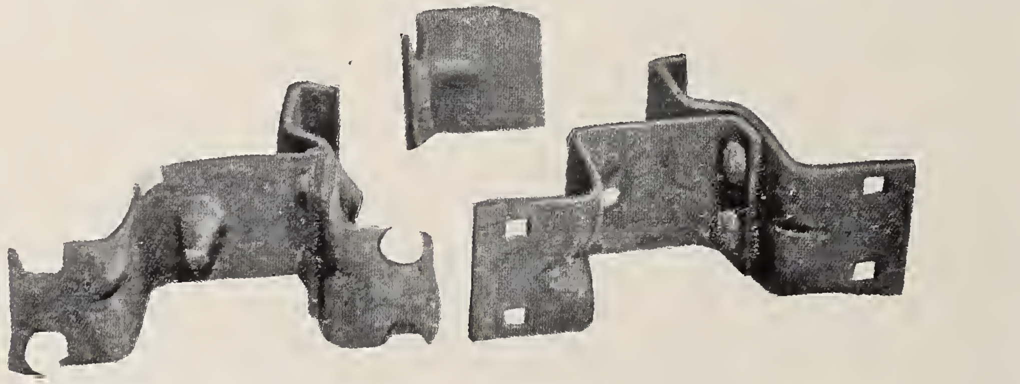
According to a report of the New York State Engineer, an examination of a bridge in Rochester, spanning the Erie Canal and carrying electric railway tracks, showed that the floor beams had lost from 10 to 20 per cent. of their metal through ordinary corrosion.

It was found that the flanges of the rails had worn into the flanges of the floor beams through the impact of the passing cars. In some parts of the structure the flanges of the beams had worn to such an extent that the rail base actually cut into the vertical web plates. Upon investigation it was found, too, that the ends of the steel beams in certain places had been burned.

The State Engineer gave as a possible explanation of this, the arcing of the current between the steel beams and the ends of wooden stringers when wet. The stringers which had formerly supported the rails of the track had been removed, so that it was impossible to describe their appearance. In the engineer's opinion, the burning of the steel beams was not sufficient to cause any injury to the bridge, and there was no evidence of the action being due to electrolysis.

It is quite natural that ordinary corrosion should be discovered at various points on any bridge or metallic structure exposed to the elements or to continual moisture. The "possible explanation" in the report, of the burned appearance of the steel beams being due to the arcing of the current between the beams and the wet stringers, however, is more likely to be a case of electrolysis. The same thing has often happened before, and is quite common where rails or rail chairs rest upon wooden stringers or ties set in soil usually wet. The bottom flanges in some such cases have been found practically destroyed.

An illustrative case is presented in the accompanying cut, which shows some chairs removed from a street railway track.



CORRODED RAIL CHAIRS REMOVED FROM A STREET RAILWAY AT PEORIA, ILL.

The two flanges which were spiked to the ties at their base were in contact with the moist earth both outside and inside when in place, making a convenient outlet for the current from the rails to earth and water mains. The chair at the left has been so reduced by electrolytic action at its base that its original shape is lost.

This will be seen by comparing it with the one on the right, which is not so damaged. Although damage to the rails does not much concern us in the case of the Rochester bridge, the illustration is useful in showing a clear case of electrolysis under probably very similar circumstances to the one mentioned.

In the absence of any reported electrical measurements, it is not well to accept as final that no electrolysis exists, simply because in the engineer's opinion there is no evidence of such. On the other hand, it would seem that the appearance of the beams as having been burned at places can more reasonably be explained on the basis of electrolysis rather than of arcing between the steel beams and wet wood.

It is quite evident, however, from the engineer's report, that a heavy flow of trolley current is passing into the bridge, thence finding its way to the canal, and back to the power house by the canal as far as the latter offers a conducting path. The important point to note is not so much the condition of the damaged parts here and there that can be seen, as the condition of the parts hidden deep in the soil, concrete or masonry, such as the anchor bolts, etc. Current is just as liable to be leaving such places as any others about a bridge, and it is well known that where current leaves metals, electrolytic action takes place.

In any case, evidence discovered by proper instruments of trolley current flowing into a bridge should be regarded with grave concern by those responsible for the safety of such a structure, for the simple reason that this current must come out and may cause damage at unseen and unknown points. In every such case it should be made incumbent upon electric railway companies to keep their currents entirely out of such structures.

It is probable that in this country nine out of every ten iron bridges over which trolley roads run are suffering more or less damage from electrolytic action, particularly where they span waterways.

In may cases it is the practice to lay rails directly upon the cross girders of a bridge. This is not only detrimental to the bridge as explained, but to any water or gas pipes placed upon it, as in such case where the mains touch the metal work, the effect is equivalent to the rails being bonded to the mains. Many such cases have been discovered by the writer.

The effect of electrolysis upon steel or wrought iron is quite different from that upon cast iron; in the case of the former there is a melting away of the metal, as shown in the rail chairs illustrated, and in some instances it may easily be mistaken for burning through arcing. The effect of electrolysis upon cast iron, however, is to produce soft spots in the metal, resembling graphite.

In San Francisco there is one telephone for every four families; in London, one for every sixty; in New York, one for every twelve, and in Boston, one for every six families.

Developments in Electric Traction

THE paper on "Developments in Electric Traction," read by W. B. Potter at the January meeting of the New York Railroad Club, and abstracted in the February issue of The Electrical Age, was again the subject of discussion at the meeting on March 17.

In opening the discussion, Mr. Potter stated that the systems of electric traction might be summed up in three classes:—Direct current, for concentrated traffic and frequent stops over short distances; single-phase, for similar traffic over longer distances; and three-phase, for long distances and infrequent stops. He concluded by expressing a wish to hear from the steam railway men present.

N. W. Storer said that two points were brought out prominently in the former discussion, one being that electricity was to have a large place in railroad work in the future, and the other that the third rail, however well it had served its purpose in the past, would not fill all the requirements for heavy and high-speed work. It was lacking in one element—it was an obstruction and a constant source of danger in spite of protection. In planning the electrification of steam roads, the speaker said, conservatism must be the rule. The steam locomotive was doing its work and electricity must give something better before taking its place. In conclusion, Mr. Storer discussed the advantages of direct-current, single-phase and polyphase systems.

A. H. Armstrong said that he had always had drummed into him that the goal of the electrical engineer was the electrification of steam railroads. The question, however, was one of finance rather than engineering. Heretofore electric locomotives could not give economies over steam locomotives, but the art has so developed that the electrical engineer is justified in making a proposition to equip a steam road electrically, partly or wholly. In choosing generating and distributing methods for a large system, each section should be considered by itself, for a section including a long, heavy grade will be different from others. The operating expenses of such a section should be separated from those of other sections. He believed that the polyphase system had been overlooked in single-phase development. As to which system will prevail, local conditions make it impossible to state which is for the future.

I. C. Hubbell said that although improvements are being made in the electric locomotive, the same is true of the steam locomotive. He ventured to predict that within five years the latter would be capable of giving a horse-power on 18 pounds of water per hour, as against the present 22 pounds of water.

A. M. Waitt expressed the opinion that electric traction would be adopted not only because of increased economy, but also because of other advantages. The incandescent lamp had been adopted, not because of greater economy, but because of added advantages. The third rail, in his opinion, was to be the current-carrier of the future, because of the absence of danger in freight yards to the men on car roofs, and because there is no room for overhead wires, with the complicated crossings, switches, and the like.

F. J. Sprague said that in a good many years the steam locomotive will be found at the old stand. Regarding the third rail, he expressed his belief that the experiments on the New York Central will show a rail which will settle some of the difficulties formerly met with. Mr. Potter, in concluding, also gave this as his belief.

Car Fares Based on Size of Passengers

AN American inventor, in behalf of a combination weighing and measuring machine which he is offering to railroad people, argues that passengers should be charged fare according to their weight and the space they occupy in a car, rather than according to their age, as is the present custom.

In connection with this, "Railway and Locomotive Engineering" prints the following story, showing that in Switzerland a somewhat similar rate of fare is in use:—

"When we reached Switzerland," said the tourist, "we found in the railway stations, alongside of the ticket office, machines for measuring the height of children. I said to the agent at Geneva:—

"'A half ticket for my little girl.'

"'Isn't she too tall?' the man asked. 'Let her step on the measurer, please.'

"My daughter's height was duly taken. It was four feet five.

"'All right,' said the agent. 'She passes, after all.'

"Then the man explained to me that on account of innumerable disputes over the age of children half fares were now sold in Switzerland according to height instead of according to age. Children under three feet traveled free. Those between three feet and four feet six, paid half fare. Those over four feet six, paid full fare. All the measuring is done at the ticket office."

Fog Dispersion by Electricity

A Description of Sir Oliver Lodge's Method of Dispersing Fog by the Discharge of Electricity

By LIONEL LODGE

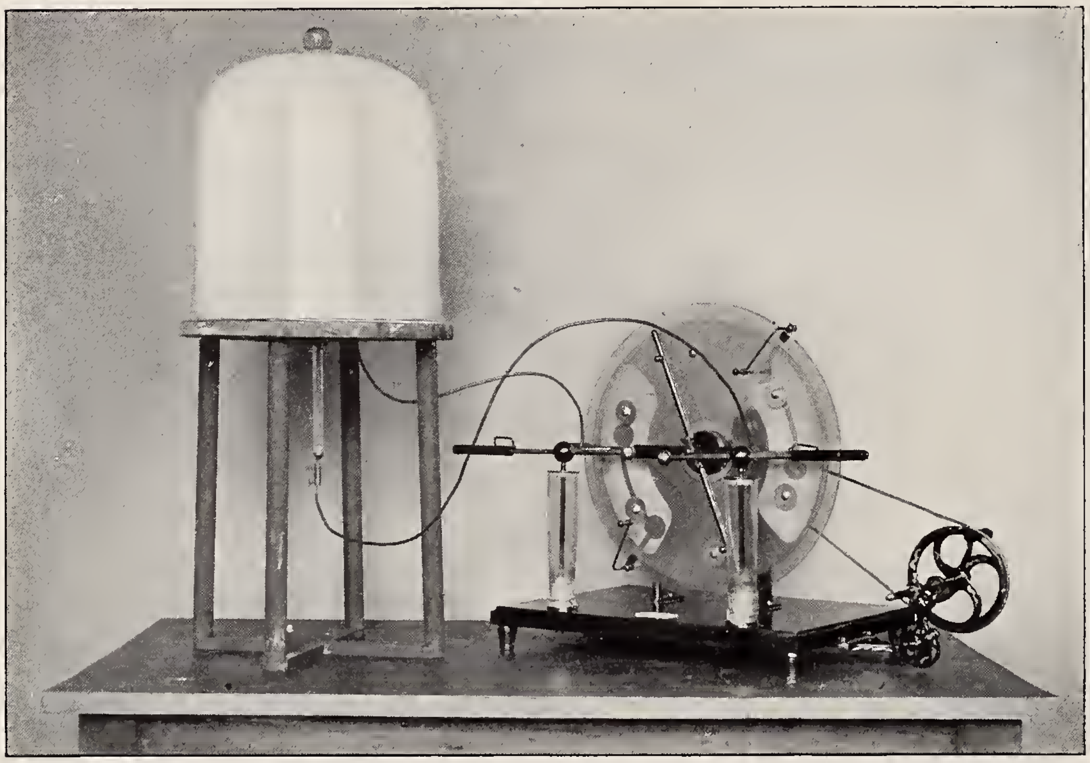


FIG. I.—BELL JAR FILLED WITH FOG, AND ELECTRO-STATIC MACHINE, REPRESENTING THE OLD LABORATORY EXPERIMENT OF 1884.

IT seems remarkable that no attempt has yet been made to overcome the fog nuisance, especially in the towns where the actual loss for each foggy day has been calculated at about £150,000. Certainly it would be far better not to make fogs, but as it must be a long time before the open coal fire is banished from British towns, it would meantime be interesting to try the method suggested by Sir Oliver Lodge in 1884 for depositing fog, namely, that of discharging electricity of very high tension into the air.

The idea originated in an observation made by Tyndall in 1870, that a dark or dust-free space formed over a hot body when held in strongly illuminated dusty air. This phenomenon may be easily observed by holding a hot poker or flame in the beam of an electric lantern; the appearance is as though dense black smoke were streaming upwards from the hot body. That it is not smoke, but anti-smoke, is perhaps rendered most evident by observing the utterly different appearance of smouldering brown paper or other smoke held in the same place. The explanation which Tyndall gave was that the air was dragged up in currents faster than the dust it supported, which consequently got left behind.

Ten years later Lord Raleigh reexamined the phenomenon and found that Tyndall's explanation was not correct. He made a most interesting reversal of the experiment by substituting a block of ice for the hot poker.

He then observed that a dust-free space was formed below, instead of above, as with a hot body; the dark flame was clearly defined and bordered by bright fringes of dusty air, which he attributed to the dew points being passed and the consequent condensation of moisture upon the dust nuclei.

In 1883 Sir Oliver Lodge investigated the matter and carefully repeated all known experiments. He was able to disprove some of the false theories which had previously been suggested as the cause of the dark space, and also to prove that the dust particles were driven upward by the molecular bombardment which emanated from the hot body. Before arriving at this conclusion it had occurred to him that the air in streaming over the body might become electrified and repel the dust particles, leaving the air around the body clear. To test this, he arranged his now well-known experiment of the bell-jar filled with smoke, a discharging rod brought up inside and connected to the terminals of an electro-static machine, as shown in Fig. 1.

The result was highly gratifying. The small particles of smoke were rapidly attracted to one another, forming into long streamers, and these were repelled from the discharging point and deposited upon the sides of the bell-jar. The experiment was repeated, using fine dust, various kinds of smoke, and steam. With the last a Scotch mist is formed which slowly sinks to the bottom of the bell-jar.

In this experiment originated the idea of dispersing fogs. It was suggested at the time that it should be tried on a practical scale, using a large

FIG. 2.—THE BELL JAR SHOWN IN FIG. I AFTER DISCHARGE OF ELECTRICITY BEGINS. THE SMOKE HAS FORMED INTO FLAKES, AND THESE, IF THE DISCHARGE BE STOPPED, FALL LIKE SNOW. IF THE DISCHARGE IS CONTINUED THEY ARE RAPIDLY ATTRACTED TO AND DEPOSITED ON THE SIDES AND FLOOR OF THE BELL JAR. THE SAME THING OCCURS ON A LARGER SCALE IN A ROOM

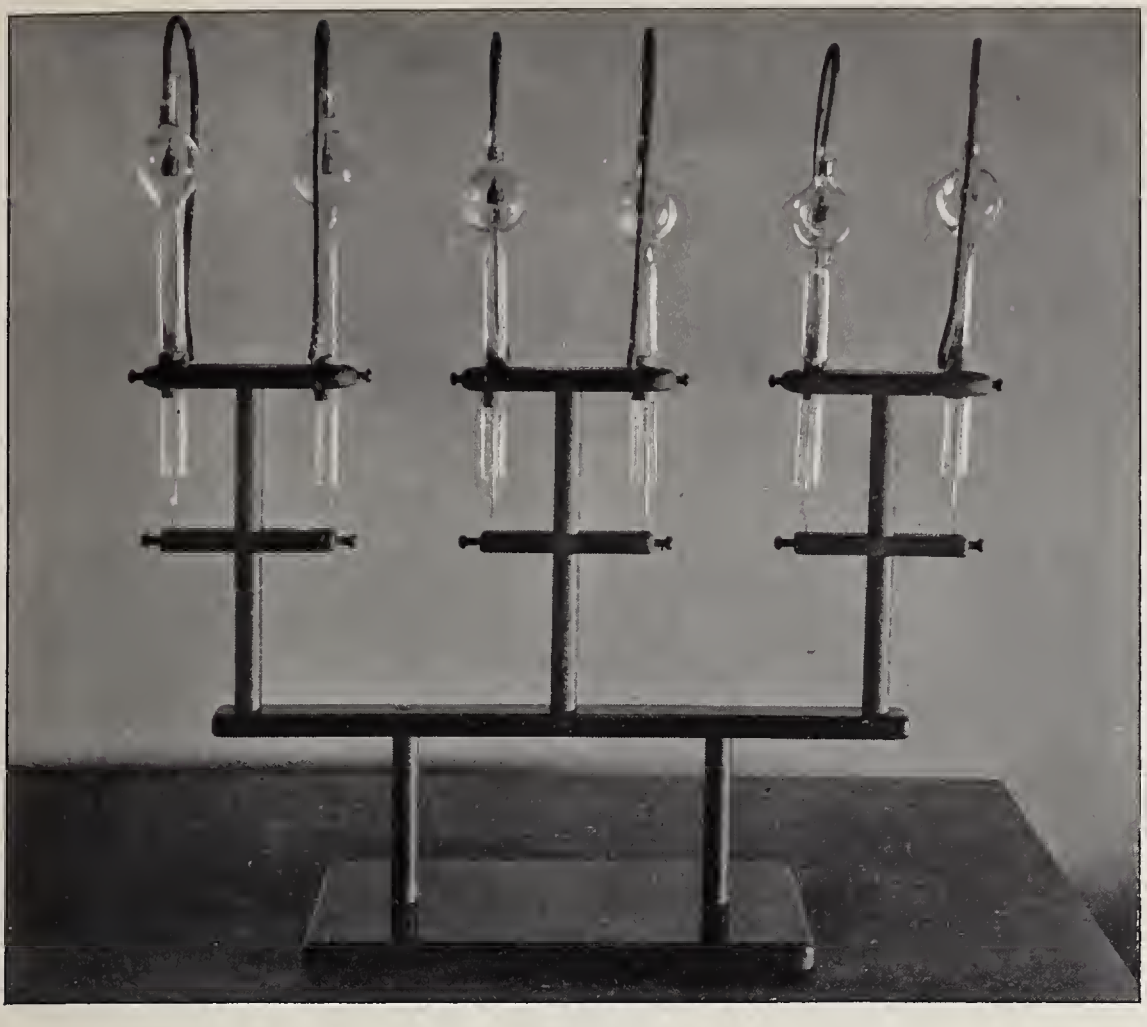


FIG. 3.—A SET OF MERCURY RECTIFIERS ON AN INSULATING STAND

Wimshurst machine as the source of power. But there were numerous difficulties, and Sir Oliver Lodge was unable to spare sufficient time to follow up the experiments. Electrostatic machines also are delicate and too easily affected by moisture to be employed for practical work.

So the matter rested until five years ago, when Sir Oliver Lodge again took it up, and had a mast erected at Liverpool on top of the college buildings, the power being supplied from a large Wimshurst machine. This apparatus was up about eighteen months, during which time there was only one fog, and this while Sir Oliver was away; but his assistant, who was in charge of the apparatus, started it, and observed that the fog around the building quickly dispersed, clearing the air to a radius of about 50 yards. When the apparatus was stopped, banks of fog rolled into the previously cleared space, only to be dispersed again when the current was switched on. This experimental apparatus, although successful in dispersing the fog, was not wholly suitable for practical work. Even in a laboratory, where every precaution was taken to keep it in working order, it could not be absolutely relied upon.

But now, by employing a form of mercury rectifier, it is possible to use a current generated by a dynamo, a far more efficient and practical method than using the electrostatic machine.

This new method has been possible only since the discovery of the mercury rectifier by Dr. Peter Cooper Hewitt. The rectifier consists of a vacuum-tube filled with mercury vapor, which, owing to its peculiar characteristics, allows the current to pass in only one direction. These rectifiers can be so designed that they will rectify at a potential of a million volts or even higher. This very high potential is employed in order that the electricity may brush off freely from the discharging wires; otherwise a needless strain is thrown on to the rectifiers. But with this potential the insulation becomes a difficult problem,—very much more difficult than the insulation for the high-tension currents used in long-distance power transmissions, where the highest voltage is less than one-twentieth of that used for fog dispersion, and where a loss of current is of small importance compared to the hundreds of amperes transmitted. But the current discharged from a large fog-dispersing station would be measured in milliamperes, so that a small leakage would be a considerable percentage of the whole output.

Another difficulty in the design of the insulators and apparatus is that with this high potential all surfaces in the neighborhood of the wires become to a certain extent electrified, causing the small particles of dust and moisture in the air to adhere to them, thus forming a good conductor for the electricity.

The insulators shown in the illustrations have been specially designed to overcome this difficulty. The aerial

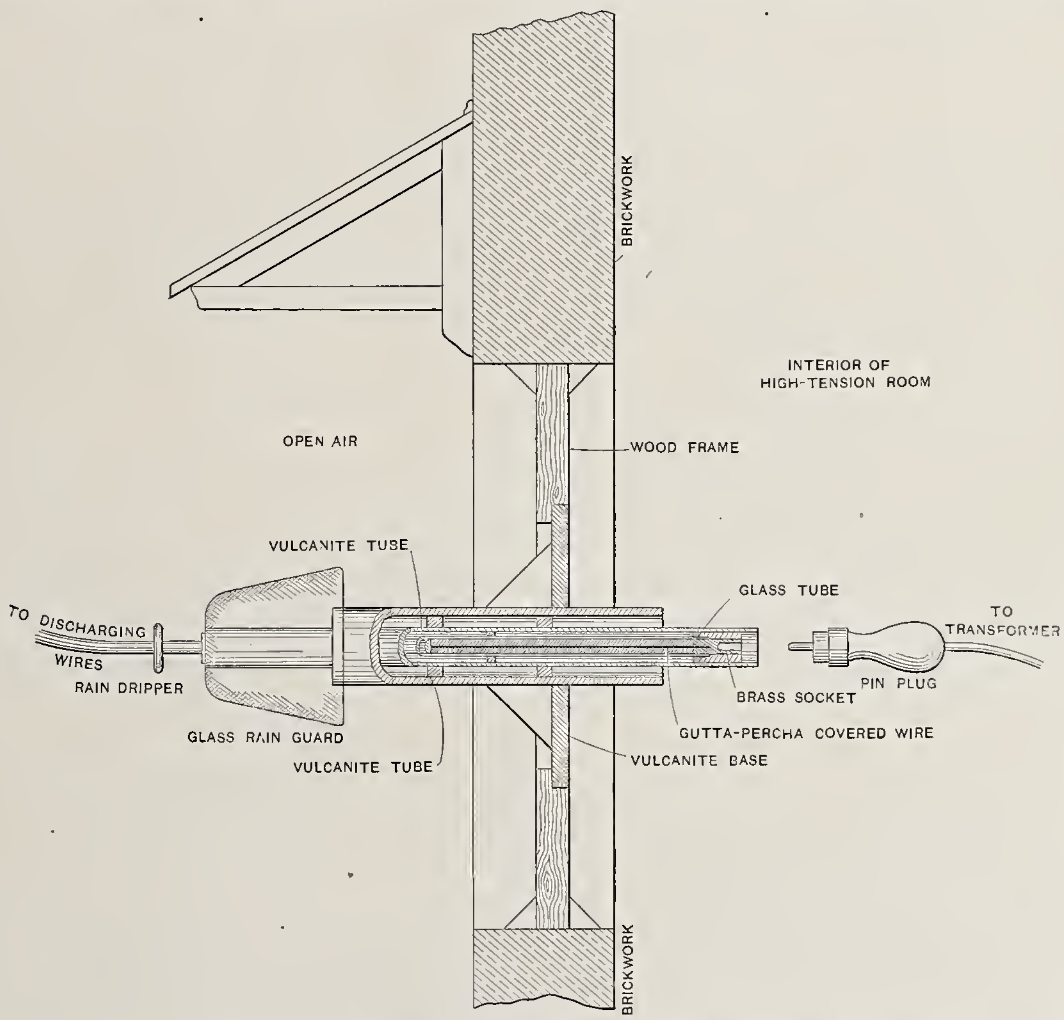


FIG. 4.—A WALL INSULATOR. THE ARRANGEMENT FOUND NECESSARY FOR CARRYING THE HIGH-TENSION LEADS THROUGH A WALL AND ENABLING THEM TO MAINTAIN 1,000,000 VOLTS IN THE DAMP ATMOSPHERE OF A FOG

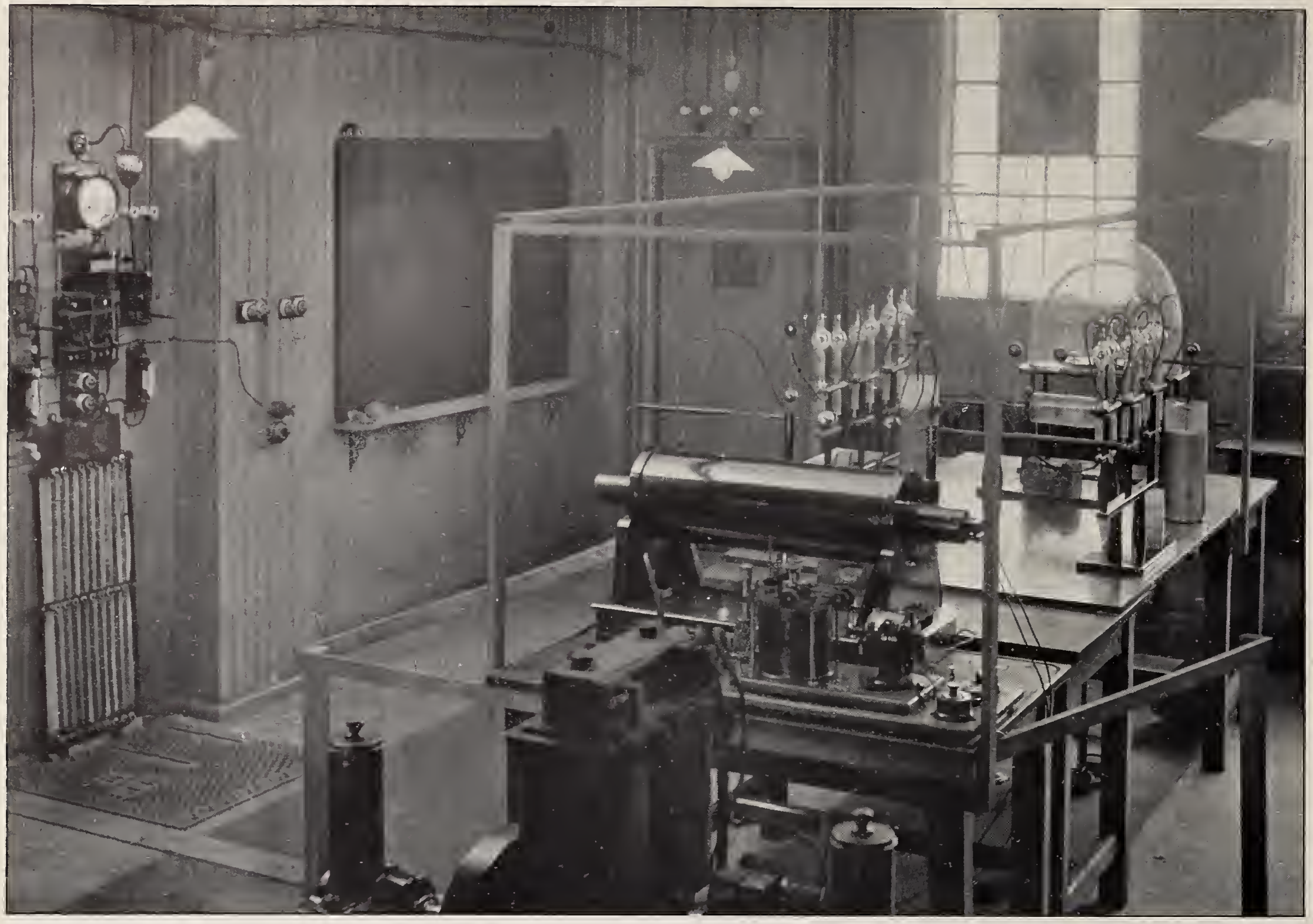


FIG. 5.—FOG-DEPOSITING APPARATUS ARRANGED TO WORK FROM DIRECT-CURRENT MAINS. ON THE LEFT IS THE SWITCHBOARD; FROM HERE THE CURRENT GOES TO A SPECIAL FORM OF CALDWELL BREAK—NOT SHOWN—THEN TO THE LARGE INDUCTION COIL, THROUGH A DOUBLE SET OF RECTIFIERS, AND THEN OUTSIDE TO THE DISCHARGING WIRES

insulator shown in Fig. 7 consists of a number of glass bells arranged on an ebonite rod, protecting the ebonite from dirt and at the same time forming a long and circuitous path for a leak. The size of these insulators, of course, varies according to the potential.

The insulation used for the high-tension wires is thick gutta-percha, covered to protect it from the weather. These wires are carried on highly insulated stands to avoid any tendency to brush off to any near objects.

The current can be taken from the ordinary city mains, either alternating or direct current. If alternating, the current is taken to a transformer which raises the potential to the pressure required, then to a number of rectifiers connected in the form of a valve, as in Fig. 6. These sort out the positive and negative impulses, allowing positive to flow in one direction and negative in the other, so that the discharging wires are supplied with a constant direct current.

If direct current is used, an induction coil with an interrupter takes the place of the transformer; the rectifiers are used as traps to allow the current to flow forwards, but prevent it getting back through the coil. Leyden jars may also be used as a reservoir to wipe out the sudden oscillations.

The apparatus is shown in Fig. 5 arranged for direct current. The photograph here reproduced was taken from the experimental apparatus erected in Sir Oliver Lodge's laboratory in the Birmingham University. The chief reason why this method has not already been tried is that the first cost of the apparatus is high, but compared to the enormous loss sustained from fogs, this should be of small consideration.

If it were proposed to erect a sufficient number of fog stations, say in London, to keep the whole city clear, the cost of the apparatus would be less than what it is calculated London pays for one day's fog.

The stations should be erected in the busiest parts of the town, where the apparatus would be most needed, as it is costly and difficult to take the high-tension supply wires any distance. The size of each station would be determined by how far the high-tension wires could be economically taken, and this would depend upon the site chosen.

The discharge into the air could be effected either by a number of points which might be arranged at the top of the lamp-posts, or else by barbed wire,

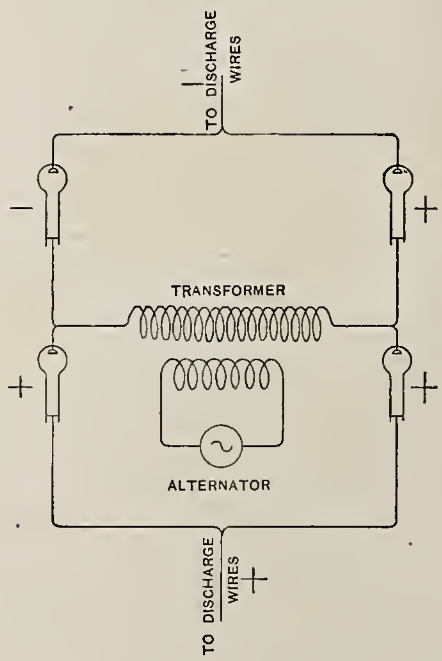


FIG. 6.—DIAGRAM OF CONNECTIONS FOR ALTERNATING CURRENT, SHOWING THE RECTIFIERS

FIG. 7.—ONE OF THE FORMS OF AERIAL INSULATORS USED TO FASTEN THE END OF A DISCHARGE WIRE. IT IS SUPPORTED ON A WIRE ROPE

which might be suspended from aerial insulators high up along the center of the street. This latter method would probably be the most effective, but possibly would not improve the appearance of the street.

It would be necessary to arrange the discharging wires over only a small area, as when the apparatus had cleared a small space, this would act as a nucleus and start the deposition of fog over a large area,—how large, of course, it is impossible to say, until the system has been put into practice.

The real utility of the apparatus will be in depositing natural fogs, as in harbors or low-lying country, but a station erected in London would be interesting and might even be a commercial success.

The use of telephones for the benefit of the deaf members of the congregation was recently tried with success at the First Methodist Church in Melrose, Mass. A powerful transmitter was installed in the pulpit and four receivers were placed in the rear rows of pews. Several parishioners who are hard of hearing used the equipment with satisfaction.

According to "The American Brewers' Review," the breweries of the United States use 250 dynamos and 700 motors, while 1000 dynamos and 3000 motors are needed for complete and modern equipment.

The Beginnings of Young Electrical Engineers

J. SWINBURNE, IN AN ADDRESS TO THE STUDENTS OF THE INSTITUTION OF ELECTRICAL EGINEERS

FROM the number of applications I receive from young fellows, it seems to be a common idea that consulting engineering is a good thing to begin upon. This is a curious notion. A consulting engineer is supposed to be a highly skilled engineer, with so much experience that he is an authority. I should have thought at least twenty or thirty years' experience, apart from school and college training, was necessary for a consulting engineer to be worth his salt. But there are various grades of consulting engineer, and I am entirely at a loss to know what the qualifications of the consulting electrical engineer really are. Then still less do I know what the consulting electrical engineer will be by the time you have had twenty or thirty years' experience. At present most of the large towns are electrically lighted and have their tramways; railways will be electrified by that time, and it is probable that the work will be done by their own men. Supervising contractors who are doing wiring will not be much of a profession in twenty years; and if that is consulting engineering, I do not think so much as twenty years' training is necessary.

In manufacturing work there is the designing of dynamos, motors, transformers, and so on. This was considered high-grade work when I was a young man; and even very able men built some very queer machines in those days; and we were all pretty ignorant. But the works were smaller then, and salaries for dynamo designing were not princely. But now there is not much opening in electrical machine designing. There is some, of course, but it is not as it used to be. There are many openings to be had in central station work, and stations are growing bigger and more important every day. At present there are also many applicants for every opening. Central station work in a position of responsibility is very anxious. I do not think it is very well paid, either. You will find exceedingly able engineers in most of the large town stations, and I am sorry to say their incomes are often very small for men of their technical and commercial ability. The assistants are often poorly paid, especially I think in municipal stations.

A large number of young men go in for installation work—which sounds as if they started bishops on their episcopal careers—but really means that they do what is in fact electrical plumbing under an unnecessarily imposing name. There are a great many of them, and they seem to spend most of their time going into and out of partnership with one another, like ions, and sending notices round to that effect. At other times they go bankrupt and send no notices. The upper grades in teaching science are well paid, more especially as a position goes with an appointment, and there is time and facility for original research, which is a luxury and brings reputation. Moreover, a steady income with no expenses is a very blessed thing. But the lower grades are very poorly paid in proportion to their ability.

All this may sound rather discouraging, but I am dealing with the difficulties of getting on, and I am sure it will not discourage anyone who is worth his salt. At first it is very discouraging to make very little, and the good man has little chance of showing his superiority to the common run. But he should always remember that income as a young man is very little criterion of real value. There are many careers in which a young man can make something almost at once; but in all cases the income increases very slowly. In such a business as engineering a man of first-rate ability may be quite unable to make enough to marry on till he is thirty, or enough to be comfortable on until he is forty. An eminent north country engineer, whose name you would all know, though he has been dead some years, said that he did all the hard work of his life for 30s. a week, and when he was well on in life money came rolling in of its own accord. I have reason to believe that one of our foremost engineers, now dead, never made £500 a year until he was over forty.

Though you may not like it, a hard struggle is very good for a young man who has anything in him. It gets him into the way of overcoming difficulties, so that when he gets above the small obstacle he goes on overcoming large ones from the mere force of habit. Nearly all great men rise from almost nothing with infinite trouble in their youth. There is nothing worse for a young man than to have about £200 a year of his own. He lives comfortably and does not worry; and when he is thirty he wants to marry and finds he cannot, and it is too late to begin life seriously then. If any of you has this sort of private income he had better go into partnership in installation work for a year or two, and then begin his business seriously.

Telephone Line Engineering

By C. J. H. WOODBURY, Assistant Engineer, American Telephone and Telegraph Company

A Paper Read Before the Franklin Institute, Philadelphia, Pa., January 12

THE salient characteristic which justifies all commercial applications of electricity, except those of industrial chemistry, is that it overcomes the impediment of distance, and it is essential that the conductors spanning these long extents, free from direct supervision, shall be as permanent as possible in order to maintain conditions of constant service. The amount of capital amassed in the approximate 4,000,000 miles of line construction necessary to connect together the subscribers of the Bell telephone system is of itself a warranty as to the importance of the subject; while the rapid depreciation to which most of this property is subjected requires both technical skill and business judgment to decide upon the most judicious methods of construction of this vast plant, amid varying circumstances of natural conditions and commercial use, in order to reach the most economical point of investment.

Analyze the general problem as one may, and standardize the general methods to cover a wide range of circumstances, yet there are exigencies and varying conditions which require the exercise of that type of constructive engineering which "does things." "The picture is first rate, but we built the bridge last night," said the Maine lumberman in the army to his West Point commander.

The application of mathematical principles is essential to any constructive work which is not merely a repetition of precedents, and the ordinary precedents of safe construction have been established upon the wrecks of past failures. In this paper it is proposed to describe some of the engineering difficulties which have been met in line construction and the manner in which these obstacles have been overcome, as well as ordinary methods of standard construction. The electrical problems form a subject apart from that of this paper.

The increase of every commercial application of electricity to meet the demands to supply service to patrons has been so great that an essential portion of every problem in constructive electricity must take into consideration provisions for future growth as well as the inevitable depreciation.

POLES

Although 45 per cent. of the wires are on poles, the total extent of the pole lines exceeds the length of the underground conduits, as the latter are used only in cities where the conduits contain a greater number of lines to reach the concentration of patronage. The extent of the pole lines is shown by the fact that in the Bell telephone system there are approximately 6,300,000 poles, and about 1,000,000 are required annually for replacement and for extension of lines.

A number of years ago a large collection of logs, known as the Joggins raft, was towed from Nova Scotia to New York, and this raft contained many long poles which were not suitable for masts. Some of these long poles, carrying 250 wires each, were used for the largest pole line ever built, at the westerly side of New York City. At the present time there are single underground cables composed of 4.8 times as many conductors, and under the main streets in the principal cities are conduits of sufficient capacity to carry 400 times as many wires as one of these pole lines.

Where the soil is not firm enough to sustain a pole imbedded in the usual manner, security may be obtained by extending the supporting area by a plank at the bottom of the excavation and filling the hole with concrete, or braces may rest upon a platform placed on the surface of the ground. In some instances these platforms rest on piles. In other instances the braces rest on a plank placed underground, or, in place of a single pole, they are placed in pairs, either vertical or joined at the top and connected by strong wire at the ground, making what is known as a A pole. When the line changes its direction or there are other causes to make a lateral pressure against a pole, it is secured by braces or by guys, running either to an anchorage in the earth or to some other object.

When a telephone line is built in or near cities, the close connection with supplies and labor makes that portion of the work comparatively easy, but in the construction of long-distance lines, connecting cities, towns and villages within speaking distance of each other, it is necessary to provide means for the execution of the work on an independent basis. In a suitable locality, a camp consisting of a number of tents is pitched, one of them being a dining tent, another is for cooking, and another the engineers' tent, where such details as must be left until the work is in progress receive attention. Several tents are also necessary for sleeping in.

If the route runs through a wooded country, a wide swath is cut in the forest and the post holes may be made by the diggers, or in other instances a charge of dynamite deposited in an auger hole makes quick work, the greatest relative gain being in compact clayey soil.

In the meantime, the poles have been brought by teams and then moved to the exact place by the help of an axle mounted on a pair of wheels, termed a dinkey; gains are cut and the cross-arms attached. They are then raised, either by pikes, or, if the country is not too rough to permit, by a portable derrick mounted on a wagon and hauled to the site. Then the derrick wagon is drawn to the next pole and the work proceeds rapidly.

When the line changes in direction, the pole is made more secure by guys, and the pole line is ready for the wires, which are paid out from a number of reels in a wagon, thence passing through a set of guiding holes which prevent snarling. The final attachment of the wires to the insulators on the cross-arms is very carefully done, because it is necessary that the wires should be drawn to such an extent that they will not sway against each other, and yet not so tightly that the contraction in cold weather will put such a stress on the wire as to cause danger of breakage. The stresses to which a telephone pole is subject are the result of many and variable combinations of live and dead loads upon a beam fixed at one end and loaded near the other end.

There is scarcely anything in engineering construction so actively the subject of depreciating conditions as are the poles. The top is exposed to the weather, and the important section near the surface of the ground is the portion most attacked by decay. The wood is assailed by animal life, whether it be gnawing by horses in town, or the perforation by woodpeckers in remote districts. Poles in wild countries are bitten by bears in search of bees, whose humming is imitated by the vibration of the wires, and it is said that in India the tigers use the poles to sharpen their claws upon after the manner of their second cousins, the domestic cat, but with so much more vigor that the poles become weakened. Not only are they wrecked by storms, but freight-car roofs frequently fly off and strike the poles edgewise with destructive results.

Iron poles are rarely used in this country, the principal condition governing their selection being on some lines in prairie countries in the West where campers are so prone to cut down wood poles for fuel, that tubular iron poles have been substituted. In Europe there are many iron poles, and in tropical countries infested with white ants it is necessary to use iron poles or to attach the wires to living trees.

Antiseptic methods for treating poles as a preventive against decay and the attacks of insects have not been so general in the United States as in Europe, as the relatively sparse settlement and distances between cities having the elaborate plant necessary for treatment would make the transportation of the poles for treatment and back to the sites where they are to be used a prohibitive expense. However, poles treated by creosoting have been used in this country wherever transportation conditions between the saw mill, the treating plant and the sites where they are to be used will permit. These conditions apply to certain portions of the South, where southern pine is sawed to dimensions and then treated.

As the cost of this treatment is based on the volume of the timber, these poles are sawed to such proportions of taper as to give the most economical volume of timber to resist the stresses the pole is subjected to. The weakest section of these poles, as computed, is from 8 to 10 feet above the ground.

While gravelly soil will hold a pole to the limit of its strength, it is necessary to build lines in many places where such conditions do not occur. The New Orleans and Mobile line, along the north shore of the Gulf of Mexico, traverses marshes composed of soft mud which extends to a great depth, and upon which a rank sedge grass grows 12 to 15 feet in heigth, whose coarse roots form a compact mass about a foot in thickness. In order to prevent this line from being injured by the fires which rage among these marshes in the early spring, the grass is kept cut to a width of 100 feet along the route.

It has been possible to sustain poles along this route by bolting heavy pieces across them at the ground level, an opening having been cut among the roots through which the butt of the pole can be inserted. The pole is then braced as occasion may require, sometimes in four directions, each of these braces being supported on a cross piece at the marsh level. In some instances a pair of, or even three, poles are used, each being attached to the same cross-arm.

At the Tybee marshes, near Savannah, Ga., the ground is so soft that it cannot be walked on, and the men engaged in building the line were obliged to lay a line of boards to proceed along the route. When a pole was to be set, cross pieces were temporarily attached to it near the lower end, and men standing upon these supports "jounced" in unison while the pole was held vertically by pikes. Under this human pile driving, the pole sank rapidly, but the mud is so adhesive that in a short time the pole is securely held.

Similar methods are used in building the lines across the New Jersey flats, although the conditions are not so severe as at some places further south. When ground is too wet and soft to permit digging, poles are frequently set by hewing their butts to wedges, and while the pole is held in a vertical position it is grasped by cant hooks and twisted back and forth, causing it to sink, like the ordinary motion used in boring a hole in wood with a brad awl. When once set, the pole is either held securely by braces or guys, or it may be made firm by driving a wood curb around it, excavating the mud between the curb and the base of the pole and filling the space with concrete.

In sandy soils, particularly in New Jersey, poles are set on the principle of the jet pile, wherever there is a supply of water. A ½-inch pipe about 6 feet in length is temporarily attached to the side of the pole, with its lower end at the butt. The other end of the pipe is attached to a garden hose, and when the pole is up-ended the stream of water makes a quicksand into which the pole sinks until the water is shut off, and the pole is sustained by pikes until the water settles, leaving the pole securely held by the sand, which becomes water-packed around it.

In mountainous countries the ledges are an impediment to excavations for poles, and although dynamite is frequently used, yet poles are set upon rock without excavation and a large number of stones are piled around them in such quantities as to grip the poles securely, although guys are generally necessary.

A pole line is not designed merely on the basis of the stresses to which the pole is subjected in drawing the wires to the necessary tension, for in most northern climates the sleet will at times form upon the wires until they become icy cylinders perhaps 3 inches in diameter. The problem is not that of the mere added weight, for the force of the wind applies a greater horizontal load, which combines with gravity and produces a resultant force in a diagonal direction, greater than either of the contributing units.

An ice-laden line swayed by the wind may be successfully resisted by the poles until the oscillations are in synchronism with the vibration of some pole on the line which responds to their influence and breaks. Then adjacent poles are relieved of the pull on one side, and the excessive unbalanced stress breaks them. Such is the story of a wrecked aerial line, broken by stresses not included in the ordinary course of events, and which must be provided for by large factors of safety.

It is indeed fortunate that rain at just above a freezing temperature, meeting a colder stratum, without wind, near to the earth, and followed by a gale, is rare and generally limited to a small area, for these conditions cannot be fully circumvented. Officers of the Weather Bureau reported in connection with a sleet storm of unusual severity, that there had not been similar conditions in that locality for 23 years.

The breakages of lines resulting from a severe storm in Southern New England, a few years ago, revealed the fact that the damage was confined to the valleys of the rivers emptying into Long Island Sound, while the storm did not appear to be of sufficient severity to cause any damage to the lines on higher land. It is claimed that sleet never forms to a destructive extent on the wires in certain portions of the northerly part of the United States, and this may be one of the instances of the rarity of such occurrences.

A pole is not to be compared to a mast upon a vessel, for these extreme conditions of severe exposure to telephone lines occur in winter, when the ground is frozen and holds the base of the pole rigidly, while a vessel in a gale heels when struck by puffs and the sails "spill the wind," and in this manner the masts stand exposure to winds which would break them if held rigidly against long continued strain.

PREVENTION OF CROSSES

The most undesirable occurrences in connection with the wreckage of aerial lines are the disturbances resulting from the contacts of different electrical systems with each other, when the various lines are so near as to collide, when one or both break. While the currents used on the telephone system are so minute as to be without power of damage, yet their wires, in crossing the lines of electric lighting or power systems, may in making short circuits cause serious mishaps to the electric lighting or power plant and in any event materially interfere with the service.

While the imposition of an electric lighting or power current upon a telephone line would destroy the fine apparatus and perhaps cause other injuries, were it not for the protectors for preventing this, it is far better to prevent the occurrence of harmful conditions than it is to abate their injurious results, by a temporary sacrifice of the continuity of the service; for the operation of a protector serves to open the telephone circuit and to prevent the use of the instruments for the time being, until the lines are cleared and the protectors renewed. The remedy against the liability of such crosses is the simple one stated by a judge of a United States court, that the distance between the high and low-potential lines should be equal to that of the highest pole, so that in the event of the falling of a pole the wires would come short of reaching the other line. In many instances congestion of electric service and narrow streets prevent any such wide separation, and it becomes necessary to take every precaution for substantial construction.

It is necessary for such different lines to cross other routes, and in such instances provision against collision is made by the use of extra heavy construction, thoroughly bracing and guying the poles, arranging against overhauling of the lines in case of their breakage, and guarding the wires so that those on the upper line could not fall over the ends of the cross-arms in case of their separation from the points of support.

As high-tension wires are of larger diameter and fewer in number, their poles should be higher at the crossover. The crossover span should be so short and at such height that in case of breaking next to an insulation, the remaining portion of the span wire should not be long enough to reach to the lower line. The necessary height of poles, or the impracticability of placing them in such positions as to provide for the short crossover spans, may sometimes render it unfeasible to adopt this construction, and a grill of hardwood slats placed at frequent intervals across a pair of steel wires or cables between the two spans interposes a screen which prevents a broken wire on the upper span from reaching the lower span.

In some instances, where there are but few wires in each line, they are attached to the same pole, and the contact is prevented by a framework carrying guard wires below the upper line. It is not as a general principle advisable to use a single pole crossover.

House tops at first furnished an attractive route for aerial wires, and some of the fixtures for carrying these wires were of great size, but the framing of most buildings is ill-suited to resist the excessive stresses due to such loads, and the introduction of underground conduits has furnished suitable means for such main conductors; but it is necessary to carry branch wires over the tops of houses in order to reach patrons to whom the wires cannot be led in any other manner. In place of the old timber constructions, suitable iron pipe frameworks are now generally used.

AERIAL WIRES

The aerial wires are so visibly in evidence, and often to an obstructive extent, that they may be cited as the portion of the system which naturally receives especial attention from the public. Before presenting instances of construction, it is worth while to submit two matters of principles of aerial lines and materials.

The tension on a line suspended between a pair of horizontal supports varies with the sag and is at a minimum when the sag amounts to 7-20 of the span, and the tension increases whether the sag is greater or less than this proportion. For example, with No. 12 hard-drawn copper wire, weighing 173 pounds to the mile, 0.104 inches in diameter, and having a span of 130 feet, the minimum tension of 3 pounds would occur if the sag was 43 feet 6 inches, while it would slowly increase with increase in the sag, and if Nature had furnished a chasm deep enough for the experiment, it would be expected to reach its breaking tension of 550 pounds at a depth of 16,470 feet, or 3.17 miles. On the other hand, the increase in tension proceeds rapidly as the wire is drawn to approach a straight line, the breaking tension occurring at a sag of $1\frac{1}{2}$ inches.

As a comparison with these stresses in a local line on long-distance lines with No. 8 hard-drawn copper wire, 0.165-inch in diameter and weighing 435 pounds to the mile, when the span is 150 feet, the minimum tension occurs at a dip of 52 feet 6 inches, when it is only $8\frac{3}{4}$ pounds, and in like manner as in the foregoing instance, its breaking stress of 1328 pounds would be reached at the slightly less dip of 16,100 feet, of 3.04 miles, still too great to admit of confirmation by direct experiment; but if the wire were pulled until the sag was 2 2-10 inches, it would require the breaking load of 1328 pounds.

It is desirable that the wires should be drawn tight enough to prevent them from swaying against each other; but it is important that they should not be drawn so tight that the contraction during extreme cold weather would cause the wire to break. The temperature is carefully noted when lines are being drawn, and the sag is left in accordance with the table given on this page, which is based on a factor of safety of five, computed for the usual lengths of span throughout a range of natural temperatures.

Natural Temperature Fahrenheit	Length of Span of Hard Drawn Copper Wire, in Feet					
	75	100	115	130	150	200
	Sag in Inches					
—30	1	2	2¾	3½	4½	8
—20	1½	2½	3	4	5	9
+10	1½	3	3½	4½	6	10½
+30	2	3	4	5½	7	12
+60	2½	4½	5½	7	9	15½
+80	3	5½	7	8½	11½	19
+100	4½	7	9	11	14	22½

When a wire is laden with sleet, the strain lengthens the wire and the increased sag diminishes the tension sometimes to an extent sufficient to save the wires, which would otherwise be broken were it not for this elongation.

HARD-DRAWN COPPER WIRE

The electrical advantages of copper over iron did not hold for aerial wires, because commercial copper had so little resilience that it would continually stretch under its own weight and break, until Thomas B. Doolittle produced the hard-drawn copper wire which is now in universal use on aerial lines. The treatment consists in omitting the annealing processes during the latter portion of drawing the wire, but it deviates from the usual method by attenuating the wire by smaller gradations at the latter die plates.

The rate of diminishing the wire is wholly an empirical one, at first determined by long and thorough experimentation, and as the hardening occurs for the most part near the surface, the tensile strength per square inch of section is greater with smaller than with larger wires. For example, No. 8 wire is 0.165 inch in diameter and has a tensile strength of 62,100 pounds to the square inch, while No. 12 wire, 0.104 inch diameter, has a tensile strength of 64,600 pounds to the square inch.

In comparison with commercial copper wire, which has a tensile strength of about 32,000 pounds per square inch, the strength is nearly doubled. The modulus of elasticity is increased from 12,000,000 pounds to 19,000,000 pounds, or about 60 per cent., while the elongation before rupture is reduced from 35 per cent. to 1¼ per cent.

It will be noted that this remarkable change in the mechanical properties of copper wire is produced entirely by manipulation and without the admixture of any alloy. Its electrical conductivity is practically the same as that of commercial wire drawn from the same ingots, the slight increase being due to the change in the molecular condition of hard copper.

Mr. Doolittle did not patent this valuable process of the manufacture of hard copper, which has extended the limit of electrical transmission of speech four times the distance available with iron wire and has been of incomparable value in other electrical service. The award of the Edward Longstreth medal by the Franklin Institute in 1898 was a most suitable recognition of an invention which has been usefully applied to the service of mankind throughout the world wherever electric wires are spanned.

The relative cost of iron and copper wire is not a measure of the comparable expense of such lines in actual service, as copper does not have an oxide of high resistance, and its life has not yet been determined. The value of copper scrap from wrecked or reconstructed lines is about 2 cents a pound less than that of new wire, while galvanized iron line wire costs about 4 cents a pound, and when taken down is of no value and is generally thrown upon a dump.

The rusting of iron wire at the joints adds materially to the resistance of the line. A few years ago an iron telephone line crossing swamps near Norfolk, Va., was reported open after a thunderstorm, but an inspection showed that there was no break in the continuity of the wires; however, electrical tests revealed that the joints insulated the various sections of the wires from each other, the strokes of lightning having produced oxides of high resistance.

LONG SPANS

Where lines traverse mountainous districts or water courses it is frequently necessary to build spans of great length, using either one of the special bronzes or steel wire for the purpose. The Connecticut River at Middletown is crossed by wires having a span of 1350 feet, suspended between a steel-trussed tower 185 feet high on the east side, and a similar tower on the bluff on the west bank is 85 feet high.

From Enfield to Windsor Locks the Connecticut is spanned by a suspension bridge consisting of two steel cables 1 inch in diameter and 955 feet long, to which are fastened 2-inch x 3-inch joists, 4 feet 4 inches long, set 12 inches on centers. On this bridge are laid four cables containing 100 pairs of wires. The towers on the banks are 45 feet and 33 feet high, respectively.

The St. Francis River, near Madison, Ark., is crossed by a span of 1000 feet, with the wires supported upon steel-trussed towers 100 feet in height, as it was necessary that the wires should be clear of steamers on the river, which has a varying level of 30 feet between flood and drought. At the Raritan Canal crossing, near New Brunswick, N. J., a 60-foot span is raised 112 feet above the canal to avoid the shipping.

There are numerous long spans crossing ponds and rivers not used for navigation at which it is not necessary to erect such high towers or to draw the wires up to a small dip to avoid masts. Long spans are frequently strung in cases of emergency, as when the flood of June 2, 1903, carried away the bridge crossing the Kaw River at Kansas City, Mo., and also the wires attached to it, a span of wires 900 feet in length was immediately suspended between high spars erected on either bank. The Missouri River at this city is crossed by a span of 1500 feet, consisting of fifty No. 8 bronze wires suspended between steel-trussed windmill towers 80 feet in height, and the Delaware River at Yardley, Pa., is crossed by an aerial span of 1300 feet in length with a dip of 10 feet.

In all instances, it is necessary to use great care in the anchorage of these long spans, for a rigid attachment would cause the wires to become broken when swayed by the wind. In some instances it has proved sufficient to carry the wires through semi-circular grooves cut into a curved wood saddle upon each of the towers at the ends of the span, but the recurrence of breakages has been stopped in other cases only by attaching the saddles to springs which will yield to the swaying of the wires. The very long spans constructed across the Mississippi, Hudson and Susquehanna rivers have been advantageously replaced by submarine cables.

The most spectacular work in line construction has been done among the mountain ranges of the West. Lines have been built against the face of cliffs bordering deep canyons, where it was necessary to incline the poles so that the tops carrying the wires overhang the deep abyss, in order to avoid icicles and avalanches falling down the precipice.

In building telephone lines through this mountainous country, a couple of poles are slung like panniers on the sides of two or three mules in tandem, and these sure-footed animals will carry them along the rough trails. The wire is wound in great lengths in connecting coils, which are placed on the sides of the saddles of a train of pack mules, which are thus connected on one side by wire from coil to coil, around the front of the foremost mule and thence back along the other side of the train. By removing the last pair of coils and unreeling, and thence in turn to the next coil, the pair of wires for a metallic circuit can be laid down along a route.

The Mosquito Pass, near Leadville, Col., was crossed at an elevation of 13,130 feet by a line of poles which were set only 15 feet apart at the more exposed places, but even this construction did not resist the storms of winter. Telephone lines were afterwards maintained through this Alpine exposure by an expedient far out of the ordinary. The line of poles was replaced by submarine cable carried to this elevated site in continuous coils, as in the case of wire transportation over the mountain trails upon a train of mules, and laid in trenches among the rocks to avoid any disturbances from avalanches.

There have been instances when it was necessary to make expeditions to these altitudes in severe weather to make repairs. The rough valleys through which the routes pass are picturesque in summer, but in winter the snow accumulates to such depths that linemen attend to their duties on snow-shoes, reaching the lines on 25-foot poles as if they were wire fences. Among these mountains are ravines which can be crossed only by long spans, where the difficulties are increased by the inclination between the opposite ends of the span. This produces severe end thrusts at the points of support, built of three poles capped by cross-beams which must be held by the most secure guying.

A few of these spans will illustrate the conditions necessary to be overcome in order to extend the telephone to these isolated mountain towns, at all times difficult of access, and during the long winter a hermitage were it not for this telephone service.

Imogene Basin, Col., at an elevation of 13,700 feet, is crossed by a span of 950 feet, which inclines at an angle of 27 degrees. Near Telluride and the Tomboy mines, ravines are crossed by similar long spans. A surveying party, arranging for the extension of some of these lines, found the snow to be 20 feet deep in these basins in the middle of July, while avalanches had rolled down opposite sides of the valley, leaving a narrow pass bordered by snow and ice 100 feet in height.

These lines running from the valleys up to great elevations on the mountains are charged with atmospheric electricity, particularly in winter, which is discharged to earth by bridging retardation coils across the lines and grounding the central part of the coils.

The surveying party noted that these disruptive discharges of static electricity occurred about 16 times a second, producing a continuous sound which could be heard by one near to the wires. The mountain appeared to be enveloped by static electricity, the poles and the engineers' transit glowed with St. Elmo's fire, and an irritation was felt at the head, and the hair would fly up if the hat was removed. This electric envelope did not appear to extend to the ground, as one was entirely free from sensations when lying down, but if, while in such a position, a hand was raised to about 3 feet above the ground, a sharp sputtering sound of static electrical discharges would occur.

Other continuous structures are used for conveying large numbers of wires, especially bridges and the elevated railways in cities.

IMPEDIMENTS TO WIRES

Trees are a serious impediment to wires, and although it is at times feasible to arrange for a severe trimming, yet for the most part it must be made in moderation and the lines arranged to go over or under, or, like the priest and the Levite, "pass by on the other side." At one of the electric light conventions, a speaker was asked what method was used by his company for trimming obstructive branches, and he replied: "For the most part the electrical method." While a high-tension circuit, carrying sufficient current, will burn its way through a branch of a living tree, yet the self-interest of all electrical companies, without regard to other important considerations, impel them to the utmost care in avoiding trees.

Considerable damage is done to electric lines by trees felled during gales, and at St. Louis, May 27, 1896, and also at Minneapolis, August 20, 1904, tin roofs have been bodily stripped from buildings and placed upon the telephone wires, the metal contacts connecting various telephone lines and causing confused jabber at any listening telephone unequalled since the days of Babel.

Telephone lines are patrolled by inspectors alert to observe incipient conditions of weakness, threatening decay of poles, trees growing too near the lines, and possible hazards to the service from other electrical wires. Especially in cases of severe storms is the utmost vigilance necessary to take prompt measures in case of any occurrence which will prevent the subscriber, perhaps 1000 miles away, from having the conference which he has the right to expect when he takes the telephone from the hook.

Useful as the telephone may be in affording facilities for communicating between different portions of a city, there are other methods of reaching one's townspeople,—messenger, mail, or, like the leader in a child's game, "send myself,"—but there is no equivalent for the question and the answer which can be exchanged between persons 1500 miles apart, their voices reaching each other in less time than if they were conversing across a room. To give a concrete example, the time for telephonic transmission over the 1064 miles between Boston and Chicago is 0.006 second, while the distance that the voice is transmitted through the air in that time is 6½ feet.

There are many thousands of miles of telephone lines without poles, for the business of lumbering and the wood-pulp industry is conducted over telephone lines traversing the forests. By the use of the telephone the methods of log driving have been changed for the better. The facility of communication between different gangs along a stream enables the logs to be conveyed without the disturbances caused by jams, which can be prevented by prompt action, and also avoids the destruction of timber, which would otherwise result from the use of dynamite to relieve these jams. Smaller and more rapid streams, hitherto unsuited for lumbering, have been utilized by the construction of dams, which husband and release the water as may be considered necessary by the men perhaps miles below, who speak through the telephone to those operating the gate at the dam.

The first telephone line of anything beyond a local line was in a wild country, for during the winter of 1878 telephones were used on the telegraph line connecting the signal service observers at the station on the summit of Mount Washington, N. H., to the base, while the first telephone central station with subscribers, in the present sense of the term, was opened at New Haven, Conn., January 28, 1878, although switchboards were used by associated groups of a few persons prior to that date.

One of the most useful applications of the telephone is in connection with the life-saving service, the telephone lines of which extend along the shore. The patrolman carries a small portable telephone which he can connect at fixtures upon the side of frequent poles, and in this manner communicate to the life-saving station for routine report and to summon help in case a vessel is in peril off the shore.

A telephone is a portion of the elaborate system of police signal in cities, while in smaller towns the simpler form of a telephone in a box serves the purpose. For the household, it gives an assurance of safety in the opportunity to summon the fire department or other help in case of emergency.

UNDERGROUND CONDUITS

The number of wires necessary to supply the patronage in cities so far outnumbered the possible capacity of pole lines along the streets that it became necessary to place them underground, and this required the development of the underground conduit and the telephone cable as new arts. While 55 per cent. of the telephone exchange wires are underground, yet the great number of wires in these conduits in comparison with those upon poles makes the number of miles of pole lines throughout the country seventy times the length of the streets occupied by underground conduits.

While no other ratio may give an adequate impression of the predominant use of the telephone for communication over long distances, yet in comparison with the length of steam railroad rights of way in the United States, the length of Bell telephone pole lines exceeds that of the railway system by over 26 per cent.

The first experimenters upon underground systems attempted to make them water-tight and insulators also, by means of a solid mass of asphalt concrete in which wires, frequently without insulation, were imbedded. The lack of satisfactory results caused the Bell Telephone Company to begin the development of the work under Joseph P. Davis, chief engineer, on the principle of providing a conduit of substantial construction containing ducts in which the cables could be placed or withdrawn, and relying upon the conduit merely to provide a protection against injury.

A conduit was built in Boston in which the ducts consisted of 3-inch iron casing pipes treated by the hot coal-tar process for protection against rusting, and imbedded in a concrete of eight parts of fine roofing pebbles to only one of cement. This has remained in good order for 22 years. The manholes were made of brick, covered on the outside with coal tar, and the foundations laid on plank covered with coal tar before the bricks were laid. This construction was afterwards used in New York, but there was not a sufficient supply of iron casing pipe in the market to supply the demand, and as it was necessary that the work should proceed as rapidly as possible, other materials for ducts were also used. Logs were bored from end to end and then squared parallel to this core, and sockets and plugs to fit were cut at alternate ends to bring the cores securely in line. The wood was treated by the creosoting process before the logs were laid. Cement-lined sheet-iron pipe imbedded in concrete was also used in large quantities. At a later date vitrified clay conduit was introduced, and has been extensively used.

Other materials and methods have been used, notably wood pulp tubes treated with indurating materials to render them impervious to water and proof against decay. Tunnels for underground cables have been dug through the soft limestone underlying the city of St. Paul, and one of the largest engineering works of the day is the extensive system of tunnels under the streets of Chicago, which has provision for cables as well as the transportation of material. In rare instances short tunnels are built, as under the canal and railroad at Trenton, N. J.

In addition to the usual difficulties which beset all constructions under highways, the size of the manholes or underground chambers which afford places for splicing cables, changing their direction and similar handling, render other occupants under the streets serious obstructions. When underground conduits were first built in an Eastern city the engineer prepared sets of standard drawings, and so many were the modifications rendered necessary by other underground work that only one manhole was built in conformity to the standard design.

A conduit 260 feet long, containing 13 ducts, at Seventeenth street and Allegheny avenue, Philadelphia, was successfully lowered 12 inches at one end and 18 inches at the other, on account of a change in the street grade. When large underground work, such as subways, are built in cities, the changes in conduits as well as lines of pipes and sewers present difficulties, of which it can only be said in the present available limits, that the changes were made. While a trench was being dug for an underground conduit in Rochester, an unexpected ledge was uncovered. There were no facilities for that work at hand, and a steam roller was hired to supply steam for the drills, and the ledge was soon blasted away.

Underground conduits have made a great change in the housing of the telephone central station plant, as the rigidity of an underground system requires that the distributing centers should be of equivalent permanency, and the telephone plant could not in such cases be subject to the mutations of hired property, but be in buildings owned by the company. Therefore, fireproof buildings have been constructed by telephone companies all over the country, until the Bell Telephone system owns the greatest number of fireproof buildings of any single interest in the country, and its holdings of buildings and land in cities make it a vast realty enterprise.

If the underground conduits remove conductors from the effects of decay of poles and exposure to storm and the hazards of foreign currents, yet the underground conduits have their share of mishaps. Breaks in water pipes or sewers disturb the foundations of these conduits, rainstorms flood them, illuminating gas percolates into them, waiting to be ignited by a spark from a horse's shoe at some leak around a manhole cover, or it may be lighted by men going to work in a manhole with a lantern, looking for trouble—and finding it.

The superficially attractive proposition of joint conduit systems, particularly in connection with a scheme of municipal conduits for all electric wires, has been attended by serious occurrences. Crosses among high-tension conductors in cables occur from time to time, and if the wires of signaling systems were exposed to the narrow limits of a manhole, they would be disabled. In one city where an inclusive conduit was laid by the municipality, the work was fortunately in good hands, and the manholes were built very large, with the cables of various classes placed on supports upon opposite sides of the manholes, and the cables containing high-tension wires were enveloped with split underground tile conduit tied together.

The attempt of a municipality to force a Bell telephone company into an inclusive underground conduit system under circumstances which were considered to expose their cables to hazardous conditions, gave rise to litigation in which the contentions of the telephone company were fully sustained by the Supreme Court of that State.

CABLES

The necessity for cables was coincident with the decision that underground conduits must be constructed on the "drawing-in" and not on the "built-in" system, and at about the same time it was foreseen that aerial cables must replace the opening wiring in cities wherever there was a great number of local wires, on account of their compactness and greater resistance to storms. For electrical reasons, it is necessary that open wiring must be used for long telephone lines.

The first telephone cables, both aerial and submarine, are believed to have been those used at Philadelphia in 1881, and at that time experimental constructions were being made at Providence, Brooklyn and Boston. In the latter city parallel rubber-covered wires, giving conditions of such great electrostatic capacity that a mile was the utmost limit of telephonic transmission, were tried, but when about a third of a mile was inserted in a telephone line, subscribers complained that their instruments were becoming worn out, as they could barely hear; and the induction between the parallel wires was so great as to transmit cross talk between the various circuits.

The induction was stopped by placing the wires in twisted pairs, but the problem of insulation with a low static capacity required long experimentation by many persons. W. D. Sargent, of Brooklyn, tried paper insulation and found that the static capacity was reduced and the transmission correspondingly improved, which T. D. Lockwood found to be due to the occluded air among the loosely twisted fibrous paper, and not to the paper as an insulating material. John A. Barrett, of New York, was intimately engaged upon experimentation and manufacture of cables, and to him are due many improvements in cable design.

At this time W. R. Patterson, now of Chicago, was working along independent lines, and made a form of hydraulic press for drawing on the lead cable sheath, which is still in use as the standard method of manufacture, although many changes of detail in the conductors have been introduced, with the result of improving telephonic transmission to over five times that of the first cables using twisted pairs.

Underground cables can be drawn through devious ducts, around turns and across manholes, to an extent which was not anticipated. The early cables were wound with steel wire twisted on a long pitch to carry the stress of drawing in the cable. Experiments on one drawn through an irregular conduit showed that the pull was about 20 tons, but such severe treatment is now avoided as unnecessary. The cables are usually drawn in by man power, either direct or applied to hand winches, but of late mechanical power has been applied to this work. Automobiles have been used for this work, but a cheaper and more efficient means has been reached by a 7-H. P. gasolene engine on a platform wagon, which also carries a winch.

In advance of a cable, the ducts must be first traversed by a wire to draw the cable, and the forerunner of this wire is either a number of wood rods hooked together and pushed along as section by section is added. When the length to the next manhole is completed, a strong wire is attached to the last rod, and as the first rod is pushed into the next manhole it is inserted in the corresponding duct on the other side of the manhole and pushed and pulled along, or if it is at the end of the cable run, the rods are pulled along and disjointed section by section.

A fine wire is sometimes drawn through a duct by a conical piece of wood with a thin leather washer filling the duct, and forced ahead by the air pressure at the rear, which is exerted through the application of an air pump at the front end of the duct at the next manhole. This piece of wood is termed the "mouse," and the name is probably responsible for the persistent story that lines are first drawn through the conduits by a fine string tied to the tail of a tame rat which has been taught to do this work.

Cables are applied for miscellaneous other uses outside of conduits wherever the lines need protection against water, moisture or accidental violence. They are used for submarine lines at bridge draws and river crossings, where they appear to be the especial targets for fouling anchors and snarling propellers. The cables across the Mississippi at New Orleans become overlaid by the soft viscous mud of the river, which is so tenacious that it is impossible to pull them up again. They are applied in tunnel work and in mining, and have even been led to a stranded steamship.

At Honolulu there are special facilities for laying temporary cables to vessels anchored in the harbor, furnishing them with telephone service when in port. In all United States seaports, vessels moored to wharves can promptly obtain temporary telephone service, for which wires already are placed upon the wharves ready to be extended to telephones to be installed in the cabin.

The subscribers are reached from underground cables by leading the cable through a pipe from the manhole, thence turning upward at the side of a pole, near the top of which the cables terminate in a cable box and the wires are separated into their several pairs, distributing to their respective instruments, generally by twisted pairs hung upon poles in rear alleys or attached close to buildings to avoid articles falling from windows or ice from roof cornices.

An entire underground system, by which these laterals enter a basement and thence by inside conductors extend through a building or perhaps an entire block, is rare, except in the congested portion of large cities, where the number of patrons is sufficient to require the wires of a cable. Even then it is not always feasible to obtain permission from the several owners to make holes through division walls or to place in a building other wires than those used for the service of the occupants.

The modern office buildings are provided with channels in the walls for telephone wires, and also parallel grooves under the floors in multiples of 3 feet from the front side of rooms, so that wires can be run from the wire entrance of the building up through the floors to positions convenient to reach desk telephones.

These laterals and distributing pipes conveying the cables branching from the main system are sources of trouble in cold climates, for water penetrates them, usually by backing up from a flooded manhole, and by freezing in the space between the pipe and the cables, crush them until the insulation becomes impaired. The former course required the expensive method of using a portable steam boiler, generally a city fire engine, to blow in steam from 12 to 36 hours to melt the ice, and then cut out the cable, which must be replaced by another one.

The Chicago Telephone Company equipped a wagon with step-down transformers and conductors which could be attached to the electric light wires and furnish a current of 700 amperes at low voltage. The secondary wires from this wagon were attached by long clamps to the cable sheath at the distributing pole and at the manhole to furnish a current which warms the cable and in a few minutes the melted ice runs into the manhole.

In some places, where there are not any electric lighting wires within an available distance, an automobile boiler is used to give a supply of steam, at far less cost than a steam fire engine, for which the hire is $5 an hour. The cable is not disturbed, as it has been found that, although the ice pressure may have collapsed the cable to an extent sufficient to short circuit the conductors, yet the elasticity of the paper insulation is such that in a short time the insulation will be restored.

The damage by freezing does not take place in the horizontal pottery laterals of 3-inch sewer pipe leading from the manholes, but occurs in the iron pipe which comes down the side of the distributing pole and connects to this pottery pipe by an elbow of 3 feet radius and a straight run of 12 feet to the sewer pipe. It is proposed in the future to use sewer pipe runs and elbows.

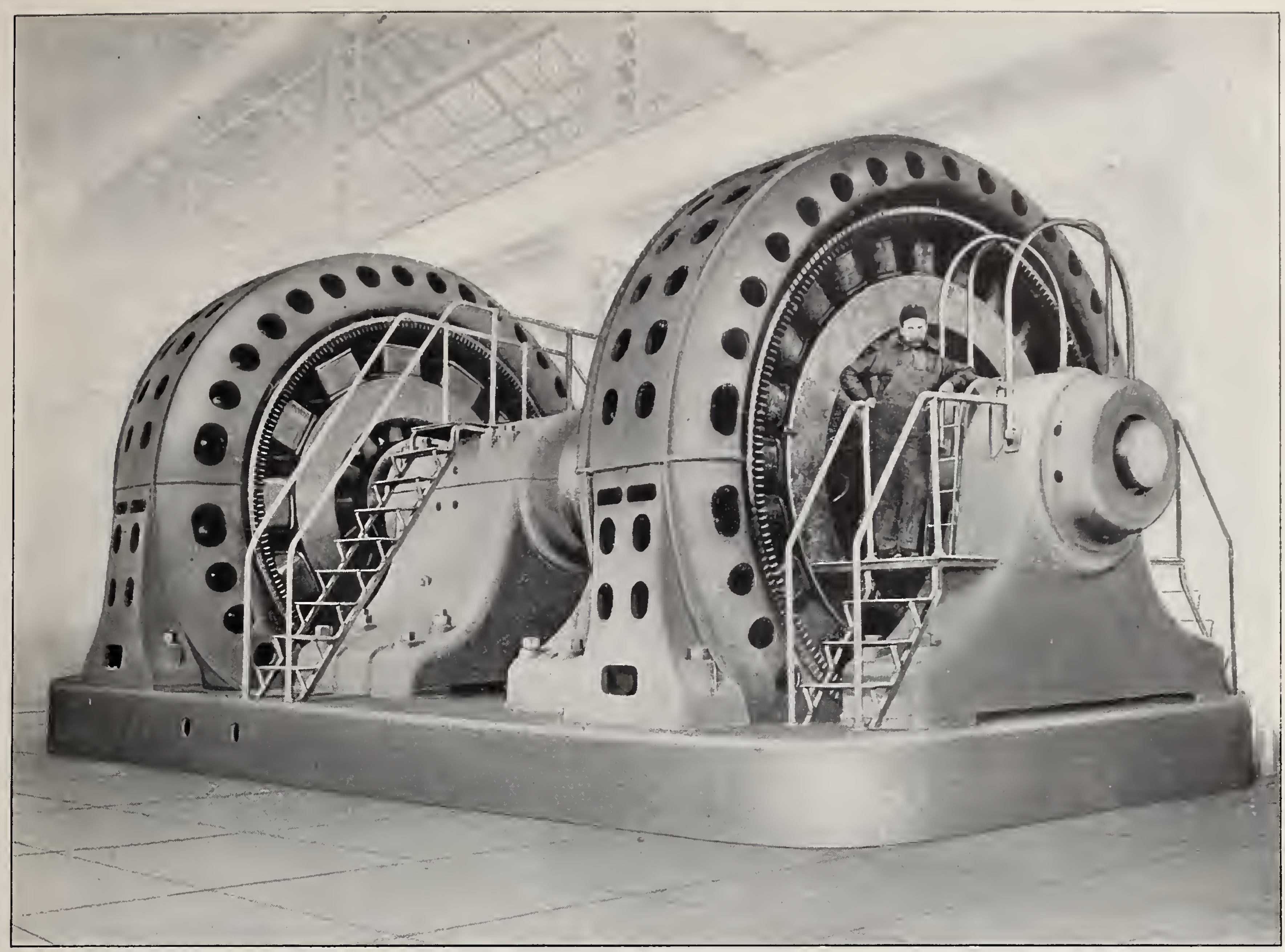
Although lead-covered underground cables entering buildings or kept in storage are frequently gnawed by rats, who are quickly punished in case the cables carry high-tension circuits, yet aerial cables have of late received the attacks of insects which cut through the lead sheaths with their sharp mandibles for the purpose of laying eggs in the interior. In China and Japan, such perforations occur near the bamboo thickets, where an insect, which lays its eggs in the bamboo stalks abounds. This difficulty is met by wrapping such cables with burlap soaked in linseed oil.

In Australia, similar difficulties have occurred over a wide expanse of territory, where it has been found that four species of beetles have in this manner perforated lead cable sheaths. In Texas, perforations are quite frequent, but it has not been found what insect produces these holes.

THE RATE OF TELEPHONE DEVELOPMENT

It has been the endeavor to describe some of the obstacles presented by natural conditions to the construction and maintenance of telephone lines, in order to secure an appreciation of the engineering skill which has overcome these obstacles to the extension of the telephone service which now knits together in one system over 26,000 different settlements throughout this country. The establishment of this vast plant from small beginnings was attended for some years with a rate of increase which may appear slow in the light of later events, until the full development of long-line service unified the whole in one connecting system, the value of whose service is far in excess of what could have been derived from isolated plants in separated towns.

These wider facilities endowed the telephone service with a higher value whose worth was appreciated, and the installation of telephones became stimulated to such a degree as to tax the resources of the various departments engaged on the work. During the



THE LARGEST ELECTRIC MOTOR EVER BUILT. IT IS HERE SHOWN DIRECT CONNECTED TO A 5750-K. W. GENERATOR. THE MOTOR IS OF THE SYNCHRONOUS TYPE OF 8000 H. P. BOTH MACHINES WERE INSTALLED BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS., IN THE PLANT OF THE SHAWINIGAN WATER & POWER COMPANY, SHAWINIGAN FALLS, QUEBEC, CANADA

last five years the number of telephones in the system has increased at a greater rate than ever before. This increase has been building upon itself like compound interest at the usurious rate of 29 per cent. a year, and compounding each year at this rate would double the number in $2\frac{3}{4}$ years, or the number of telephones has actually increased over $3\frac{1}{2}$ times during the last five years.

Each of these instruments as soon as installed comes into full service for connection with other instruments, and thus reciprocally each new telephone adds to the availability and, therefore, the value of those with which it may be in communication. During these last five years these additions of 29 per cent. a year have required corresponding amounts for the enormous increase in construction of new plant, which is entirely separate from the maintenance and repairs of the existing property.

There are over 3000 independent telephone companies in the United States.

The Largest Electric Motor Ever Built

THE largest electric motor ever built is now being installed at the plant of the Shawinigan Water & Power Company, at Shawinigan Falls, Quebec. This was recently constructed by the Allis-Chalmers Company at their electrical works at Cincinnati, and embodies in its design the characteristics of the Bullock alternators, which have proven singularly successful in their application. It is a synchronous motor of 8000 H. P. The rating of the generator operated by this motor, on standard specifications, is 5750 K. W. at 300 revolutions per minute. The combined machines, in addition to their enormous capacity, are remarkable for concentrating in an exceedingly small floor space a volume of 12,000 K. W.

The illustration of the machines given on this page was reproduced from a photograph taken while they were being tested at the shops, by the Behrend system under full-load conditions corresponding to 7200 K. W. on the generator, with the expenditure of no more than 300 K. W. in order to produce the same losses in the machine which exist under full-load conditions.

The working of the generator and motor forming the frequency changer at Shawinigan Falls will be carefully noted by electrical engineers in all parts of the world, and if it is as successful as the builders confidently anticipate, the result will be a valuable addition to existing data on the subject of alternating-current machinery.

The Milwaukee branch of the American Society of Mechanical Engineers, which was organized in that city on June 1, 1904, has gotten up a neat little book containing the constitution and by-laws, with the names of the officers elected. The council is composed of six members, as follows: M. A. Beck, president; G. P. Dravo, M. L. Jenkins, S. L. G. Knox, E. P. Worden, and W. G. Starkweather, secretary-treasurer.

Modern Large Gas Engines

A Consideration of their Suitability for Central Stations

By MAX ROTTER

A Paper Read Before the Colorado Electric Light, Power and Railway Association

LARGE gas engines, that is, gas engines in units between 500 and 5000 H. P., have come, and come to stay. It is true that their introduction into the United States has made slow headway, this being a direct result of the generally low price of American coal, and the prosperous condition of the country with less economical appliances. To these causes may, perhaps, be added the doubt which exists in the minds of many engineers regarding the possibility of satisfactorily generating power-gas from bituminous coal; and the general and natural inclination to adhere to familiar appliances demanding comparatively little attention, so long as such appliances earn ample profits in spite of their lower efficiency.

In Europe conditions are different—coal is expensive, labor is cheap—and as a result, the large gas engine has there ceased to be a novelty and has taken its place among the regular products of many shops formerly devoted to steam engine building. In fact it is noticeable that by far the majority of manufacturers of large gas engines are concerns which were noted for their large steam engines and had never built small gas engines.

It is true that, up to date, most of the large gas engines in Europe have been installed to operate with waste gases: such as blast furnace gas, formerly burnt under boilers; and coke oven gas, formerly generally wasted; but they have proven so satisfactory when running with these widely different gases—the former exceedingly lean, the latter unusually hard in gas engines because of its high hydrogen contents—that they have already been installed in central power stations, as for instance, in the city of Scheveningen, in Holland, where four 350-H. P. Nurnberg tandem gas engines, each direct connected to a direct-current generator, are in regular operation with suction producer gas; and in Madrid, Spain, where six units, each consisting of a 2000-H. P. Nurnberg tandem gas engine direct connected to a 3000-volt, three-phase alternator, will soon be running with Mond gas. In Europe there are in continuous and satisfactory operation gas engines aggregating nearly one-half million horse-power, in units ranging from 200 to 3200 H. P.; and one firm alone has on its books orders for such units aggregating 70,000 H. P. It is clear, therefore, that the gas engine has ceased to be considered a makeshift of small power.

Certain undesirable characteristics were for a long time ascribed to gas engines with such persistency that they came to be considered irradicable and essential attributes, and it will be well to look into these briefly. As to reliability in operation,—ten years ago a gas engine which would run throughout a day without some sudden and inexplicable stop was a rarity; to-day large gas engines are uninterruptedly running day and night, furnishing wind for blast furnaces, than which no class of work demands more reliability—a stoppage would involve most serious and expensive consequences.

Again, as to regulation,—we are all familiar with the gas engine with its old hit-and-miss regulation, its impulse every eighth stroke or so, its fly wheel weighing twice as much as the balance of the machine, and a regularity of speed and rotation so poor that its variations could be seen and heard; to-day, large gas engines with an impulse at every stroke are driving alternators in parallel with absolute freedom from trouble. For instance, at the plant of the Phœnix Iron Works, in Ruhrort, Germany, three 1000-H. P. Nurnberg tandem gas engines, direct connected to alternators of a frequency of 47½ cycles per second, are operating without the least trouble in parallel and with an extremely variable load, supplying current for motors around a rolling mill. These engines are merely two-cylinder tandems, the effort upon the crankshaft of which is the same as in a single cylinder steam engine; while large gas engines are also built as four-cylinder twin tandems, with cranks at 90 degrees, the regularity of which for 60-cycle work is therefore beyond a doubt; but, as this frequency is not used in Europe, no such plant can be referred to.

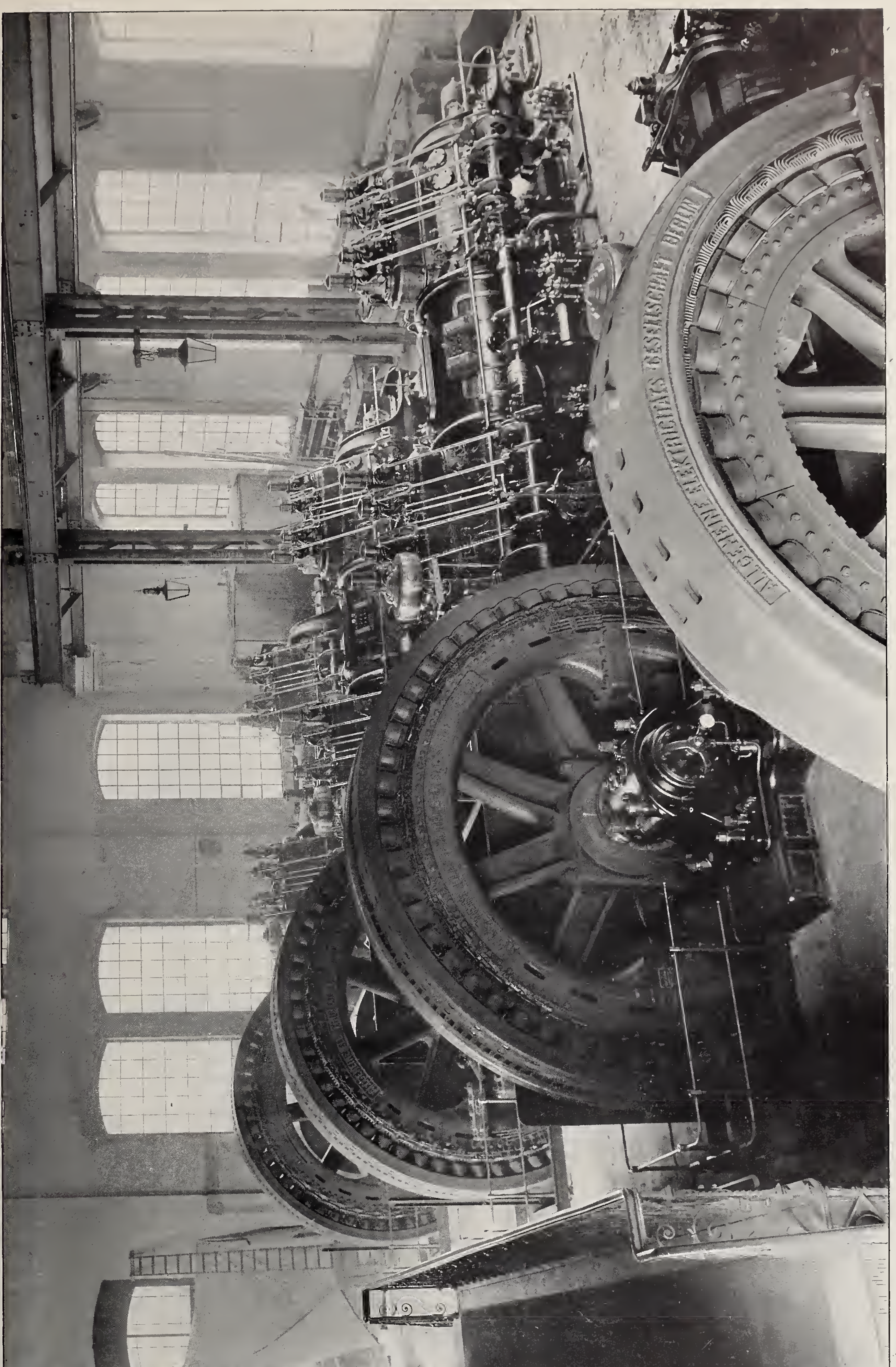
The noisy operation of the gas engine has also been eliminated, by the substitution of eccentrics for the old-time cams, and the arrangement of proper dampening apparatus for the exhaust; so that the modern large gas engine makes no more noise than does the Corliss steam engine.

Nor does the starting up of a large gas engine involve the time, manual labor, and uncertainty which characterized the old small machines. Compressed air, for the production and storage of which means are provided in conjunction with the gas engine, permits the prompt, easy, and reliable starting of the largest unit.

Yet, though the modern large gas engine be as reliable and desirable, mechanically, as the Corliss steam engine, this alone is not sufficient to warrant its being considered as a substitute. Its future supremacy must be based upon its high thermal efficiency, and in this it stands so far above any known steam power generator that circumstances which would justify its being ignored are rather the exception than the rule.

Before presenting any figures regarding the comparative economy of gas and steam plants, it will be well to call attention to the effect which conditions of operation exercise upon the efficiency of the gas engine, and the considerations which must be kept in view in the selection of this prime mover. There is much misapprehension regarding overload capacity of gas engines, and a lack of such capacity is frequently emphasized as a fundamental disadvantage of this type of power generator. The question of overload is generally viewed from the standpoint of steam engine and electric generator operation and rating, and this is not quite right.

There is for each steam engine a certain amount of power which it will, under specified conditions, develop with the greatest economy in steam consumption, and this power is cus-



THE GAS ENGINE PLANT OF THE PHOENIX IRON WORKS, AT RUHROT, GERMANY. THREE 1000-H. P. TANDEM ENGINES OF THE TYPE BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, DIRECT CONNECTED TO ALTERNATORS tomarily the "rated" power of such engine, used to designate it. But this steam engine is capable of developing power far in excess of this amount, although at a sacrifice in efficiency. Likewise an electric generator will generate continuously, without danger of overheating, a certain maximum amount of current, and is rated at this; nevertheless this same machine can, for shorter periods, generate an amount of current far in excess of its rating. This excess power or current, known as "overload," can easily mount to 50 per cent. over the rated capacity of a steam engine and electric generator, and is always reckoned with when the size of such machine is to be determined for given conditions of operation.

The fact that the steam engine operates at best economy at a load considerably below its maximum, is a distinct advantage, as almost all power plants, especially central power stations, must have at all times sufficient power capacity in operation to safely meet a known sudden maximum demand, and the engines are, therefore, during a major portion of the time, developing an amount of power far below their maximum capacity, and yet at or near their best economy. In brief, such engines are operating the greater portion of the time under the most favorable economic conditions. With steam turbines these conditions do not quite hold good, but are more closely approached than with gas engines.

In the gas engine the maximum capacity in power development is at the same time the condition of maximum economy; that is, when the cylinder of a gas engine is completely filled with a mixture carrying the largest proportion of gas compatible with perfect combustion it will simultaneously develop its maximum power and attain its maximum economy. Beyond this point its power cannot be increased, and below this point its efficiency steadily decreases.

Consequently, if sufficient power capacity is to be held ready to meet an instantaneous peak load, the gas engines in a central station will, during the major part of the time, be operating at efficiencies below their best. It would, however, be manifestly improper to rate a gas engine at 66 per cent. of the power it can develop with the highest economy—that is at 66 per cent. of its maximum power—nor would it be wise to commercially designate an engine by the very maximum it can do; so a proper allowance has been made and the gas engine is, by tacit agreement, rated at 15 per cent. to 20 per cent. below its maximum capacity. This has led to the acceptance of the loose statement that the overload capacity of a gas engine is only 15 per cent.

The whole question for the selection of steam as well as gas engines for a power plant, resolves itself into this: "What is the maximum power the plant will be required to develop?" The sizes of its units would then be so determined that, with the given load curve, the fewest possible number of machines would, during as long periods as practicable, be operating as nearly as possible at their best economy, and yet be able at any moment to meet the maximum demand for power as indicated by the load curve for such periods.

Broadly speaking, this would mean that when, during the longest period it would be practicable to run without throwing in more units, the maximum overload does not exceed 50 per cent. of the average load during such period, it would be proper to select steam engines and generators whose aggregate rated power would be equal to the average load, or gas engines whose aggregate rated power would be equal to about 30 per cent. above this average load, coupled to generators whose aggregate rated power would be equal to the average load.

These altered relations between engine and generator seem, at first glance, slightly confusing, but are in fact quite simple when everything is based upon the maximum, instead of the rated capacities of engine and generator respectively. For instance, a generator having a rated capacity of 1000 K. W., and a maximum overload capacity of 1500 K. W., would naturally be connected to a steam engine having a rated capacity of 1460 effective horse-power, and a maximum overload capacity of 2190 effective horse-power, or to a gas engine having a rated capacity of 1830 effective horse-power, and the same maximum overload capacity as the steam engine, namely, 2190 effective horse-power. Such unit would be operating at its maximum efficiency: if steam, when developing 1000 K. W.; but, if gas, when developing 1500 K. W.

It is clear, therefore, that comparisons between steam and gas engine plants must not be made on the basis of the best efficiency which each can attain under most favorable circumstances; but must be made on the basis of the known or assumed actual running conditions of the plant under consideration, with naturally a little bias in favor of familiar appliances.

Leaving out of consideration, for a moment, the relative efficiencies of steam boilers as against gas producers, and dealing with the engines alone, the approximate comparative thermal efficiencies, based on effective, and not on indicated power, are as follows, the steam engine being assumed as compound condensing, consuming 14½ pounds of steam of 150 pounds pressure, per indicated horse-power per hour, at rated capacity—all loadings being stated as percentages of rating:—

Generator load, 150 per cent.; steam engine load, 150 per cent.; thermal efficiency, 13 per cent.

Generator load, 150 per cent.; gas engine load, 115 per cent.; thermal efficiency, 29 per cent.

Generator load, 100 per cent.; steam engine load, 100 per cent.; thermal efficiency, 13½ per cent.

Generator load, 100 per cent.; gas engine load, 77 per cent.; thermal efficiency, 24½ per cent.

Generator load, 75 per cent.; steam engine load, 75 per cent.; thermal efficiency, 12½ per cent.

Generator load, 75 per cent.; gas engine load, 58 per cent.; thermal efficiency, 21 per cent.

Generator load, 50 per cent.; steam engine load, 50 per cent., thermal efficiency, 10 per cent.

Generator load, 50 per cent.; gas engine load, 38 per cent.; thermal efficiency, 16 per cent.

As will be noted, the advantage of the gas engine over the steam engine is greatest at the maximum load of the unit, namely, about 2¼ to 1, and decreases to about 1.6 to 1 at half load.

But the efficiencies of steam boilers and gas producers are not identical; 70 per cent. is usually good practice with steam boilers, while 75 per cent. is ordinarily attained with gas producers. Moreover, the losses due to condensation in the steam line are greater than the losses due to reduction in temperature in the gas line; and the auxiliaries of a steam plant absorb more power than do those of an equivalent gas plant.

Making due allowances for these conditions, as well as the advantage attained by the use of feed-water heaters in the steam plant, the efficiencies of the complete plants would be reduced to the following proportions of that of the engines alone: steam plant, 65 per cent.; gas plant, 70 per cent.; that is, the steam plant would use the following amount of coal in comparison to the gas plant, when the generator is developing the stated percentage of its rated capacity:—

150 per cent.—Coal consumption of steam plant 2¼ times that of gas.

100 per cent.—Coal consumption of steam plant 1.95 times that of gas.

75 per cent.—Coal consumption of steam plant 1¾ times that of gas.

50 per cent.—Coal consumption of steam plant 1.2 times that of gas.

These are fair average comparisons, rather inclined to favor the steam plant, and sufficient to show the vital importance of considering the exact operating conditions of a plant as a factor in determining the type of prime mover.

In spite of its mechanical suitability and high efficiency, it would be folly to make any sweeping statement to the effect that the gas engine will, at any time in the near or distant future, drive the steam engine and steam turbine out of central power stations. While it has been established that the gas engine will consume less fuel than the steam engine, it is also true that the gas engine requires more floor space and foundation, is considerably heavier, and costs more, power for power.

Technically the field of power generation is open to the gas engine; but commercially it has its limitations. Generalizations are entirely misleading; each particular plant must be carefully figured out on its own merits, giving due consideration to its conditions of operation, running hours, load factor, load curve, price of fuel, cost of water, value of real estate, and cost and facilities of transportation. For this reason figures are, perhaps, a little dangerous, as liable to call out contradictory discussion; we will, therefore, confine ourselves to a few general calculations, covering average conditions, mainly to indicate the figures which should govern the selection of one type of prime mover in preference to another. Let us take, for example, a plant having a total rated capacity of 3000 K. W., and a maximum total overload capacity of 4500 K. W., and a comparison between a compound condensing Corliss steam engine plant and a gas engine plant. The cost of the station installation, as shown by the capital account, would be about as follows:—

Site and buildings, steam $75,000, gas $90,000.

Foundations and equipment, installed, steam $225,000, gas $360,000.

Total, steam, $300,000, gas, $450,000.

As running conditions, a station factor of 40 per cent. of the rated electrical capacity of the plant, and a unit factor of 75 per cent. of the rated electrical capacity of the units, will serve as basis, these being near the average for railroad, light and power plants of this size. To avoid involved calculations, based on load curves, we will assume that the plants, whether steam or gas, would be divided up into the same number and size of units. Running 24 hours per day and 365 days in the year, the annual output of this plant would be 10,500,000-K. W. hours; or if running 10 hours per day, 310 days in the year, 3,800,000-K. W. hours.

The coal consumption of the steam plant, under these assumed operating conditions, would average about four pounds per kilowatt-hour, and that of the gas plant, $2\frac{1}{4}$ pounds per kilowatt-hour. The operating wages and repairs would be slightly lower in the gas than in the steam plant, there being less coal and ash to be handled for the producers than for the boilers, and the maintenance of the former being less costly than that of the latter.

The supply charges are, however, in favor of steam, as the gas engine requires about double the quantity of lubricating oil. If water must be pumped or purchased, the cost of this must be added. Assuming that in the steam plant the condensed steam will be returned to the boilers, but the condensing water run to waste, the quantity to be charged against the plant would be 100 gallons per kilowatt-hour. The quantity of water required for the gas producer plant and for cooling purposes in the gas engine, which is also assumed to run to waste, would be 25 gallons per kilowatt-hour. This water we will charge at a low cost of pumping, say 1-10 cent per 100 gallons. If purchased, it would cost about 6-10 cent per 100 gallons, and water saving apparatus, such as cooling towers or reservoirs, would be expedient. These would add to the capital, fixed charge and maintenance accounts, and about 10 per cent. of the water would be lost, which would bring the cost of the water to more than the assumed 1-10 cent per 100 gallons.

The accounts for the stations would stand as follows:—

Capital invested—steam, $300,000; gas, $450,000.

Fixed Charges—	Steam	Gas
Taxes, etc., 1½ per cent. on valuation	$4.500	$6,750
Amortization of buildings, 3 per cent. on valuation	2.250	2,700
Depreciation of equipment, 10 per cent. on valuation	22.500	36,000
Totals	$29,250	$45 450

Operating Costs, at 10,500,000 K. W.-hours per annum, per K. W.-hour:	Steam, Cents	Gas, Cents
Fixed charges	0.278	0.432
Water	0.100	0.025
Supplies	0.025	0.055
Repairs	0.050	0.035
Wages	0.175	0.160
Salaries	0.065	0.065
Totals	0.693	0.772

This gas plant thus shows operating costs 0.079 cents per kilowatt-hour higher than the steam plant, but a saving in coal of $1\frac{3}{4}$ pounds per kilowatt-hour. The two plants would, therefore, be operating with equal economy when $1\frac{3}{4}$ pounds of coal cost 0.079 cents; that is, when coal costs 90 cents per short ton.

With the shorter running hours, however, the conditions would be materially different, as shown by the following:—

Operating Cost, at 3,800,000 K. W.-hours per annum, per K. W.-hour:	Steam, Cents	Gas, Cents
Fixed charges	0.772	1.197
Water	0.100	0.025
Supplies	0.025	0.055
Repairs	0.050	0.035
Wages	0.265	0.240
Salaries	0.120	0.120
Totals	1.332	1.672

Here this gas plant shows operating costs 0.340 cents per kilowatt-hour higher than the steam plant, with the same saving of $1\frac{3}{4}$ pounds of coal per kilowatt-hour. The two plants would therefore be operating with equal economy when $1\frac{3}{4}$ pounds of coal cost 0.34 cents; that is, when coal costs $3.90 per short ton.

These typical calculations indicate the vital influence of conditions of operation upon the cost of running the same plant.

In the foregoing comparisons it has been assumed that the same coal would be used, whether under boilers or in gas producers; but this is not always expedient. Sometimes a coal high in sulphur and with bad slagging characteristics may be obtained at a price so low as to warrant its use for steam generation, and yet be so undesirable for gas generation that a more expensive coal would have to be substituted for use in gas producers. Such conditions would again modify the comparison. Low-priced anthracite or gas coke are doubly favorable to the gas plant, reducing the labor charges, while increasing the efficiency of the producer.

Although it is not the intention to extend this paper into the domain of power gas generation, it would be incomplete without a few words concerning this subject, more particularly with reference to the use of bituminous coal in gas producers. The perfect bituminous gas producer, that is, one which will continuously generate from bituminous coal a fixed gas of constant quality, with as little attention and little loss in heat values as does an anthracite gas producer from anthracite, has yet to be designed; but entirely practical, simple and efficient bituminous gas producers are to-day obtainable, and means for eliminating the tar and other undesirable vapors have been brought to a practical state, and, although not ideal, are generally less costly than the other types with reversing valves and other complications with their attendant uncertainty as to the quality of gas and their demand for constant watchfulness on the part of the operators.

Where the plant is of sufficient magnitude, say over 2000 K. W. rated capacity, the proper quality of coal available, and the market favorable, it will unquestionably pay to install by-product gas producers, such as the Mond, to furnish the gas for the gas engines. And in connection with still larger power installations, a retort coking plant, the waste gases from which would be used for power generation, will prove a most profitable investment. The latter combination is, however, less likely to come into frequent use than the Mond gas plant, which has proved itself eminently satisfactory as a power-gas producer.

Portable Electric Incandescent Lamps

THERE is a growing use for portable incandescent electric lamps in mines and other places where explosive gases are known to be present, because of the practical immunity from danger with which this lamp can be employed in such places. Even when the bulb of a lamp is broken in the presence of explosive gases, experiments have demonstrated that no harmful results follow. This is, in fact, the only type of lamp which can be used with virtually absolute safety in the presence of such gases, as it removes the temptation from the miner to attempt its relighting by matches. It also avoids the delays consequent upon the blowing out of oil lamps, since an imperative rule of the mines requires the collier to take the lamp back to the lamp station, where it is relighted by an official lamplighter. The electric lamp also gives a much brighter light than any oil lamp, since for other reasons its light is not dimmed by wire gauze. The portable electric lamp for this purpose requires about 6 volts and 2 amperes and weighs about 3 pounds. Small storage batteries are used. The cells are contained in a box about 5 inches square, on the side of which is placed the incandescent lamp. These lamps will burn for 12 hours, and the cells are recharged at the mouth of the pit by current from the colliery dynamos.

According to "The Scientific American," a new application of wireless telegraphy has been introduced by two English inventors. The device is purely for entertaining purposes, consisting of the electrical operation of musical boxes placed at different points from one common center. There is a receptacle in which the coin is placed, and immediately a musical box placed at a distance, such as in another room, commences to play.

Wireless Telegraphy in Great Britain

BY an arrangement between the British Postoffice Department and the Marconi Company, every telegraph office in the United Kingdom now receives messages for transmission by the Marconi wireless system from the Marconi coast stations to ships at sea fitted with the Marconi apparatus. Consul Marshal Halstead, at Birmingham, says that under the wireless telegraphy act no one can use a wireless telegraph system in Great Britain without authority from the Postmaster-General. The postmasters at various offices are kept informed of the movements of ships carrying the wireless apparatus and the locality of the shore station through which messages may be sent, and anyone desiring to send a message to a ship at sea by wireless telegraphy may do so by handing the message into a telegraph office and paying 6½d. (13 cents) per word. There must be paid, however, a minimum of 6s. 6d. ($1.57) for each telegram.

Electricity in Metallurgy

ACCORDING to M. de Neufville, in a paper before the Electro-Chemical Society of Frankfort, on the use of electricity in metallurgy, electric energy is always relatively expensive and commercially adaptable only for obtaining highly valuable products from rich materials. This has not been sufficiently considered by various inventors. In the production of gold from ores large quantities of material, not containing gold, have to be treated, and, therefore, the electric process does not pay. The electrolytic separation of gold from a solution of cyanide of potash, however, is profitable. Electrolytic refining of silver is almost everywhere in use, and refining by acids is still in vogue only where the material to be treated is very rich in gold. Silver is never produced from ores by electrolysis.

The greatest interest still centers in the problem of the electrolytic process for obtaining copper from its ores. Experiments hitherto have not failed on account of technical difficulties, but on account of the expense. Electrolytic refining of copper, however, has given good results and is much used, especially in America. Two-thirds of the total copper production in America is the result of this process, which in Great Britain has not been so largely used. Germany comes next after Great Britain, followed by the other European countries.

The question whether the multiple or serial circuit is most preferable has been much discussed. The largest works in America have adopted the serial circuit in spite of certain theories. Electrolysis in late years has also been employed in refining lead where the object was to produce lead entirely free from bismuth.

The electrolytic method has been put to practical use in the lead works of Trail, British Columbia. Direct production of lead from ores is usually not resorted to. With nickel the smelting process has been maintained; only for refining has electrolysis been used profitably. Electrolytic works for zinc have not been at all profitable, but it would seem that the electro-thermic process for zinc will become of greater importance. For iron and steel the electrolytic process is too expensive and the electro-thermic processes are more likely to be successful.

Rubber Discovery in Argentina

ACCORDING to "The India Rubber Journal," the special commissioner sent out by the Argentine ministry of agriculture has discovered a remarkably rich rubber-producing section in the province of Jujuy, in the extreme northern part of the republic.

It is in parts densely wooded, with rubber trees abounding in the newly explored area, these numbering in some districts as many as 50,000 plants to the square league, and it is estimated from tests already made that the full-grown trees will yield at the rate of 20 pounds of rubber per annum, though "The India Rubber Journal" is inclined to doubt this. The climatic conditions are, according to the commissioner, much healthier than the rubber regions of Para and other parts of South America.

Several lighting and power projects are proposed for towns in the Straits Settlements, at the southern end of the Malay Peninsula, in Southeastern Asia. The town of Ipoh has appropriated $90,000 for an electric plant, while the installation for Kula Lumpur will, it is estimated, cost about $880,000. A Singapore corporation recently secured contracts for the installation in the palace at Kuala Kangso of the Sultan of Perak of a large electric equipment, and also for an additional plant at Penang, where an electric railway is being built to supersede the present horse cars.

Private house installations of some of the Western telephone companies include plugs in the walls of each room to which a portable telephone may be connected. A fixed telephone does the ringing for the whole outfit.

American Electrical Enterprise in Mexico

By GEORGE E. WALSH

THE relative importance of Mexico as a field for the development of electrical enterprises is pretty well appreciated by the foremost American electrical engineers and manufacturers, but further exploitation of American products and manufacturing interests is rapidly approaching a climax in certain cities and mining regions. The natural conditions of the country apparently offer unusual opportunities for electrical development, both in the cities where hydraulic power is within easy reach, and in the great mining sections which are rich in valuable ores. The numerous rivers and waterfalls of the country seem to invite the engineer to harness them for developing electrical power to turn the wheels of commerce.

Mexico has taken kindly to American influence and capital in the past decade, and millions of dollars of American money have been invested in her street railways, mines and great hydraulic plants for electrical purposes. The technical student and engineer have greater opportunities in this country south of us than have any other class of Americans, unless it may be the shrewd capitalists who seek valuable concessions for future investments. Mexico is steadily advancing, both as a mining country and manufacturing place, and American machinery is opening up the country as never before in the history of the land.

A study of the map of Mexico will show that the country is intersected by great mountain and river systems. With the mountains running through the middle of the country, and the rivers flowing from them toward either coast, almost ideal conditions are presented for securing all the hydraulic power necessary to turn the wheels of commerce of the entire country. It has been the opinion of our consuls in Mexico that every town and city of any size will eventually be supplied with electric power and light generated by the rivers and waterfalls. It is, moreover, quite apparent that the rivers are so located that no very long distance transmission of electric power will be necessary.

Mexico is rich in gold, silver, lead, iron, copper, cobalt, antimony, sulphur, coal and petroleum, and the laws of 1892 are liberal in their mining concessions to Americans. There are to-day between 4000 and 5000 mining enterprises carried on in the country, most of them owned and operated by foreigners. There are also about 5000 manufactories, nearly 3000 of which are for sugar and brandy, and a fair percentage of them utilize electrical power in some parts of the plants. There are, furthermore, about 130 cotton and woolen factories so situated that electric power could be used to advantage. Ten years ago there were 127 miles of street railway, but to-day there is over three times this length in operation, and each month shows some new company entering the field to increase the mileage.

The Rio Grande River offers unusual conditions for power development. All along its tortuous course there are rapids and waterfalls. At many places cities are located which could derive their lighting and power from hydraulic plants established at favorable points. The few hydraulic plants established have proved of the greatest value to the country and apparently the same to the investors. The matter of developing the country is naturally a subject that looks to the future for large returns on capital invested, and it may be that many of the plants constructed will pay even better a decade from to-day than at the present time.

Some of the more important electrical developments of Mexico in the past year will indicate the nature of the changes which are being made in that country. In the City of Mexico millions of dollars have been invested in street railways, power plants and lighting systems. The Mexican Railway, patriotically known by Englishmen as the "Queen's Own," and one of the oldest railways of the Republic, has steadily been increasing its facilities. This company is now preparing to equip with electricity its entire line from Mexico City to Vera Cruz. The overhead trolley system is to be adopted by this railway. Another electric transportation line is being constructed from Mexico City to Pueblo. This railway will open up a new part of the country, both for freight and passenger service, that will prove a great benefit to Mexico City and its immediate environments.

A London concern controls the Mexico City electric traction system, and English capital is thus invested in considerable amounts in this part of the country. Canadian interests are also strongly concerned in the development of the same region. The direct connection of Mexico City with Pueblo, the latter a city of considerable size and importance, has stimulated an enlargement of the electric power and lighting plants at the latter terminal. The Pazuelo Electric Light & Power Company, of Pueblo, operates a 4000-H. P. hydraulic plant which furnishes light and power to the city, and at the same time supplies some 4 or 5 miles of electric railways. The enlargement of this power plant will, within a short time, enable the company to supply electricity for operating the 20 odd miles of tramways in the city and its suburbs.

Considerable American machinery and electrical equipment goes to Mexico City and its surrounding towns, although English capital controls many of the concessions. This fact indicates the possibility of American products finding excellent markets in Mexico, even under adverse circumstances, and it is a well-known fact that our exports to Mexico in the line of machinery and electrical parts are rapidly expanding.

Americans are, furthermore, obtaining concessions from the Mexican Government for the construction of hydraulic plants which, of course, will use American machinery and equipments exclusively. Notably among these achievements is the contemplated construction of an electric railway from the Rosa Amarilla copper mines in the western part of Guadalajara to the Pacific port of Navidad. This road will pass through a wild and picturesque part of the country, and although only 40 miles in length, its estimated cost will exceed a million dollars. A Chicago company which intends to work the copper mines, will control the road and build it with American capital and machinery. The power plant will be erected on two rivers which have their sources in the mountains near the mines. The fall of the rivers is sufficient to supply all the hydraulic power necessary to operate the road and to work the mining machinery. It is proposed to equip the mines entirely with electrical machinery, and to ship the copper to the coast at less cost than it can be raised in the Lake Superior district of this country. This plant should prove of far-reaching effect in giving the control to Americans of a section of the country that is rich in mining possibilities, and so favorably situated that the ore can be shipped to the Pacific Coast at a minimum expense.

Another American company operating on a large scale is opening up the great mining resources at Velardena, in the State of Durango. There are large smelting works at this place which are electrically operated by the company and also important mines that are similarly worked. Nearly all the driving machinery in the mines is of American pattern and manufacture, and the success of the company has given evidence of further extensive developments in mining operations.

To a large extent American interests in Mexico have been identified more with the mining operations, including the railways used for freight transportation purposes, than in city railways, although capital is also engaged in securing concessions for this latter improvement. One of the most important of recent developments in the latter direction is the equipment of 17 miles of electric traction in the city of Monterey. An American engineering and contracting company has secured the concession, and about a million dollars will be expended in electrically equipping the new roads and in converting the two existing horse car lines into electric lines.

Another electric line fom Guadalajara in Western Mexico to Lake Chapala will be constructed and equipped by American engineers. Lake Chapala is one of the greatest summer and winter resorts of Mexico, and the travel to it at certain seasons of the year is enormous. The line is some 40 miles long and passes through a picturesque and populous part of the country. The American company just mentioned, and which is capitalized at $2,000,000, will construct an electric line from Guadalajara to Morelia, the latter being the capital of the State of Michoacan. This is one of the greatest and most ambitious of the undertakings in Mexico. The total length of the line will be about 200 miles, and the power to operate it will be generated at Zambora, on the Douro River, where the fall of water is sufficient to drive any number of turbines. This electric railway will touch many small towns and cities.

Guadalajara is one of the most prosperous and progressive cities in Western Mexico, and its industries have steadily increased in the past ten years. More American and English capital has been invested there in the past two years than in any other city outside the capital of the Republic. An extensive electric traction system covering the whole city and its suburbs is now in the course of development, and when completed it will be one of the most up-to-date transportation lines in Mexico. Over 40 miles of street railway and suburban roads will be operated by the new system, and American machinery and equipment will be used almost exclusively. The old power plant of 2500 H. P. located on the Rio Grande, has been inadequate for present requirements, and this will be supplemented by another on the same river about 2 miles out of the city. This latter plant will not only furnish power for the railway system, but will light the city and even sell electrical power to factories and mills.

Americans have been engaged in constructing some long-distance power transimission lines in Mexico that will in many respects equal, if not surpass, those of the California coast. While rivers are plentiful and water falls numerous in the Republic, there are mining concessions located among the mountains that can be profitably worked only by the utilization of nearby water power, and to make the latter profitable it is necessary that power shall also be developed to operate freight transportation systems to the coast or some distant large city. This condition of affairs has stimulated some of the engineers to construct long-distance transmission lines for supplying current to the roads and also to the mills and mines along the route. Some of the falls harnessed for this purpose furnish abundant power for generating unlimited current.

The longest transmission line in Mexico is that now in course of construction from the Mexican Light & Power Company's Necaxa plant to Mexico City and El Oro mining camp. The total distance of this line will be 125 miles, and over 1500 miles of wire are being used in the construction of the transmission line. The mining camp is situated well up among the mountains, and is one of the largest and richest in Mexico. Its direct connection by electric railway with Mexico City will add greatly to its value. Both English and American engineers have been engaged in the survey and planning of this line, and when completed it will be a fine example of modern progressive mining methods. Besides operating the trains, the electric power will work the mine pumps and machinery. The power plant is located at Necaxa, and the initial capacity will be 45,000 H. P. The turbines used are of Swiss pattern and manufacture. In time, the plant will be increased to 80,000 H. P., for the construction of many miles of railway in and around the mines will eventually draw heavily upon the power. When all the machinery is in the mines, and the railroads leading to and around the plant are installed, nearly 50,000 H. P. will be required to operate these alone. When the roads now planned for this line are completed, they will constitute the longest transmission line in the Republic, or in fact anywhere south of the United States border.

Another long transmission line in course of construction is in the State of Jalisco. The famous Perez concessions for the utilization of water power is situated on the Santiago River, about 110 miles from the city of Aguascalientes. It is proposed to construct a huge power plant on the concession, and carry electric current to the latter city. The concession covers about 30 miles of river, with a variable fall of 670 feet, which the engineers estimate can furnish 30,000 H. P. or more. Part of this concession is owned by Americans, and American engineers and electricians are interested in its development. It is not unlikely that American machinery will be used for the work. Besides supplying Aguascalientes with electric power and light, the company will furnish current to mines and smelting plants along the route.

In the State of Jalisco there is magnificent farming land, and construction work has been going on to improve this land for agricultural purposes. Irrigation is essential, and the new electrical companies have been studying the matter of pumping water by means of electricity. It is believed by some that it will be possible to inaugurate a system of pumping which will compare favorably with that in use in California, where the electric current from the mountain power houses operate hundreds of irrigating pumps on the ranches and fruit farms located along the route to the sea coast. So satisfied are the owners of water concessions that irrigation will prove profitable to the farmers and the power companies, that extensive improvements are being undertaken to use the water from the mountain lakes. One concession permits a company to utilize sufficient water from Lake Chapala to irrigate some 300,000 acres. A new plant is being constructed on the Santiago River to operate electric pumps for handling the water. The water will be distributed through the irrigation canals by means of these powerful electric pumps, and the full capacity of the hydraulic plant on the Santiago River will be employed for this purpose.

While reference is made only to the electrical operation of railways and mining plants, considerable data could be gathered to show that Americans and other foreigners are steadily obtaining concessions in Mexico for lighting its cities and running factories, mills and other plants. Nearly every week some foreign company is organized for furnishing Mexican cities with electric lights, and incidentally supplying power for manufacturing purposes. Most of the Mexican concessions permit the electric light companies to enter the field of selling power to plants along the route, and in some of the larger cities this is a profitable side of the industry.

American manufacturers, as well as American engineers and capitalists, are profiting by the liberal spirit and conditions displayed by most of the Mexican companies. As comparatively little and unimportant machinery is manufactured in Mexico, the bulk of the orders for electrical equipments goes to the United States, England, Germany, France or Switzerland. The Swiss turbines have obtained considerable popularity in Mexico, and their services are quite manifest in many of the different States. American turbines, however, are making their appearance in large numbers, and with satisfactory results. Some of the early American turbines installed many years ago show their durable qualifications. An American turbine installed at the Bella Vista factory, near Tepic, in 1884, is still in active service, and another horizontal turbine installed in the La Aurora jute mill at Cuautitlan for driving the electric light plant, shows equal powers of endurance.

The electrification of the Mexican city railways is going on so rapidly that the horse tram car is likely to disappear almost as completely from that country within another decade as it has in the United States in the past ten years. The installations of the various lines represent investments of many millions of dollars, and there is hardly a city of any considerable size that is not considering a change in its street transportation from horse to electric power. Both foreign and local capital stands ready, in most instances, to meet the necessary expenses. The English companies have been anxious and ready to secure the concessions and put up the money without appealing for local funds. In this respect Americans come directly into competition with foreign capital, but the best methods and goods triumph in the end. As a field for special effort in the electrical line during the next ten years, Mexico is probably not surpassed by any other country, certainly not by any lying so close to our own land, and the bulk of the orders should come to the United States.

Electric Lighting for City Streets

FROM A PAPER BY A. S. HATCH, READ BEFORE THE INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS

THE principles involved in outdoor illumination are two,—an even illumination of the section under consideration, and a brilliant illumination of the street intersections only. The first principle is the ideal lighting, since it more nearly approaches that of moonlight and gives a greatly improved police protection in lighting the alleys and yards as well as the street corners, and is best accomplished by the tower system, although small lamps at frequent intervals on both sides of the street are a substitute for lighting the streets only, and on account of the numerous shade trees are better. But the public will not have either. They insist on having their eyes dazzled, and in commenting on the lighting of a city, it is not with reference to the even illumination but the blaze of light on the down-town streets. In Detroit, the Lighting Commission have endeavored to give the main thoroughfares this even illumination by means of the towers.

The idea of the tower system originated with a windmill contractor who had erected several windmill towers on some buildings in Elgin, Ill., for lighting purposes. In May, 1884, an experimental windmill tower was erected in Cass Park, being made of gas pipe, triangular in cross section and tapering to a point at the top and 22 feet on a side at the base. There were nine 18-foot sections, the first three being of 2½-inch pipe, the middle three being 2-inch and the top three, 1½-inch; making the total height 162 feet. Six lamps were placed on this tower. It was evident that this style of tower would not be practicable in all parts of the city on account of the size of base required, since in some places the space was so limited that only a pole could be set, so the conditions resulted in the invention by J. S. Adams of the tower as finally built by the Brush Company and as still used by the Lighting Commission. These towers are also triangular in cross section, but the sides are parallel instead of tapering and are built of 2-inch and 1½-inch gas pipe standards, a section being 8 feet 2 inches high and 6 feet on a side. The girts are 1-inch pipe and each section is braced with a ⅝-inch diagonal stay rod. The base of the tower is a single wrought iron pipe 15 feet high; on this is a cast-iron fitting to which both the horizontal and brace supports are fastened. The tower is guyed in four directions by two sets of guy ropes consisting of ½-inch steel strand, fastened to wooden stubs. In order to facilitate trimming, an elevator is placed in the center, which, with the trimmer, is counterpoised by a weight. The intense light near a pole lamp is entirely done away with. A pole light so blinds the eyes that, after passing through the bright area, the dark zone between lamps appears all the darker, while the tower lights are so far above the range of vision that the eye is not affected by the rapid change. This is the result experienced after driving on the boulevard where tower lights only are used and then driving on a street lighted by pole lamps.

There are two methods of electrical distribution,—the series and multiple; the former is with a constant current (quantity), and the latter with a constant potential (pressure). Consequently, as loss varies with quantity, the first needs one size of wire only, while the second, varying as the square of the current and the distance, requires a change in the size of wire corresponding to the changes in the current, thus making a greater cost.

For this reason, inventive ingenuity endeavored early to perfect a series system for street lighting, and the first commercial demonstration was on the Avenue de l'Opera in Paris, during the fall of 1878, by the use of Jablochkoff candles. In spite of their extremely short life—a single candle lasted about two hours—they came into extensive use, and it was only recently that the system was discarded in an Australian city. This system stimulated inventors in the line of the incandescence of refractory materials, and though dormant for several years, it has been recently revived by the introduction of the Nernst lamp.

While the Jablochkoff candles were made of a piece of kaolin melted away by the heat of the arc, in the Nernst lamp the kaolin is heated externally until it becomes a conductor, when it is made to glow by the current passing through it. The light is very pleasant, being between the yellow of an incandescent and the white of an arc, but like the candles, it is made for alternating current only, differing in that it uses a constant potential while they used a constant current. For this reason the Nernst lamp will not be extensively used in street lighting except in the case of frequent lamps along the main thoroughfares in the center of a city, for which it is admirably adapted, since it is between the intense light of an arc lamp and the mild light of an incandescent. The mechanism of the lamp is as complex as was that of the Jablochkoff candles, although for an entirely different purpose. The aim in the candles was to secure long burning, while that of the Nernst is automatic starting and regulation. The first is secured by a heating coil just above the glower or kaolin pencil and automatically cut out or into circuit by the heating or cooling of the glower. The automatic regulation is secured by a ballast consisting of a coil of iron wire in series with the glower, varying in temperature in inverse ratio to that of the glower, thus keeping the glower at an even temperature and, so, an even heat and light.

The maximum luminescence of an open arc lamp is between the angles of 30 and 55 degrees from the horizontal, which would be between 18 and 43 feet from the pole with the lamp 25 feet from the ground. Either side of this zone it gradually grows darker. Thus it has been the endeavor to increase this zone or render the luminescence more uniform either by putting the lamps higher or by using shades and reflectors. With the desire to make the illumination more uniform has been the design to lengthen the hours of burning from one trimming. The first attempt with open arc lamps was the Wallace lamp, which used plates of carbon set vertically. These lamps would last 100 hours, nearly as long as some of the latest types of enclosed lamps, but the diffusion of light was very poor.

During the past five years the open arc lamp has been superseded by the enclosed arc, either alternating or direct current, nearly all the principal lighting companies having changed their systems. The open arc lamp was made in two general sizes, the divided arc requiring from 6.5 to 7.5 amperes, and the full arc 9.6 to 10 amperes. The longest life with a double-carbon lamp has been about 28 hours, but in all cases, whether using carbon rods or plates, the consumption is about the same,—one-fourth of a cubic inch of carbon per hour.

The term, open and enclosed, as applied to arc lamps, refers to the condition of the arc, which, in the open, has the arc unprotected except by a large globe, thus allowing it to be exposed to draughts of air which cause an irregular light. Attempts were made early to enclose the arc so that a longer life and a more uniform burning would be secured, but such lamps were not commercial successes until the present form was adopted, which is essentially a small glass globe enclosing the lower carbon and tightly fitting against a metal plate through which the upper carbon feeds.

Much of the trouble with the early enclosed lamp was due to the poor grade of carbons used, so that for several years after the lamp was on the market nothing but imported carbons were burned. At least one carbon is cored, that is, the center is of softer material than the outer part, which is to secure better control of the arc. Some users claim to secure better results from the series-alternating lamp by using both upper and lower carbons cored. The enclosed arc lamp is about the only one being installed now either on direct or alternating current circuits. In many of the large cities constant-potential lamps are used on the commercial mains, being turned off and on by boys or trimmers in the center of the city. The outer sections of the city are lighted by the series system, either alternating or direct. Although the enclosed arc lamp was striven for early, it has been only during the last five years that it has been extensively introduced; so that to-day in nearly all the larger cities the open arc lamp has been discarded for the enclosed.

Besides the use of the open and enclosed arc lamps for street lighting, there are many incandescent lamps still in use, but mostly in decorative effects. A new electric lamp, the flame, is being introduced, and is recommended principally on account of its brilliancy and long life, one form claiming to be as long as the incandescent in life. The popularity of the electric system for street lighting is probably due to its brilliant light and the ease in lighting, not needing a lamplighter, although the introduction of electric lamps for street lighting was delayed in some cities by the political influence of these city employees. There are but few of the larger cities which use electricity only in lighting their streets, a majority using gas also, the electric lamps being used on the main streets and the gas on the resident and minor thoroughfares. Other systems in some of the smaller cities and towns use naphtha, acetylene or kerosene, but in nearly all cases as a means of rendering luminous some refractory substance.

In the classes of construction for electric street lighting, the tendency for low potentials is advantageous, since it lessens the danger of both fire and accident, particularly in the center of the city; hence, if a company is willing to use constant-potential lamps on their commercial circuits, it should be encouraged.

A very common method of suspending lamps at street intersections is by the use of a center suspension, but I do not approve of it since it requires two poles with the necessary guys and span wires. The neatest construction is the use of a mast arm which throws the lamp toward the middle of the street, thus lighting the roadway and both walks and using only one pole.

Early construction placed a switch at the top of the lamp, and it has been only recently that the practice of individual switches has been introduced. The advantage of a separate switch is in the ability to entirely disconnect a lamp from the service if needing attention while the circuit is in operation, thus insuring safety in handling and better service in operation. The tendency among manufacturers is to mount the switch above the lamp, but the objection to such construction where mast arms are used is on account of open circuits caused by the continual swaying of the lamp, finally breaking the wire. With the switch at the pole, the line wire is rigid to the switch, so that a patrolman can locate an open more quickly since in using a battery connected one pole to the positive of the circuit and the other to ground, he will always get the current so long as he is positive of the open. If the switch is on the pole he can short-circuit the fixture with its flexible wires and will not be compelled to retrace his steps to the previous lamp as he would with the switch at the end of the mast arm, since an open in the negative cord would not be known until he had gone to the next lamp.

Where lighting is done by contract, it should specify the watts at the lamp terminals, the class of construction, the hours of lighting and the method of inspection which refers to the testing of the wattage or the current; the latter can be done by a recording ammeter. The time of lighting for an every-night all-night service is usually specified as starting a half-hour after sunset and extinguishing from $\frac{3}{4}$ of an hour to an hour before sunrise, a total of about 3750 hours per year. An all-night moonlight schedule runs about 2500 hours per year. Deductions for lamps out are generally made, but it should be incorporated in the contract how they are to be computed.

With regard to future methods of lighting, there are in use or proposed three systems,—incandescence, heat luminosity and electroluminosity. The first, incandescence, is the principal one, it being that of both the incandescent and arc lamp. The incandescent lamp is made luminous by the substance, usually carbon, being raised to a temperature at which the radiations begin to appear within the range of vision, but too low for vaporization. As this temperature is increased, the efficiency of the lamp increases until at the boiling point of the substance we have the maximum efficiency and light. This is the arc lamp, so we have the incandescent lamp as the lowest and the arc lamp as the highest in efficiency of lighting by incandescence. Within this range lie all the improvements to be derived from carbon, but combinations of carbon with other substances will improve the light by changing its color, and in some cases, as in the flame lamp, increase its luminosity.

There are several metallic oxides which have an abnormal degree of radiation at intermediate temperatures. This is heat luminosity, of which the principal examples are the Welsbach gas mantle and the Nernst lamp. The intermediate temperature of the glower in the Nernst lamp is considerably below that of the carbon arc, so its efficiency cannot be expected to be above the arc lamp, and this is proven by tests. For this reason, also, that the cost of a Nernst lamp of equal candle-power is about the same as that of an arc its substitution for arc lamps will be only where the care is a desideratum, although it will make a field between the arc and incandescent lamp. Electroluminosity is the radiation produced by non-conducting gases and some solids in a vacuum under electric stress. These are Geisler and X-ray tubes. Metallic vapors carrying current at moderate pressures in an enclosed space will give a luminous arc similar in appearance to that of the tubes, but of far greater volume. This class of lamp does not depend on temperature for its luminosity. From this it is evident that improvement in efficiency will be principally along the lines of substitutes for carbons in the arc lamp and improvement in metallic vapor lamps, particularly in regard to color.

Thus far we have been considering electric street lighting. The street construction cost for electric and gas is about the same, so that any economy is in the operating only. The cost of a gas jet per year is about one-third that of an arc lamp, the light is about one-thirtieth, so as regards illumination the investment is a poor one. For the same reason, the use of incandescent lamps would prove a poor investment. During the past three years all series incandescent lamps have been discarded in Detroit and arc lamps substituted. The problem to-day is to have enough light where needed and still not too much, that is, lamps of different wattages burning on the same circuit. There are places in a city where 450-watt lamps are required and others where a 250-watt lamp or even less would be sufficient.

As an illustration, where two streets intersect in the business section a small lamp on each corner would be best, since there would be no dark places in case of street cars or heavy traffic; but at another street intersection one 450-watt lamp in the center of the street would be sufficient. Again, when side streets leave a main thoroughfare in opposite directions, but at slight distances apart, so one lamp cannot light both ways, if the regular lamp is placed at the intersection of one street a smaller lamp would be sufficient in the middle of the block in the other. Possibly the simplest way of accomplishing this would be with duplicate circuits at least half the distance, which, on the basis of costs to the Commission in Detroit, would be about $20 per lamp. The saving in power would amount to $7.50 per lamp. If the alternating system is used, a series transformer could be installed at a less cost. In the case of small towns and isolated locations it may not be desirable to have an electric circuit; then individual acetylene or naphtha burners could be used, but they should be large enough to do more than make the darkness apparent.

Fuel Briquettes from Peat

WORKS are now being erected at Orlando, Fla., for the manufacture of briquettes from peat. The beds which it is proposed to work cover 20 acres and form one of many such deposits all through the South.

Experiments are also being made by E. Woltman, in San Francisco, in making briquettes of peat and California petroleum. The peat is obtained from islands at the junction of the San Juanquin and Sacramento rivers, where there is a very large supply. As taken from the marshes, it carries about 80 per cent. moisture, but this is to be removed by compression, and the crude oil is to be mixed in the remaining spongy mass of partially decomposed vegetable matter.

A Practical Lamp Display

ONE of the prominent features of central station work to-day is the attempt being made by managers to place before the public the striking advantages and other interesting points of the service they are prepared to sell. An interesting example of a scheme adopted to show busy customers at a single glance the cost of operating incandescent lamps of different sizes may be cited in the practice of the United Electric Light Company, of Springfield, Mass.

In its general office the company has mounted a horizontal row of nine 110-volt lamps upon a suitable board, each lamp being controlled by a snap switch. Over the lamps is the following statement:—

COST PER HOUR AT REGULAR RATES

$\frac{1}{10}$ ct.	$\frac{2}{10}$ ct.	$\frac{39}{100}$ ct.	$\frac{45}{100}$ ct.	$\frac{51}{100}$ ct.
2 c.p.	4 c.p.	6 c.p.	8 c.p.	10 c.p.
$\frac{9}{10}$ c.t.	$1\frac{3}{10}$ ct.	$1\frac{8}{10}$ ct.	$3\frac{1}{10}$ ct.	
16 c.p.	25 c.p.	32 c.p.	50 c.p.	

Aside from the quickness with which a customer determines the rate per hour for a number of lamps upon his requirements, the arrangement is useful in enabling the most recalcitrant consumer to see the justice of heavier charges based upon the use of lamps of higher candle-power in his total monthly bill.

The latest blow at public ownership of an electric lighting plant has been delivered by the Hudson County, N. J., Grand Jury. Col. Edwin A. Stevens, of Castle Point, Hoboken, the foreman, handed up a batch of seventy-eight indictments, including a presentment which said in part:—"The Grand Jury calls attention to the running of the electric light plant. (The county operates the plant to light the big county driveway.) This plant has been operated in the most unsatisfactory manner and at a very large expense. The evidence shows that these conditions have been materially improved of late. The Grand Jury questions, however, whether it will be possible for the county to produce current from its station as cheaply as it can be bought."

To show the possibilities of travel by means of electric roads, a trip was recently made under the arrangement of the Indianapolis & Eastern Railway from Indianapolis to Dayton, thence through Springfield, Columbus and Zanesville back to Dayton, then to Lima and Cincinnati and back to Dayton, returning to Indianapolis. The distance covered was 644 miles, and the trip occupied three days.

From the World's Technical Press

Electrical Shock Causes Gangrene

THE strange case of a fatal electrical shock causing gangrene in all the extremities of the victim recently came up for discussion by the members of the London Clinical Society.

The report of the case, as printed in "The Electrical Engineer," of London, is that the victim, a healthy lad aged 15½ years, was employed at the London Electric Supply Corporation's station in Blackfriars road. The current is received at this station from Deptford at high pressure, the maximum being 10,000 volts. Transformers are located on both sides of the station, and those on either side are "alive" in turn. The lad mounted one of the "dead" transformers to dust some slabs of slate above, and in descending the iron plates on the soles of his boots caused him to slip on the iron of the transformer and, overbalancing, his right hand came in contact with the main cable carrying the 10,000 volts. This current, it is imagined, passed through him for about 30 seconds, when a man, attracted by the flash of the escaping current, rushed over to the boy, who was rigid and apparently lifeless.

Artificial respiration restored consciousness. When taken to the hospital he showed signs of shock, and all his limbs were gangrenous. His socks and boots were extensively burned, and the latter were burned entirely through. On the third day, his right arm was amputated at the shoulder joint. On the sixth day it was evident that the gangrene of the legs was spreading, and the patient's temperature was rising; both legs were therefore amputated. Two days later, however, symptoms of toxic infection appeared, and on the ninth day from the accident the boy died.

The remarks made during the discussion by F. Aspinall, electrical engineer, suggested a new explanation of the cause of death. He stated that when an arc was formed, metals became volatilized, and he suggested that the inhalation of these vapors might prove fatal. It was stated in the course of the discussion that when an accident is accompanied by burning of the skin, the shock is usually less severe. Allusion was also made to the now well-recognized fact that the effect of a shock is dependent more upon the nature of the contact than the voltage. Dr. S. Jellinck, of Vienna, recommended that in framing rules for the prevention of accidents in establishments where electricity is employed, regard should be had not only for the tension of the current, but for the dielectric condition of the ground.

Marconi on Wireless Telegraphy

IN a lecture recently delivered before the British Royal Institution, and abstracted in "The Electrical Engineer," of London, Mr. Marconi observed that the recent improvements in wireless telegraphy included means to prevent interference and secure independence of communication, to increase the distances over which communication was possible, and to obtain greater efficiency and accuracy. He thought the difficulty regarding liability to interference had been exaggerated by the non-technical mind; the expert telegraphist knew that the same thing was possible with ordinary telegraphy, but that it was prevented by rules and regulations devised to that end.

In some instances—such as a shipwrecked vessel calling for assistance—it was a distinct advantage that the messages should be received by a number of other ships or stations; but as this interference must in some cases be recognized as a drawback, he had devised a method of obviating it. This method, as is now well known, consists of the syntonization of the apparatus at the various stations to different periods, by which it is now possible to transmit messages to each one of them without the others being affected, and even five years ago it was possible to send and receive several messages simultaneously without one interfering with another.

Mr. Marconi then dealt with receiving apparatus, and exhibited his magnetic detector, which is to supersede the coherer. He stated that the alterations effected in the detector as the result of experience render high speed and automatic transmission attainable. At first the detector had the disadvantage that it could not be made to actuate a recording or writing instrument, the current impulse with which it worked being too rapid to have any appreciable effect on the tongue of a relay, but by altering the circuits and the character of the iron employed in the magnets, the impulse had been slowed down, so that it was possible to operate a relay, and, therefore, a recording instrument. With this arrangement the lecturer stated that a speed of 24 words per minute had recently been maintained over a distance of 152 miles overland. This speed is somewhat less than that which Captain James announced he had attained with the De Forest system in the Far East.

Dealing with long-distance transmission, the lecturer adhered to his optimistic attitude, expressing confidence that in a short time it would be demonstrated that transmission across the Atlantic was not only practicable, but trustworthy, and the method so economical as to be within the means of the majority. Besides this, he hazarded the assertion that Lord Kelvin's prediction as to wireless communication with the Antipodes might be realized.

Referring to the differences in transmission by day and night, Mr. Marconi stated that these were only noticeable over long distances, the range by night being much longer than that by day, as clear sunlight appeared to act as a fog to the Hertzian waves; but the lecturer took the opportunity of reminding the audience that clear sunlight and blue skies were not general in Great Britain.

A Large Electric Mine Equipment

THE electrical equipment of Vesta No. 4 Mine, of the Vesta Coal Company, of California, Pa., according to "Mines and Minerals," is second to none. Two 500-K. W. units generate current at 550 volts, the engines being of the cross-compound Corliss type direct connected to Westinghouse generators.

Twenty electric locomotives are employed. Three 4-ton and one 10-ton Baldwin - Westinghouse locomotives are used in the First Hill Mine. In the Second and Third Hill Mines, a 10-ton and an 8-ton Baldwin-Westinghouse locomotive haul from two inside partings each to the end of the rope haulage at the pit mouth of the Second Hill Mine, bringing out about 40 to 25 cars respectively at a time, although the larger one has hauled as many as 80. The coal is gathered to the four partings by ten 4-ton, one 6-ton and one 8-ton Baldwin-Westinghouse locomotives, and one 5-ton General Electric locomotive. The twentieth, a 6-ton Baldwin-Westinghouse, was recently installed. They are all wound for 500 volts.

Excepting near the outcrop, where the roof is too poor and in ribs, all coal is mined by electric machines. Nineteen Jeffrey chain machines with self-propelling trucks are used, each machine making a cut 44 inches wide and 7 feet deep, and cutting from four to five rooms in a shift. Some experimenting has been done with one Sullivan electric long-wall machine, with which excellent results have been obtained. It is claimed that it can cut as many as thirteen wide rooms in a single shift.

Scrap Copper

THE bulk of old copper marketed in America, says "The Engineering and Mining Journal," is credited to the electrical industry. Usually old copper wire of good quality commands a premium over other forms of scrap metal, and sells today at about 13.5 cents per pound at New York, a price that is only 0.5 cent or 1 cent less than casting copper. Wire is made from the purest of copper, and because of its freedom from foreign substances, is preferred for brass-making and similar purposes, when marketed as scrap.

Other sources of supply of scrap copper are in the form of boiler and kettle bottoms, worth about 12 cents per pound; tubing, nails, type-shells, sheet clippings and the like, marketable at 12.75 to 13 cents per pound. The demand for copper bottoms is limited, because their value is impaired by their shape and the fact that nearly all are tinned and soldered, causing difficulty in melting and making an impure casting.

A peculiarity, rather surprising to the uninitiated, is the small margin between the price for old and new copper. Only in recent years, however, has this difference caused comment, but the fact that the demand from experienced foundrymen is increasing suggests a reason for the advance in the price of scrap copper.

Natural Gas for Gas Engines

SOME interesting figures concerning the cost of fuel to operate gas engines were printed recently in "The Gas Engine." The article states that it is usually considered that with gasoline a gallon per horse-power per 10 hours is sufficient, or with natural gas 15 cubic feet per horse-power per hour, or with artificial gas 20 to 22 cubic feet per horse-power per hour. These figures apply to engines running at full load, a gradual increase in consumption per horse-power resulting if the load decreases below the full normal load.

	A.	B.	C.	D.	E.	F.	G.	Total.
Horse-power of engine, inclusive	6 to 10	12 to 20	22 to 30	35 to 40	45 to 50	60	80	..
Number of engine	*14	†7	‡13	§12	6	3	2	57
Total horse-power	114	116	344	455	295	180	160	1,664
Total hours run, per day	94	52	130	103	62	26	20	487
Total cost for gas, per month	$46.50	$30.75	$181.00	$188.90	$132.25	$63.25	$66.00	$708.75
Average horse-power	8.14	16.57	26.45	37.91	49.16	60	80	29.2
Average hours per day	6.7	7.4	10	8.6	10.3	8.7	10	8.56
Average monthly cost per horse-power	40.79c.	26.50c.	52.61c.	41.52c.	44.86c.	35.14c.	41.25c.	42.6c.

* One engine ran but one hour per day and two but two hours.
† One engine ran but two hours per day and one but four hours.
‡ One engine ran but five hours per day.
§ One engine ran but two hours and one but 1.5 hours

The figures given in the accompanying table were obtained from engines which were not run by experts, and it is not known exactly what power they were developing, for they are rated at the power at which they are sold. It is not known precisely how many hours each day each one was operated, but this is known very closely, as it was known in each case what the working hours of each plant were. It is not claimed that the figures are any indication of what may be done under expert service, but that they are the actual figures secured from engines installed and running under ordinary conditions. The engines were all of the 4-cycle type, governing on the hit and miss plan. Natural gas, costing 25 cents per 1000 cubic feet, was used for fuel.

These figures show a cost per horse-power per month so low that no engine manufacturer would guarantee them. Assume a guaranteed fuel consumption of not to exceed 15 cubic feet of natural gas per horse-power per hour. This would mean 150 cubic feet per day of 10 hours, or 3900 cubic feet per horse-power per month of 26 days. At 25 cents per 1000 cubic feet this would mean 97.5 cents per horse-power per month, which is the guaranteed maximum rate of full load.

The figures in the table show about half this guaranteed maximum rate. We must assume that the figures are correct, for the engine manufacturer, as well as the users of the engines, stand back of them. The low cost must, therefore, be due to the fact that the engines were running on less than full load, which is as it should be.

But there was considerable difference between the various engines of the same size. For instance, one 40-H. P. engine cost $13.50, another $20 and another $30, while one of the 80-H. P. cost $30 and the other $36. This was largely due, no doubt, to the difference in actual load carried by the engines, for each of those just mentioned ran 10 hours per day.

The value of these figures lies not in their statement of actual costs in any individual case, but in showing that under ordinary cases there should be a much less fuel bill than would be indicated by the maximum amount which the engine makers are willing to guarantee. In this case 57 engines, aggregating 1664 horse-power, are considered and the average among them should be worthy of consideration.

An Apparatus for Recording Lightning Discharges

IN a recent issue of the "Monthly Weather Review," published by the Weather Bureau, an apparatus for recording lightning discharges is described. It consists of a collector, a coherer, a relay, a recorder, a decoherer and batteries. The collector is a hollow cylinder 14 feet long and 11 inches in diameter, made of two sheets of commercial zinc nailed to three disks of wood, one at each end and the third in the middle. The edges of the zincs are soldered.

The coherer consists of a piece of thick glass tube, ¼ inch inside diameter, 2 inches long, into which are closely fitted two silver electrodes placed about 1-16 of an inch apart. In the space between them are placed a few filings filed from a dime with a coarse file.

The decoherer is an ordinary electric bell, to the hammer of which is soldered a stout piece of wire, 2 inches long, at right angles with the axis of the hammer, and to which the coherer is attached by a piece of insulating tape. When the bell rings, the filings are shaken and separated. The relay is of the ordinary kind used in telegraphy and has a resistance of about 150 ohms.

The coherer is connected in series with the collector and the ground, and the relay is placed in circuit with the coherer and two dry cells. The relay makes and breaks a circuit consisting of the bell, the recorder and four dry cells. Any electrical disturbance in the air will affect the collector, which is placed on the roof, and the waves passing through the coherer reduce its resistance, operating the relay and, in turn, the recording circuit.

The recorder consists of a strong clockwork, a hollow wooden cylinder 3¼ inches in diameter and 3¼ inches long, mounted on an endless screw fixed to an upright iron support at one end, and a small door-bell magnet, on whose armature is soldered a self-inking pen. The cylinder carries a sheet of paper divided into hour and 5-minute spaces, and makes a complete revolution once every hour. Every time the recorder ticks, the pen, which is suspended over the cylinder about 1-16 of an inch therefrom, strikes the paper and imprints thereon a dot.

Electrically Operated Fans for Mine Ventilation

ELECTRICITY as a motive power is found to be very effective even with fans of large diameter for mine ventilation, but it is chiefly in the driving of small "express" fans, says "Mines and Minerals," that its peculiar advantages are demonstrated. It often occurs that there are a number of small shafts having communication with different seams, each requiring a comparatively small fan. To put down a steam-driven fan in each of these cases would mean a great outlay in steam pipes or boilers, while on the other hand small cables are easily run from a central electric power station to small motor-driven fans. Again, small or secondary fans are sometimes placed in certain parts of the mine to carry air to detached or remote workings. For this latter purpose, especially, electrical driving is convenient, economical and efficient; in fact, before the application of electricity to this purpose, it was impossible to find a means of adequately ventilating some portions of extensive mines.

With an electrical fan it is possible to regulate the output of air in a simple and economical manner, according to the requirements of the mine, a small quantity being economically produced when opening out, increasing gradually as the workings extend and at any moment capable of a considerably enhanced output for a short period in the event of an inrush of gas. If power is not to be wasted, a system which is elastic enough to economically and adequately meet the varying requirements of the mine must be adopted and small electric fans seem to provide an excellent means of doing this.

There is no doubt that as the mines get deeper, and the working faces are thus in many instances more remote from the shaft, great difficulty will be experienced in passing sufficient quantities of fresh, cool air if the present ventilating arrangements are to be continued. There is clearly a limit, both to the mechanical and manometrical efficiency of the fan. It is not enough to simply enlarge the fan in order to obtain more air. On the other hand, it is not always possible and seldom economical in other respects to restrict the number and dimensions of the airways and to force the air through them at high gauges.

With electric fans, main and secondary, no difficulty is in this way experienced, and in spite of increase of depth and temperature, the workmen may still be supplied with an ample and cool current, passing through the mine at an easy and comfortable velocity, which will be impossible unless the airways are made extremely large, or unless some such method as we describe is adopted.

Insulation of High-Tension Currents

THE Compagnie de l'Industrie Electrique et Mécanique of Geneva recently conducted some experiments on the insulation of direct and alternating currents of high tension. There are power transmissions by direct currents of up to 25,000 volts in Switzerland, and the question is, how much further one might safely go in this direction without incurring considerable current losses on long lines. The experiments once more show that direct currents strain insulators less than do alternating currents of the same pressure.

The experiments, as recorded in "Engineering," were rather unfavorable to direct currents, because the commutators of the dynamos consisted of only 96 bars, while, on the other hand, the alternator gave pressure curves with rather flat tops. Three direct-current dynamos, yielding 1 ampere at 25,000 volts, were coupled in series; the alternator was a six-pole machine for 75 K. W. at 50 periods. Only a few of the porcelain bell insulators tested were ruptured by the currents; in most cases the spark went round the bell edge.

Homogeneous china, with faultless glazing, stands higher continuous-current pressures than would follow from the striking distance in air at that pressure. Insulators perforated by alternating currents, afterwards, in the laboratory, resisted higher continuous-current voltages; in the rain, outside in the open, about two-thirds the pressure (average ratio 1 : 1.63) could be resisted. Under direct currents the insulators never became perceptibly warm; the heating seems to be a capacity effect. The energy loss with direct currents at 20,000 volts is very small—about 0.02 watt per insulator—and insignificant even in foggy weather. This confirms observations made on the St. Maurice-Lausanne line, where 5000 H. P. are transmitted about 60 kilometers at 22,000 volts.

To judge from these experiments pressures of 70,000 volts should not be subject to considerable losses from faulty insulation and electric radiation. As regards the striking distance in air, the largest striking distance—99 millimeters, with 60 000 volts direct—was found with a point as positive pole and a plate as negative pole; the smallest—35 millimeters—between two ball electrodes. This well-known difference between various electrodes was also observed with alternating currents, the extremes at 60,000 volts being 149 and 74 millimeters. The comparative influence of the electrode shape is shown in the following table, which gives the ratio of the striking distances for direct and alternating currents of equal pressures:—

Shape of Electrodes.	At 30,000 Volts.	At 60,000 Volts.
Ball against ball........	1.6	2.5
Plate against ball.......	2.4	1.85
Point against plate......	2.2	1.5

Different insulators were perforated at—

	Volts	Volts	Volts	Volts	Volts
Direct currents.....	24,000	34,000	40,000	45,300	40,800
Alternating currents.	15,000	21,400	27,000	24,700	31,160

Press-spahn (insulating cardboard) plates, 5 millimeters in thickness, stood 9000 and 11,000 volts direct for 255 seconds before they were perforated; another make, perforated by alternating currents of 10,000 volts after two minutes, broke down under direct currents, whose pressure was raised above 20,000 volts, after eight minutes. Marble, 20 millimeters in thickness, broke down at 45,000 volts direct in the fifteenth minute, the pressure having been raised from 10,000 volts by steps of 5000 volts in two minutes. The same plate succumbed to 20,000 volts alternating in 75 seconds.

Electricity from Refuse

THE primary object of a refuse-destructor, says London "Engineering" in a recent issue, is to afford a sanitary and economical means of disposing of the various domestic and street refuse of towns, and provided this is accomplished satisfactorily, no more can be absolutely required of it. The first improvement which followed from experience in the working of such plants consisted in making the furnaces self-supporting—that is, able to effect the cremation of practically every kind of refuse, by utilizing the fuel value of the combustible matter it contained, without the use of coal or other additional fuel.

A very high furnace temperature is necessary to insure the complete destruction of noxious gases, etc., and when this had been attained by the use of forced draught and other means, advantage was taken of the fact to use the heat carried off by the waste gases in the flues to raise steam for driving the fan-engines and other machinery in connection with the plant. As it became possible to utilize more and more waste heat in this way, new uses were found for the steam so generated, and it was applied to sewage and water-pumping, crushing clinker from the furnaces, mixing mortar, and in fact formed the whole source of power for the works.

At Oldham, England, the amount of steam raised by the flue gases outgrew the demands of the destructor works, and in March, 1896, steam was supplied to the adjoining electricity works of the corporation, and the first public supply of electricity aided by refuse-raised steam was then established. The possibilities of utilizing refuse in this way were at once recognized, and it was not long before combined destructor and electricity works were put down to take the greatest advantage of the steam-raising value of the refuse. The vestry of Shoreditch led the way with their combined works, and there are now more than forty combined plants at work, and about twenty more are being erected.

The idea of combined works appears at first sight very attractive, and no doubt the combination has many advantages; but, on the other hand, it must not be assumed that under all circumstances the apparent gain outweighs the attendant disadvantages. Both the quality and the quantity of the refuse collected in winter are better than during the summer months, and this corresponds roughly with the demand for electricity; but not only is the total amount collected from a district usually quite inadequate to supply the whole of the power for lighting, but the refuse itself varies so greatly from day to day on account of the weather and other causes, that its value must be largely discounted by the uncertainties that its use introduces into the working of the station.

The case for combined plants was well put in a paper recently read by W. P. Adams before the Institution of Electrical Engineers. In this the author devoted himself, however, more particularly to the consideration of the working of the five combined plants in the metropolis. Besides the variation of the calorific power of refuse from month to month, a very striking fact is the greater efficiency of the plant when working at full load. The units generated per ton of refuse are, in general, from two to three times as great during the peak of the load as during the hours of light load, the actual values being from 30 to 40 units per ton in the morning, to over 100 units in some cases at the peak. The reason for this great difference is not clear, as the rate of burning is practically constant, and, in fact, could not be altered much even if desired. Mr. Adams considers that 40 units per ton may be taken as the value of average London refuse all the year round; and if this estimate is justified, it is a most uneconomical process to dispose of the refuse otherwise than by using it in a steam-raising destructor plant. Since the paper was read some figures have come to hand showing the result of the working of the Meldrum destructor plant at Burnley. During the quarter ending on June 25 last, the refuse collected averaged 203 tons per week, varying irregularly from 178 tons to 266 tons. The average water evaporated was 3517 pounds per ton, or 1.57 pounds per pound of refuse, giving a production of about 117 units per ton on the assumption that one unit could be generated for 30 pounds of steam.

Mr. Adams insists strongly on the desirability of keeping the cost accounts of the destructor plant and the electricity plant quite separate, so that the financial results of each of them may be accurately known. He assumes a considerable saving in capital expenditure by combining the plants, on account, among other things, of the less land space required; but, on the other hand, it must not be forgotton that the earning power of a destructor is comparatively so small that it may not even justify its location upon valuable land, the capital charges of which an electric light station would not seriously feel.

A destructor plant, to be worked at its greatest efficiency, should be used in connection with storage batteries, and this implies a low-tension continuous-current generating station, which can only be economically situated in as central a position as possible in the district which it serves. The combination of a destructor with such a station would therefore generally necessitate the introduction of the latter into a thickly-populated neighborhood, and, apart from the value of ground space, the existence of a destructor in such a place is not desirable for many reasons.

Again, there seems good reason to believe that the dust inseparable from a refuse-destructor is a serious nuisance to the machinery of the generating station, and results in a liability to breakdowns and a higher repair bill. This might be mitigated to some extent by a high party wall between the plants, but cannot be wholly avoided. The question of the advisability, or otherwise, of erecting combined electricity stations and destructor plants must be decided on the merits of each individual case; in an increasing number of townships both plants are essential, but it by no means follows that there would be a net gain, all things considered, by working them in conjunction.

Electricity in Bread-Making

IT is generally well known, says "Cassier's Magazine," that electric motors are now largely employed in driving the machines, such as mixers, kneaders and others, in large bakeries, whereby no part of the human body need come in contact with, or even in proximity to, the flour or dough at any part of the process of bread-making, which, apart from the economies effected by means of the machinery, is obviously a very desirable consideration from a sanitary point of view. Another proposed, but not so successful a use of electricity in bread-making, has recently been announced in a report to the Paris Academy of Sciences. On the mistaken notion that the whiter the bread the better its quality, it appears that the bread consumers of Paris have for years been demanding whiter and whiter bread, with the result that to gratify this demand the most nutritious part of the wheat grain, that which contains the most albumen, is excluded from the flour. It was thought by certain interested chemists that if the wheat flour were brought into contact with electrified air, the ozone might possibly bleach the flour to a whiteness that would please the eye without detriment to its nutritious and palatable qualities. Experiments were, therefore, made to determine these points. The expected result as to whiteness was obtained by the electric treatment, and the amount of phosphorus was the same as in flour treated in the ordinary way. The electrically treated flour, however, was found to be quite unpalatable, the fatty and acid substances varying largely, the fatty substances proving rancid and glutinous and becoming oxidized and partly converted into white sebacic acid which could be dissolved in alcohol. Needless to add, therefore, the use of electricity or ozone for this purpose was not adopted.

High-Tension Transmission with Continuous Currents

A VERY interesting example of electrical transmission is at present being carried out by the Société Grenobloise de Force et de Lumière, who, after having considered several alternatives, have decided upon the adoption of the extra high-tension continuous-current series system, in which the current is constant and the voltage varies according to the power supplied.

As told in "Engineering," of London, it is required to transmit 6300 H. P. from Montiers to Lyons, a distance of about 112 miles, part of the power being to supply the 600-volt tramway system of Lyons, and the remainder to feed the existing three-phase system working at a constant pressure of 25,000 volts. The motor-generator sets for the latter purpose are reversible, so that, should it be necessary, the three-phase system can supply power to the continuous-current circuit, and vice versa; and it is probably the first time that two generating stations of such entirely different natures, and at so great a distance apart, have been arranged so as to be capable of mutual assistance.

The power-house at Montiers will contain, to start with, four 1600-H. P. sets, each consisting of a pair of dynamos driven by a turbine. There will thus be eight dynamos, each of which has an output of 75 amperes at 7200 volts, so that when connected in series they will give 75 amperes at 57,600 volts, or 4320 K. W. at full load. These machines are series-wound, with six poles, and run at variable speed corresponding to the load on the system, their maximum speed being 300 revolutions per minute.

The generating station is of the simplest possible form; there is no switchboard nor any electric controlling apparatus, save one governor, which regulates the speed of the turbines, every dynamo being provided with a simple switch, a voltmeter and an ammeter. A lightning arrester post at the entrance of the transmission line completes the equipment. The transmission line, composed of two wires, each 9 millimeters in diameter, is carried overhead nearly as far as Lyons, where it is taken underground for a few miles by means of a pair of armored cables. Another set of lightning arresters is fitted at the point where the line enters the earth.

At Lyons the primary continuous current is led into a sub-station, where it drives motor-generator sets, the low-tension current from which feeds the traction system at 600 volts. These machines have an output of 500 K. W. each, and run at a constant speed of 428 revolutions per minute. Generators and motors are designed with a view to a very high efficiency, this being expected to reach 94 per cent., and the total efficiency of the system at full load 88.5 per cent.

In a second sub-station, common to the extra high-tension systems, both alternating and continuous, there will be at first two 500-K. W. motor-generator sets, each composed of a continuous-current machine taking 75 amperes at 7640 volts, working either as a motor or generator, and coupled to a three-phase synchronous machine, also reversible in its action. All the continuous-current machines are so arranged that in future, if desired, they may be made to work at 150 amperes instead of 75, by means of a very slight alteration to the connections. This will allow their capacity to be doubled if the demand for power should justify it. The central point of the series of generators is earthed at Montiers, and the corresponding point of the motors at Lyons, so that the difference of potential between any point of the system and earth cannot exceed 28,800 volts, or half the entire voltage of the system. The electrical equipment of the generating and sub-stations is being supplied by the Compagnie de l'Industrie Electrique et Mécanique, of Geneva.

The Electrolysis of Lead

THE electrolysis of lead, says "The Engineering and Mining Journal," presents some peculiarities. As a metal it should pass to the cathode and be deposited there; but lead is "ambiguous" in its chemistry. In the ordinary electrolytic cell, lead forms the dioxide or plumbic-acid anhydride, which, of course, must appear at the anode with other oxidized and oxidizing acid residues. Hence the trick is to cajole lead to go to the cathode as a reduced metal.

The Betts process, now in use at Trail, B. C., employs a lead fluo-silicate as the electrolyte, whereby the leads acts as a metal and seeks the cathode. A recent invention cleverly suggests an electrolyte of fused lead-chloride, with an anode of galena. The metal is said to be deposited at the cathode, and the anodic chlorine attacks the lead sulphide, regenerating the lead bath.

Canadian Niagara Power Interests

THE nineteenth annual report of the Commissioners of Victoria Park, on the Canadian side at Niagara, which was submitted to the provincial legislature March 31, is an interesting contribution to the literature treating of the Niagara power development, as it contains a valuable and luminous exposition of the progress and present status of the work of the electrical development at Niagara.

The opening portion of the report, according to "The Iron Age," is a résumé of the work done in the development of the park since the appointment of the first commission in 1887, the park having been opened free on May 24, 1888. Originally the area was 196 acres, which has since been increased to 787 acres. The total amount spent in acquiring and maintaining this property up to December 31, 1904, has been $1,351,139, while the total receipts for the same period have been $1,328,679, the excess of expenditures over receipts during this time having been $22,460.

But the most interesting feature of the report is the wonderful manner in which the recources of the park have been built up by the assessments made for power franchises and rights. It is shown that the Niagara Falls Park & River Railway, the scenic line along the cliff and through the park proper on the Canadian side, has paid the commissioners $132,500. The Canadian Niagara Power Company, which was first to secure rights in the park, has paid a total of $224,577.78. The

Ontario Power Company has paid \$110,000, and the Electric Development Company of Ontario, Ltd., has paid \$30,000, while the photographic and other concessions have paid \$103,700. This makes a total of \$620,777.78. The three power companies have paid a total of \$364,577.78, and the only power yet developed is that in the station of the Canadian Niagara Power Company, where 30,000 electrical horse-power is available. The Ontario Power Company, which has paid \$110,000, will have power generated during the coming summer, while the Electrical Development Company will hardly have power this year, but has paid \$30,000. Each of the companies will add to the amounts mentioned this year by its semi-annual payments. It is further stated in the report that the annual revenue now assured to the park is \$84,200. This revenue, it is stated, will increase from year to year, with the growing demand for electrical energy, and in all probability will amount within the next five years to over \$200,000 per annum. On the important question of the further development of Niagara power the commissioners go on record in the following statement:—

"Seeing that three franchises have already been granted for the withdrawal of water from the Niagara River for the development of approximately 375,000 electrical horse-power, and a further franchise for 100,000 horse-power to be drawn from the Chippewa River, making an aggregate development already authorized of possibly 475,000 horse-power, it rests with the government to decide whether as a matter of public policy any further concessions shall be granted at the present time. The points to be considered are:—

(a) The franchises already granted to three separate corporations for such a large aggregate development should for the present be sufficient to induce effective competition in the supply of electrical energy, and until the extent of the demand there will be for its use in Ontario is definitely known.

(b) If such demand in the near future appears to require further development, additional concessions can be granted in good time to meet it.

(c) If the methods adopted by the various power companies for disposing of electrical power at Niagara and throughout the province by transmission are satisfactory both in respect to efficiency of service and price, the government will then be in a position to decide whether the public interests will be better served by granting further corporate franchises or in otherwise dealing with the development and sale.

(d) If a greatly increased demand arises in the future for electrical power, doubtless the value of franchises for the use of Niagara River water will be largely increased and better terms will be secured for any additional concessions that may be hereafter granted.

(e) If franchises are granted, which are likely to be, on the American side of the river, involving the withdrawal of a large volume of water from the river, thus seriously affecting the existing levels, it may become necessary in the protection of Ontario interests to have equal or greater withdrawals of water on the Canadian side of the river, or that an international agreement should be arrived at for a defined limitation of such withdrawals.

"It should also be borne in mind that the granting of new power franchises in the park or the enlargement of the existing licenses, as now asked for by the Electrical Development Company, will necessitate the construction of buildings on the shore of the river, which constructions may cause an undue defacement of the park and water views, which, if possible, should be avoided."

The Invention of the Mirror Galvanometer

REFERRING to a story now going the rounds which gives to Lord Kelvin the credit of being the original discoverer of the mirror galvanometer, the instrument which he adapted so cleverly and beautifully to the operation of the first Atlantic cables, "Cassier's Magazine" says:—

"Lord Kelvin's fame is so well established that it stands in no need of that which belongs to others. The story goes that one day while Lord Kelvin, then Prof. Thomson, was experimenting, his eye-glass fell off and swung in front of the magnet, reflecting its movement, and instantly the idea of the mirror galvanometer suggested itself. 'Thus,' adds the narrator, 'a monocle may be credited with a direct effect on modern science.' It is a pity to spoil so interesting a story, and more especially to deprive the monocle of the honor of this beneficent effect on modern science, but the fact is that Gauss and Weber, in 1833, in the operation of their electric telegraph system, used the reflections from a mirror attached to a magnet by which to read arriving signals; while Weber's reflecting galvanometer employed the same principle at a time when young William Thomson was hardly in his teens. To a student and reader like Prof. Thomson, the falling of his monocle, if he wore one, was not necessary to suggest the reflecting galvanometer."

A New York-Philadelphia Electric Railway

IT is suggested by "The Western Electrician" that the 88 miles between New York and Philadelphia be known as the "trial track," inasmuch as it has been a sort of proving ground for methods for the annihilation of space from the days of road coaching until the present time. Upon this path the practicability of the relay stage coach system was demonstrated. Over it Col. Robert L. Stevens conducted one of the earliest steam railroads in 1832, the first paying electric telegraph system was operated over these same 88 miles, and the first long-distance telephone line connecting large cities spans these two points. At one terminus of the "trial track" there is now a city of over 3,000,000 inhabitants, and at the other end one of approximately 1,300,000, with large cities scattered between. Two steam railroads are now carrying yearly 1,500,000 round-trip passengers between New York and Philadelphia, and still the traffic demands are not adequately met.

With the completion of the electric railway tunnel under the North River at New York, another demonstration of the utility of the "trial track" will be made, and it is stated that an electric railway to be known as the New York & Philadelphia Electric Railway will be in operation between the cities named. It is hoped that 1,000,000 round trips per annum between the termini of the electric line will be made by its patrons, and though some of this will undoubtedly be traffic diverted from the steam roads, much of it will also be new traffic originated by reduced rates. Much interest attaches to the completion of this road, which, when accomplished, will be the shortest electric line in the world connecting two cities of such magnitude.

It is reported that a trackless trolley line is to be constructed in Italy from Spezia to Portovenere, a distance of $25\frac{3}{4}$ miles.

During the coming year a magnetic survey of the North Pacific Ocean will be made by the Department of International Research in Terrestrial Magnetism of the Carnegie Institution at Washington, D. C.

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Leading Articles

Continuous Service in Isolated Plants

CONTINUOUS service is one of the most important objects to be attained in every electric plant conducted on a business basis. Familiar as this fact is to engineers, it is astonishing that so many plants are inadequately supplied with equipment to insure steady and reliable output in times of trouble. Many installations have no recourse but a total shutdown in case a steam pipe bursts, a pump goes wrong, or an exciter fails.

The street railway companies and the central light and power stations have for some time past appreciated the importance of continuous service. This is largely due to the fact that their respective earnings are direct; it is as plain as daylight that the machinery of the central station and the rolling stock of the transportation system must move in order to produce revenue.

The same point applies with special force to the isolated plant during the hours when its product is needed, although the process is a little more roundabout. Particularly is this true in commercial buildings, such as hotels, offices and stores. The loss caused there by plant shut-downs occurs through the general impedance of business, rather than through the loss of saleable power.

In every isolated plant which has so few units or is so fully loaded that the failure of any one would cause serious embarrassment of business, it would seem worth while to install a breakdown connection with the local central station's circuits if it lies within the bounds of possibility. Sometimes the breakdown demand of an isolated plant reaches a power total of several hundred kilowatts, and in cases where the local central station is already heavily loaded in regular revenue-producing service, it is out of the question to furnish a breakdown connection enabling such a volume of power to be drawn from the distributing system at any sudden emergency which may arise within perhaps two or three years of the date of the breakdown connection's installation. Nor could the isolated plant afford to pay fixed charges upon the purchase of extra machinery by the central station, the output of such machinery to be held subject to demand.

The situation is very different from that of a gas company, which can store a million cubic feet of its product in a single additional gas holder, and thereby anticipate any sudden demand upon its resources. The larger the central station, the more probable is it that breakdown connections with isolated plants can be made to advantage, but in smaller cities and towns the prospects of upsetting the service supplied to regular customers are so certain in stations of moderate size that such connections should be made only after the closest study of local power conditions and loads.

In the case of central stations which are not blessed with a substantial motor load the problem is simpler, but it is safe to say that in every feasible instance the isolated plant should be required to notify the central power station before throwing in its load,—a point which can be secured by the installation of switches that shall normally be open at the central station end of the supply circuit.

Consideration of these facts should deter one from installing but a single machine in any commercial isolated plant unprovided with a breakdown connection. Self-evident as this conclusion is, it needs emphasizing in view of recent practice in more than one isolated plant layout. Here is a 120-K. W. plant, for instance, furnishing power and light to a large wholesale house, the entire power supply being drawn from a single machine, and a belted unit at that. A broken belt, a burned-out armature, or a severed exciter wire will shut down the whole establishment, employing perhaps 100 hands. Forty or fifty dollars an hour are scarcely a measure of the company's loss in case of a shutdown.

Again, a large mill, equipped with over a score of motors and perhaps 1000 lights, installs in its new plant, otherwise a model of good engineering, one 800-K. W. unit to furnish its entire power supply, without a breakdown connection. A cylinder head blows out, and five or six hundred dollars an hour are thrown away while the repairs are being made at high-tension pace.

A department store plant has a single feed pump for its boilers—no duplicate pump or injector. The pump goes wrong about 5 o'clock on the heaviest afternoon of the week, and the result is easy to state. In less than ten minutes the loss in customers in two or three of the main departments would pay for an extra pump, with something to spare.

Doubtless it is easy to overdo in this matter of duplication, but the foregoing illustrations certainly would seem to indicate that the line has in some cases been drawn much too far on the side of the low first cost of installation. Isolated plants exist in great numbers where the choice of equipment has been made with great good sense and judgment, bearing in mind the results of shutdowns. In residence plants, equipped with other than electrical means of illumination, the question of continuous service is of far less moment. Such plants can scarcely be said to operate upon a business basis.

The exact method of insuring continuous service in any given installation can be determined only after the local conditions are known. The importance of the subject goes hand in hand with the matter of economical operation, and it deserves even greater attention at the hands of designers than it has yet received.

Electric Heating on Shipboard

THE advantages of electric heating in many phases of human activity on land have of late been widely recognized, but the peculiar facility with which the electric current can be employed on shipboard for heating service is not so well appreciated. It is not too much to say that every characteristic of the electric heater which commends it on shore is emphasized with peculiar force in marine work, where compactness is of vital importance, weight at a premium, cleanliness and convenience are prime objects, and safety is paramount.

Thus, the last-built steamers of the Cromwell Line, together with the "Oceanic," "Celtic," "Cedric," and other mammoth transatlantic liners, have all their upper deck staterooms heated by electric radiators; electric griddles and broilers, laundry irons and hot-water urns have made their way into the galleys of many fast ships; while for stateroom service, electric heating pads, once used, are almost indispensable in cases of sickness. The Hamburg-American and the North German Lloyd lines have been completely equipped with electric curling-iron heaters and electric food warmers, and extending use is made by them of electric radiators.

The private yacht also offers an attractive field for the introduction of electric heating. The slight additional cost is far outweighed in such cases by the comfort and convenience of an electrical installation. The ease with which electric wires may be installed in comparison with the expense and difficulty of supplying steam connections is a strong point of advantage. No heat is wasted, the fire risk is greatly reduced with approved workmanship and materials, and the coolness, flexibility and freedom from disagreeable odors, dirt, oil and grease are cardinal points of favor in the sight of yacht owners.

Automatic Repeaters on Long Telegraph Circuits

WHAT is probably the longest telegraph circuit in the world has been in operation for over a year on the lines of the Indo-European Telegraph Company, between London and Teheran, Persia's capital. This circuit is 4000 miles in length, and in its course it traverses the North Sea for 200 miles and passes through Belgium, Germany, Russia, Turkey in Asia, and Persia.

The Wheatstone automatic system of transmission and reception is employed on the circuit. In the operation of the Wheatstone automatic system the messages are first prepared by punching holes in a paper strip somewhat analogous to those seen in automatic piano players. Certain combinations of holes in the paper strip correspond to certain letters of the Morse telegraph alphabet. The paper strip is then passed through an instrument which transmits the message over the line. At the receiving station a sensitive relay responds to the letters transmitted, reproducing them on a paper strip in the shape of dots and dashes, when they are transcribed upon ordinary telegraph blanks by copyists.

By the Wheatstone automatic system messages are transmitted at the rate of from 80 to 400 words per minute, according to the nature of the circuit, as against 24 to 35 words by manual Morse transmission. On the London-Teheran circuit there are ten automatic repeating stations, namely, at Lowestoft, Emden, Berlin, Warsaw, Rouno, Odessa, Kertch, Sukhum, Kaleh, Tifiis and Tauris. The business for and from Manchester and Liverpool is also handled direct with Teheran. It will be understood that automatic repeaters virtually take the place of operators at the repeating stations. In the case of the circuit under consideration there are repeating instruments and batteries at each of the ten repeating stations. As the line is divided into eleven parts, each part is comparatively short.

The use of automatic repeaters on telegraph circuits corresponds in a measure to that of "relays" in the days of stage coaching. In those days a pair of horses would be detailed to draw the coach to a certain station, having reached which they were relieved by a fresh set of horses termed a relay. The stage was then drawn to the next station, when another relay of horses would be attached to the coach, and so on. The obvious reason for these changes was that the horses had become fatigued, and while they might have drawn the coach further, the work would not have been done so quickly nor so well.

What the relay of horses did for the stage coach, automatic repeaters virtually do for the telegraph message. They take it off the hands of a tired wire, if the expression may be used, and pass it on with fresh vigor to another wire. Automatic repeaters are made necessary on telegraph wires, because of the fact that a portion of the current on the wire escapes at each insulator and also wherever the wire touches a tree or foliage. Hence, the longer a line may be, the more electricity will escape in this manner, so that on long lines the current that reaches the distant end might become too enfeebled to operate the instrument. Apart from the question of escaping current there would also be the matter of decreased current due to the high total resistance of the wire, besides the retardation of signals due to the static capacity of the line. On a 4000-mile telegraph circuit the total resistance of the line might be 50,000 ohms, which resistance would require an electromotive force of at least 2000 volts on the line to provide sufficient current to properly operate the Morse relays, assuming no escape of electricity.

On a line such as the one under consideration, which passes over mountain, forest and desert, and which is exposed to floods, sleet and lightning storms, and to dense sea fogs along the Black Sea coast, it is obvious that in order to secure fairly rapid signaling the automatic relays must be comparatively short distances apart. It is, it may be added, of course, well known that the presence of automatic repeaters on a circuit, by the inertia of their mechanism, conduce to reduce the speed of signaling somewhat, but the gains otherwise far outweigh this disadvantage, as the great improvement in the handling of business reported in the case of the London-Teheran circuit, since direct Wheatstone transmission was adopted, amply demonstrates.

Relative Costs of Steam and Electric Traction for Main Line Service

IN an editorial on "Electric Locomotives," "The London Engineer" concedes that in the matter of train acceleration and the benefits which it confers on the conduct of traffic, the electric locomotive has the advantage. But rapid acceleration, it argues, becomes of little or no importance or pecuniary value, direct or indirect, for long run traffic.

"It would not," says the "Engineer," "make the slightest difference to the running of a Great Western train to Birmingham without a stop whether one minute or five minutes were expended in getting up to full speed. The comparative merits of the two systems of traction must be fought out on other considerations altogether when we come to deal with main line express traffic. We may admit without a moment's cavil that for special conditions of metropolitan traffic it is worth while to sacrifice much, and to spend a great deal of money, in order that trains constantly starting and stopping may be got away and pulled up with as much promptitude as the passengers can endure; but with such trains we have nothing for the moment to do. If electricity supplants steam on main line traffic, it must be because it possesses some special advantages over steam with which acceleration is not concerned.

"So far, no high-speed long-distance running has been regularly attempted by an electric locomotive, or, indeed, by electricity at all. The work done in this direction in Germany and Italy has been purely experimental, and by motor trains. But such as it is, it in no way favors the hope that to work railway traffic by electricity will effect an economy. It is a fact not generally known that the cost of coal per mile on our tube railways is very nearly twice that required for steam locomotives. In the face of such a fact it is, of course, useless to infer that the cost of a horse-power in the generating station is very much less than that of a horse-power developed by a locomotive engine. We are not at all concerned with statements of this kind. To propel a given train by steam requires, say, 36 pounds of coal per mile; to do the same thing by electricity costs 72 pounds or thereabouts per mile. There is much reticence manifested about coal consumption by those in charge of power houses; and if we have been led into error, nothing will give us more pleasure than to publish the latest corrected figures. But we have no doubt that we are substantially accurate when we say that the expenditure of fuel per train-mile is much greater with electricity than steam.

"The capital outlay which would be required before the electric locomotive could supersede steam is enormous; and its expenditure could only be justified if advantages could be secured which would greatly add to the popularity of a given railway and induce a large influx of money as a result of that popularity. If, now, we examine the arguments urged in favor of a change, it will be found that they are invariably based on the assumption that speeds very much higher than any now in use can be reached.

"A board of directors called upon to consider a scheme for electrifying a main line may therefore narrow the range of their consultation in the first instance to the question of whether, in order to secure another 10 or 20 miles an hour, it would pay them to incur an expenditure of so many hundreds of thousands of pounds. There is the secondary consideration that it may cost less to haul trains by electricity than by steam. This may be so—we do not say that it is not possibly true; but we do say that there is no evidence available on the subject one way or another based on facts. If we take the capital outlay into consideration, there is very good reason to think that haulage on main lines by the electric locomotive would be more expensive than the present system.

"It is, however, always unwise to dogmatize, and the questions involved are well worth careful discussion; but discussion of the kind must be based on experience to be of value. It is, perhaps, too much to expect as yet the publication of detailed statistics of, say, the Liverpool & Southport Railway, but figures must be available very soon. They will not apply, of course, with minute accuracy to the working of main line traffic, but they will be very useful in many ways in enabling the railway world to form opinions as to the propriety or the reverse of considering the extended use of electricity in main line traffic at no very distant date."

The American Institute of Electrical Engineers

THE annual business meeting of the American Institute of Electrical Engineers will be held in New York City on Tuesday, May 16, 1905, at which the reports of the board of directors and the treasurer will be presented. Further particulars regarding this meeting will be given later.

A "General Proposal List" of candidates for office at the annual election has also been issued, together with a list of "Directors' Nominees." In voting the directors' ticket, other names may be substituted for those already printed, but such names must be selected from those appearing in the "General Proposal List." The "Directors' Nominees" are:—

For President.—Schuyler Skaats Wheeler (182).

For Vice-Presidents.—Charles A. Terry (160); Townsend Wolcott (121); Gano S. Dunn (111).

For Managers.—Cummings C. Chesney (155); Calvert Townley (81); Bancroft Gherardi (51); Charles L. Edgar (47).

For Treasurer.—George A. Hamilton (487).

For Secretary.—Ralph W. Pope (509).

The "General Proposal List" contains the following:—

For President.—Schuyler Skaats Wheeler, 182; Ralph D. Mershon, 107; Calvin W. Rice, 36; William S. Barstow, 29; E. Wilbur Rice, Jr., 26; blanks and scattering, 175; total, 155.

For Vice-Presidents.—Charles A. Terry, 160; Townsend Wolcott, 121; Gano S. Dunn, 111; Benj. G. Lamme, 66; Francis W. Jones, 38; John W. Howell, 38; Henry W. Fisher, 34; W. S. Franklin, 34; M. H. Gerry, Jr., 27; C. C. Chesney, 20; James A. Lighthipe, 14; E. Wilbur Rice, Jr., 12; L. B. Stillwell, 12; blanks and scattering, 978; total 1665.

For Managers.—C. C. Chesney, 155; Hammond V. Hayes, 89; Calvert Townley, 81; Harold W. Buck, 61; Paul Spencer, 57; Loyall A. Osborne, 56; Bancroft Gherardi, 51; Charles L. Edgar, 47; Percy H. Thomas, 47; H. H. Humphrey, 46; Frank W. Roller, 46; Benj. G. Lamme, 43; Philip Torchio, 37; Henry G. Reist, 34; Sergius P. Grace, 28; A. A. Hamerschlag, 27; F. B. H. Paine, 27; Frederick C. Bates, 20; Paul M. Lincoln, 20; W. V. N. Powelson, 20; Ralph D. Mershon, 17; P. G. Gossler, 15; Calvin W. Rice, 14; Frederick Darlington, 13; F. A. C. Perrine, 13; Cecil P. Poole, 12; Samuel Sheldon, 12; blanks and scattering, 1132; total, 2220.

For Treasurer.—George A. Hamilton, 487; blanks, 68; total, 555.

For Secretary.—Ralph W. Pope, 509; blanks, 46; total, 555.

Candidates receiving less than 2 per cent. of the entire number of votes cast have been omitted from the above list in compliance with the constitution.

The figures printed opposite each name indicate the number of votes received for nomination.

High-Pressure Line Construction for Electric Railways

THE LATEST PAPERS BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

AT the meeting of the American Institute of Electrical Engineers, held at New York on March 24, the secretary announced that the board of directors had made the following nominations for the coming election of officers of the Institute:—For President, Schuyler S. Wheeler; Vice-Presidents, Charles A. Terry, Townsend Wolcott, Gano S. Dunn; Managers, C. C. Chesney, Pittsfield, Mass.; Calvert Townley, New Haven, Conn.; Bancroft Gherardi, Brooklyn, N. Y.; and Charles L. Edgar, Boston, Mass.; Treasurer, George A. Hamilton; Secretary, Ralph W. Pope.

Two papers were presented at this meeting, "High-Pressure Line Construction for Alternating-Current Railways," by Theodore Varney, and "Line Construction for High-Pressure Electric Railroads," by George A. Damon.

Mr. Varney's paper was first presented. He premised his remarks by saying that the chief advantage to be derived from the direct application of the alternating current to railway service is in the use of high trolley pressures. Having a successful alternating-current motor, the remaining problem of greatest importance is the method of supplying current to the car. The third rail, which is largely used in heavy railway work, is obviously unsuited for carrying 3000, 6000, or 10,000 volts on the score of insulation and of safety. Moreover, the third-rail construction, whatever be the pressure, is not suitable for terminal yards in which there are many tracks and in which derailments are not unusual. A smash-up would be almost certain to result in tying up the system.

He then gave numerous details of some preliminary work which has been carried out on a practical scale with overhead conductors for high-pressure alternating-current railways.

In the absence of Mr. Damon his paper was then read by Prof. G. E. Sever. In Mr. Damon's opinion the single-phase high-pressure trolley has come to stay. While the advantages gained by delivering energy directly to a car without the necessity of a heavy investment in synchronous converters and heavy feeders has long been recognized, and while it has been fully demonstrated that it is entirely practicable to take current from a high-pressure conductor, it has required some time to show that there is a paying field for a single-phase traction motor. A number of motors of this type are now, however, on the market, and within the last few weeks have been put in actual operation.

To get the full benefit of the new system, Mr. Varney thinks it is desirable to carry as high a pressure as practicable on the trolley wire. The object of Mr. Damon's paper was to present a brief record of what has already been accomplished in line construction, and to examine the requirements and difficulties of installation in order to obtain permanent insulation at reasonable cost, safety to the public and reliability in service.

For moderate-speed lines in country districts the full benefits of the high-pressure system will be obtained only when the first cost of such a road has been reduced to a minimum consistent with good work. Nearly all the territory in the middle Western States which promises even a fair return on the investment has been preempted, and some roads are being built to-day where there may be some doubt as to their ability to stand the fixed charges resulting from the cost of the illogical synchronous converter sub-station system.

There are, however, still remaining whole sections of rich productive agricultural districts which will continue unserved by a trolley road until a system is developed so simple in its requirements that it can be built and equipped complete for less than $15,000 per mile, and operated on a basis equally economical. Such a system will involve a trolley pressure as high as possible, as well as transformer sub-stations operating without attendance and working in parallel from one transmission line.

For high-speed interurban roads, the high-pressure trolley opens up new possibilities,—heavier cars with more powerful motor equipments, operated at high speeds without prohibitive first cost; "limited" electric train service with speed schedules of 60 miles an hour, without the necessity of changing from third-rail to trolley in passing from private right of way at corporate limits.

The electrification of steam roads will present a different set of conditions. There the steam locomotive will share the tracks with its electric successor for some time, and with its acid-charged gases will make the installation of a contact wire anywhere except at the side of the track a doubtful proposition, and thus calls attention more strongly to the view that line construction problems must be divided into classes.

Bearing in mind the distinct requirements of the three classes of roads referred to, the problem of line construction entails careful consideration of (1) pressure and insulation; (2) location of conductor; (3) requirements for safety and stability.

From present appearances, 3300 volts are to be the standard pressure for interurban single-phase lines, but it would be well to consider whether it would not be advisable to use a trolley pressure of 6000 volts, since from an operating standpoint there seems to be no reason why this higher pressure is not just as practicable as a lower one; and to get the full benefit of all the advantages inherent in the high-pressure system, the higher pressure should be adopted. There is, Mr. Damon said, no reason why, with the catenary suspension, the insulation provided should not withstand a working test of 6000 volts.

For steam railroad conditions the larger amount of energy required indicates that a pressure of at least 15,000 volts will be desirable. Where to strike a balance between the cost of copper and the cost of insulation for steam road work is a problem which should be carefully worked out, but Mr. Damon thinks there is no reason why pressures of over 10,000 volts should not now be considered.

The catenary form of suspension affords so convenient a method of insulation that it should become standard practice for interurban electric lines. It has long been admitted that dry wood is one of the best insulators. The convenience with which a wooden rod fitted with suitable terminals can be worked into an overhead construction will commend this form of insulation. Impregnated with an insulating compound and of sufficient length to withstand high-pressure tests, the long wooden insulator is applicable to the insulation of guy wires, anchors and cross-suspension wires. Its use in actual practice will be watched with interest.

The wooden bracket has an element of safety not possessed by an iron support, as the insulating properties of the wooden arm would be useful in the case of the failure of an insulator. Unless the wooden bracket were wet it would safely hold up a 6000-volt catenary until the line could be repaired.

For moderate-speed roads the natural tendency will be to have the trolley wire where it has proved to be so thoroughly satisfactory; that is, over the center of the track, and to continue to use the present trolley harp and wheel. For speeds not exceeding 40 to 50 miles an hour at trolley pressures up to 3300 volts, this arrangement will work satisfactorily. For high-speed electric lines there will be little objection to the conductor wire remaining over the track, provided it is properly suspended; but the danger of the ordinary trolley wheel jumping off the wire at high speeds will, no doubt, suggest the use of some form of collector other than the wheel. The bow, the roller and the shoe will each find advocates until more experience has been obtained and the results are reported and discussed.

Special cases will arise, such as the installation of a high-pressure conductor wire over a road already equipped with a direct-current trolley. In such an event the catenary construction can be very nicely adapted to suspending the wire at the side of the track. This location could be advocated for an entirely new installation on the grounds of cheaper first cost and some additional safety in case the wire should break and fall, but both these arguments lack sufficient weight to establish the wire in the side position as standard practice.

For steam-road conditions considerable objection may be found to locating the conductor wire over the center of the track because of the danger to trainmen standing on top of the cars; the fouling of the conductor wire; the deterioration of the insulation, and the destruction of the wire and supporting cables by the gases of locomotives which may jointly occupy the tracks, and the blocking of traffic when it is necessary to repair a broken wire. To avoid the deleterious effect of the locomotive gases it would seem to be imperative to place the contact wire at one side and as low as possible consistent with general safety.

Whatever method of construction is followed, every precaution should be adopted to prevent accidents to the public or employees from the loose ends of a broken live wire. Suspensions or supports properly installed every 10 to 15 feet will lessen this danger. With bracket construction having poles about 100 feet apart, there will be no need of a double-catenary suspension for the wire which is to be used with an under-running collector. In such a case, the double suspension would mean twice as many insulators as would be required with the single catenary, thus decreasing the insulation resistance and increasing the chances for trouble.

In a hard sleet-storm every attachment connected to the wire will naturally be the cause of additional trouble. The arcs due to a coating of ice between the wire and the collector will be much more vicious at 6000 to 15,000 volts than at 500 volts. In this country one of the high-pressure lines using a trolley wheel on a 3300-volt wire has already passed through a hard siege of sleet; and though the sparking was spectacular, very little damage was done. The frequent trolley supports, however, add considerably to the sparking.

Greased trolley wires are sometimes used to prevent the trouble caused by sleet. It is well known that the grease finish of an aluminium wire prevents the collection of sleet upon the wire, and it may be possible that a coating of grease on the high-pressure conductor wire would entirely obviate this trouble. In those kinds of sleet-storms in which icicles are formed and hang from the wire, a top-bearing collector would have every advantage, but when the sleet freezes equally all round the wire, the lighter pressure of the top-bearing contact might put it at a disadvantage.

The transmission lines from the power plant to the sub-stations will be at a higher pressure than the trolley pressure, and will therefore require careful treatment. For a road which is to be built economically, a single set of transmission wires serving all of the static transformer stations in parallel will be sufficient. These transmission wires will ordinarily be carried on the tops of the same poles which support the trolley bracket.

The first investment in the transmission line, the cost of maintenance and the loss by leakage—all these can be cut in half by thoroughly grounding one side of the single-phase transmission line so as to use the earth as one leg of the circuit. An actual trial of this suggestion to further simplify the distribution system is under contemplation, and no doubt will furnish valuable information as to its effect on telephone and telegraph lines as well as data in connection with the resistance of the earth with alternating currents.

Where the transmission lines pass over other wires, there should be a cradle of grounded wires to prevent a broken transmission line from coming in contact with a foreign wire. This cradle will be of little use unless it is of ample dimensions. Some effort has been made on European roads so to install grounded wires that the breaking of a conductor would at once cause the live end of the wire to make a contact with the grounded guard-wire, but in two cases which have come to notice the grounded guard-wire caused more trouble than it eliminated; for this reason it was soon abandoned. Mr. Damon's general conclusions are:—

1. There are no reasons why the standard pressures of the conductor wire for interurban electric lines should not be at least 6000 volts; this is suggested as a standard in order to provide for interchange of equipment.

2. For the electrification of steam roads a pressure of about 15,000 volts on the conductor wire is desirable.

3. For electric interurban lines, the present tendency is toward the catenary form of suspension, with the trolley over the center of the track. A connection should be made about every 10 feet, between the steel catenary wire and the trolley wire.

4. For steam railroad conditions a contact wire at the side of the track appears to offer the greatest advantages. Some form of construction should be adopted, however, to prevent the falling of the conductor in case it should break.

5. A successful bow collector for interurban work and a contact arm for steam road installations similar to that in use by the Huber system would allow the location of the contact wire to be standardized.

6. A trolley wire 20 feet above the center of the track is suggested for interurban roads. For steam road electrification the height of the contact wire at the side of the track could be made standard at 16 feet.

DISCUSSION

Both papers were taken up for discussion together. President Lieb said the suggestion in Mr. Damon's paper with reference to grounded guard-wires reminded him of the danger that is often introduced in undertaking to safeguard a system by introducing an element of prevention which makes the possibility of trouble greater, and he cited the case of the early use of ground shields in transformers to eliminate the possibility of the high-tension current entering the low-tension system. In two years' working the only troubles encountered with the system at all were in the ground shields.

F. N. Waterman gave some details of the Valtellina three-phase railway in Italy, 66 miles in length, which road, he said, has had the longest experience of any with the problem of conveying electrical energy at high tension to a moving vehicle. This experience has all been with three-phase low-frequency current at 3000 volts, and two trolley wires are used. Dry wood, impregnated with an insulating compound, is an important feature of the construction. For long spans and at switches an interesting type of span wire construction is used. It consists of a catenary type of cross-suspension connected at intervals by suspension wires with an upwardly arched span wire which carries the insulators, this permitting a limited rise and fall with the passage of the trolley.

In tunnels, owing to the small clearance, difficulty was experienced in keeping the wire from grounding between supports. This, Mr. Waterman states, was overcome by shortening the distance between supports and weighting the conductors by clamping small iron rails upon them, these being put on in sections several feet in length in the same manner as a mechanical clip.

For the newest construction the double catenary type of support of the trolley wire is used, two messenger wires serving to carry both contact conductors. The spacing of the conductors is maintained by wooden insulator bars upon which the insulators proper are carried, and to which supports from the messenger wires are attached.

After two years of use the trolley wires show practically no wear or evidence of burning. Very little sparking is observed at night when running at full speed; such flashing as does occur takes place at the points of suspension. The type of trolley used combines the advantages of the wheel and bow forms. It cannot leave the wire and cannot catch the insulating supports. The rolling contact practically eliminates the wear on the wire and contact conductors. One man is always on duty at the sub-stations. The total cost of maintenance of primary and secondary lines, sub-stations and patrolling of the line is about $102 per mile per annum.

Calvert Townley said that the departure indicated by the papers in the direction of high voltages is extremely important, but he thought a considerable degree of caution should be observed in recommending extremely high voltages until further experience has been gained. The advantage of using high tension should not be neglected, but he did not think the point had been reached where it would be advisable to attempt to standardize either the pressure, the location of the wiring or other features of this work.

Mr. Townley observed also that as sleet-storms did not give notice of their approach, it would be difficult to get out the greasers in time to prevent the formation of sleet on the trolley wire.

In the matter of Mr. Damon's proposition to use 15,000 volts on the conductor for steam railroads, it is not clear that raising the pressure to any such figure for a trolley road will result in economy, either in first cost of the system or in its operation.

A. H. Armstrong believed in keeping the trolley tension as low as possible and still do the work that is required. In his opinion, there was no need of going to 6000 or 8000 volts if 3000 volts would serve the purpose. We can go to any potential desired, but the advisability of doing so simply because it can be done is questionable. When it is necessary to consider the operation of heavy freight trains, where the motors must reach 1500 horse-power, it will be time enough to take up the case of potentials higher than 3000 volts; but even in those cases he has found that 5000 or 6000 volts amply take care of all conditions involved.

The frequency of hangers between the supporting cables and the trolley itself is also an open question. Mr. Armstrong believes that for high speed it will not be necessary or advisable to suspend the trolley more than once or twice between poles in order to get full use of the greater flexibility of the system afforded by infrequent support. He would suggest that perhaps it would be found advisable to place an attendant in each of the transformer sub-stations, even although they may contain no moving machinery, to be within call of some tell-tale device should the occasion arise to throw in or out a switch, or to cut in or out a duplicate transformer.

A. H. Babcock remarked that the question of line pressure and installation is one that is very vital on the Pacific Slope, especially along the ocean front. It is found that high-tension lines can be operated in the interior and in the southern portion of California with comparatively little insulation, but on the coast, where the sea fogs are to be reckoned with, the conditions are entirely different.

As to operating above 3000 or 6000 volts, it becomes a question whether it is worth while, not only from Mr. Armstrong's standpoint, but also in view of the loss by leakage. Mr. Varney states that 5 miles of single catenary construction showed a leakage under test of 1 ampere at 6000 volts. This, on a 40-mile double-track, would be equal to a constant loss of 96 kilowatts.

Mr. Babcock thought that wood construction will perhaps prove to be better for insulation purposes than porcelain for overhead construction. The experience with the porcelain overhead work of ten or twelve years ago showed it not to be durable.

From the standpoint of a steam railroad man, he thought there would be great difficulty in coming within the limits allowed in steam railroad practice for the hauling of large loads. The matter of clearance in steam railroad practice is jealously guarded. The point of grounding the single line is an important one. Its effect on the telephone lines is sometimes very serious. In one instance a low-frequency circuit from Oregon City to Portland was grounded and it rang the bell of every telephone in the town.

Ralph D. Mershon and Joseph Sachs also took part in the discussion. C. O. Mailloux contributed to the discussion in a communication read by Dr. S. Sheldon. Mr. Mailloux said that he had entertained the conviction for some time that material progress in the direction of supplanting the steam locomotive by the electric locomotive must wait for progress in methods adequate to convey electrical energy in large amounts safely, conveniently and successfully, from a stationary line to a moving vehicle. He said he is a firm believer in high-potential "contact lines," and indorses Mr. Damon's views in favor of higher line contact potentials for alternating-current railway motor cars; and, as between 3300 volts and 6000 volts, would favor 6000 volts as the standard which should be adopted for interurban lines, and for steam railroad conditions at least 15,000 volts. The fact that the sparking increases with the frequency of the trolley supports in the cases observed by Mr. Damon indicated to him (Mr. Mailloux) that ordinary trolley line construction, using the trolley line for the contact, is wholly unsuitable for high-potential contact lines.

The discussion was closed by Mr. Varney, after which the meeting adjourned.

All of the locks in the Lachine Canal, in Canada, are in future to be electrically operated, making a saving in time of 5 minutes at each lock.

Electric Power in Tunnel Work

By L. RAMAKERS

THE POWER HOUSE ON THE ROTHWEIN RIVER

IN driving a tunnel about 5 miles long through Mount Karawanken, on the railway between Trieste and Vienna, in Austria, now approaching completion, electric power has been extensively employed, current for the southern end of the tunnel being supplied from the water power of the small river Rothwein, about 6 miles from the tunnel terminal. On the northern side of the mountain a power house was erected on the Rodenbach, about 2 miles from the tunnel entrance, and a smaller auxiliary power house on one of the near tributaries of that stream. In the Rothwein power house there are three three-phase turbine-driven generators of about 400 K. W. each, the transmission voltage from station to tunnel mouth being 5500.

The power is used on both sides of the mountain for driving ventilating fans, locomotives for hauling the construction trains, air compressors for compressed air supply both to rock drills and for other purposes, and also for driving rock drills directly,—this in addition to general electric lighting about the works. Most of these applications are exemplified in the several illustrations on this and the following pages.

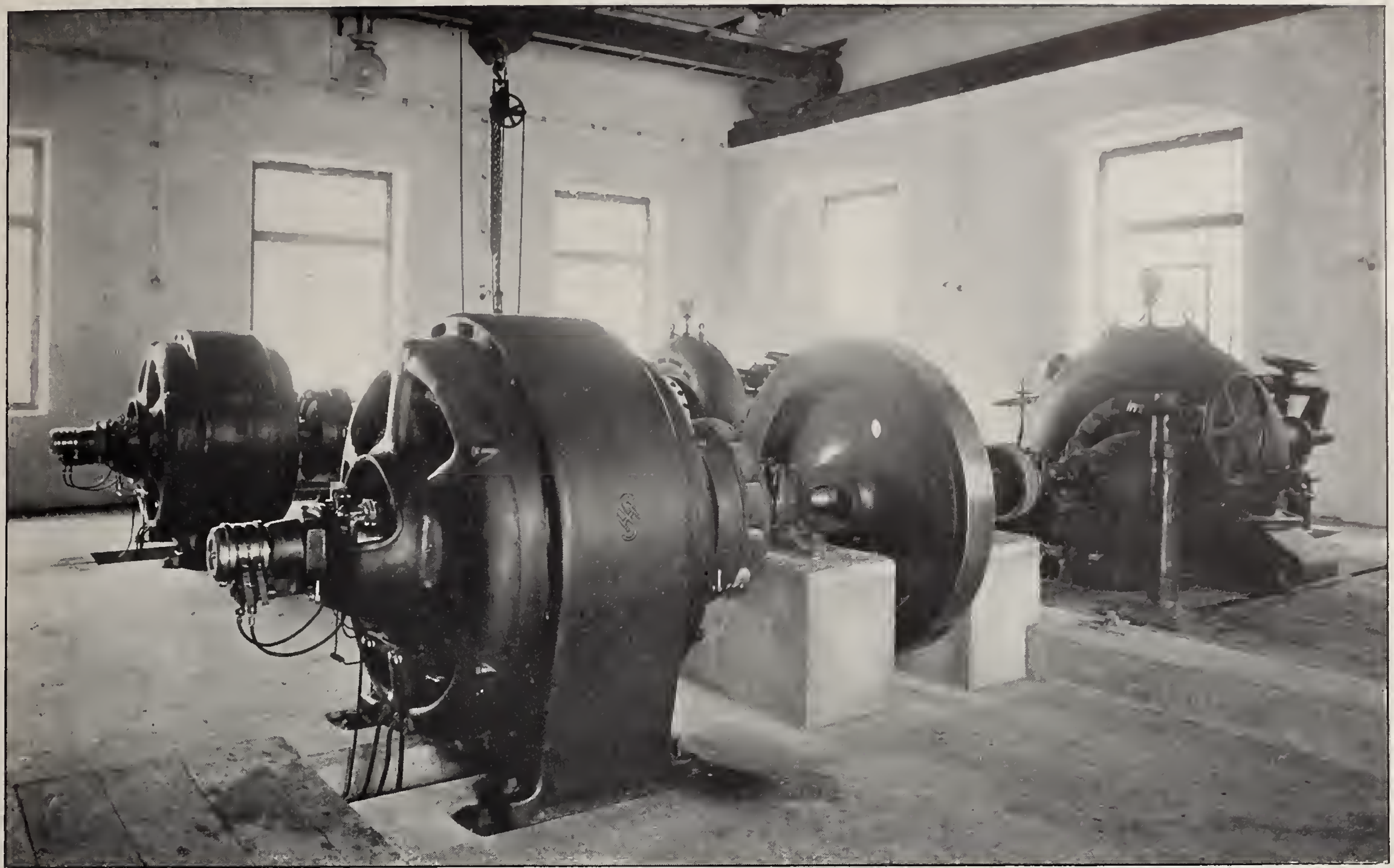
The electric locomotives are double, made up of two single engines, coupled together with multiple-unit control. The ventilating plant at the north end of the tunnel consists of two sets of three centrifugal fans. Illumination is provided for by 26 arc lamps, each of about 1500 candlepower, which are made at the works themselves. Inside the workshops, offices, dwellings for the officials and the men, etc., incandescent lights alone are used. For these lights the current from the Rothwein central station is reduced to tension of 190 volts and 110 volts, respectively. A small electric light plant has also been erected as a reserve. It comprises a 60-K. W. generator, driven by a portable steam engine.

Besides the above, there are six electric motors, developing together about 440 H. P., taking current from the Rothwein station for workshop driving and also for driving the air compressors supplying power to the pneumatic drills. A telephone plant completes the electric equipment.

The Rodenbach power station on the north side is similar to the one on the Rothwein River, each of the generators, however, developing only 270 K. W., with a line tension of 5200 volts. As on the south side of the mountain, the power is used principally for operating electric locomotives and ventilating fans and for lighting.

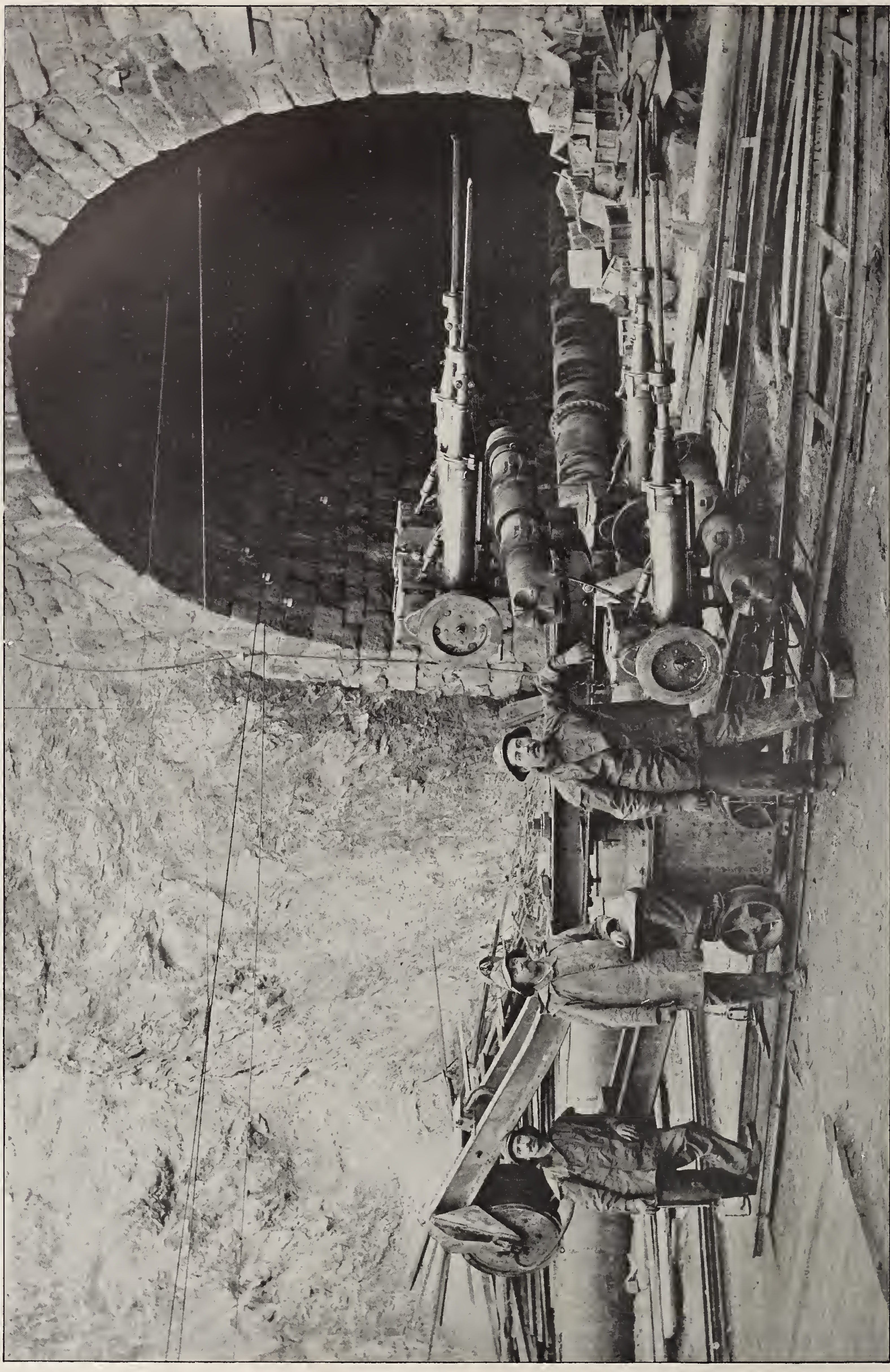
But in addition, the power is applied also to several percussive electric rock drills, one of them shown in section on page 296. The illustration there explains the principle of these drills. The drill proper is not rigidly connected with the driving mechanism, but is held between two powerful helical springs in a reciprocating carriage. A small 2-H. P. electric motor is mounted on the machine, driving it through gearing, the whole outfit being mounted on a special truck as shown in one of the illustrations, so as to be easily brought up to the working face of the tunnel heading.

In carrying power to the four drills in use, the 5200-volt line current is conveyed to a 25-K. W. transformer located at the end of the finished section of the tunnel. There the current is stepped down to 250 volts, at which pressure it is used in the three-phase drill motors. The transmission cables in the tunnel are lead-sheathed. Upon the drill carriage itself there is a cable reel holding about 200 feet of flexible cable with double rubber insulation, connected with the cable carrying the low-voltage current above mentioned. As this point of connection should always be placed about 100 feet away from the head-end of the working, and as the mean daily progress amounts to about 16 feet, the armored low-tension cable has to be pulled forward about 100 feet every five or six days. It is wound upon a drum placed in a niche blasted out of the gallery, and has a length of about 800

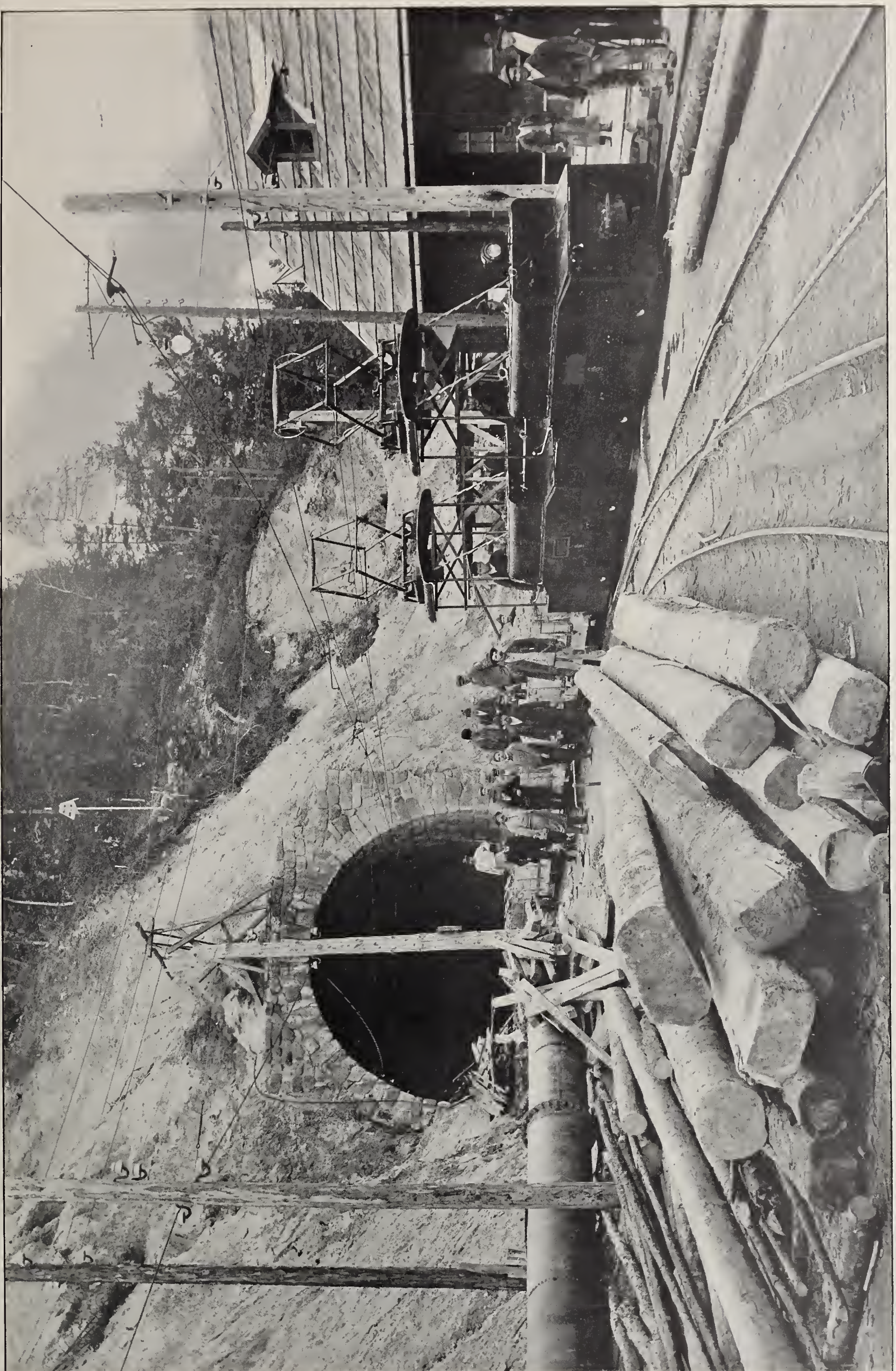


THE ROTHWEIN STATION IS EQUIPPED WITH THREE 400-K. W. TURBINE-DRIVEN GENERATORS

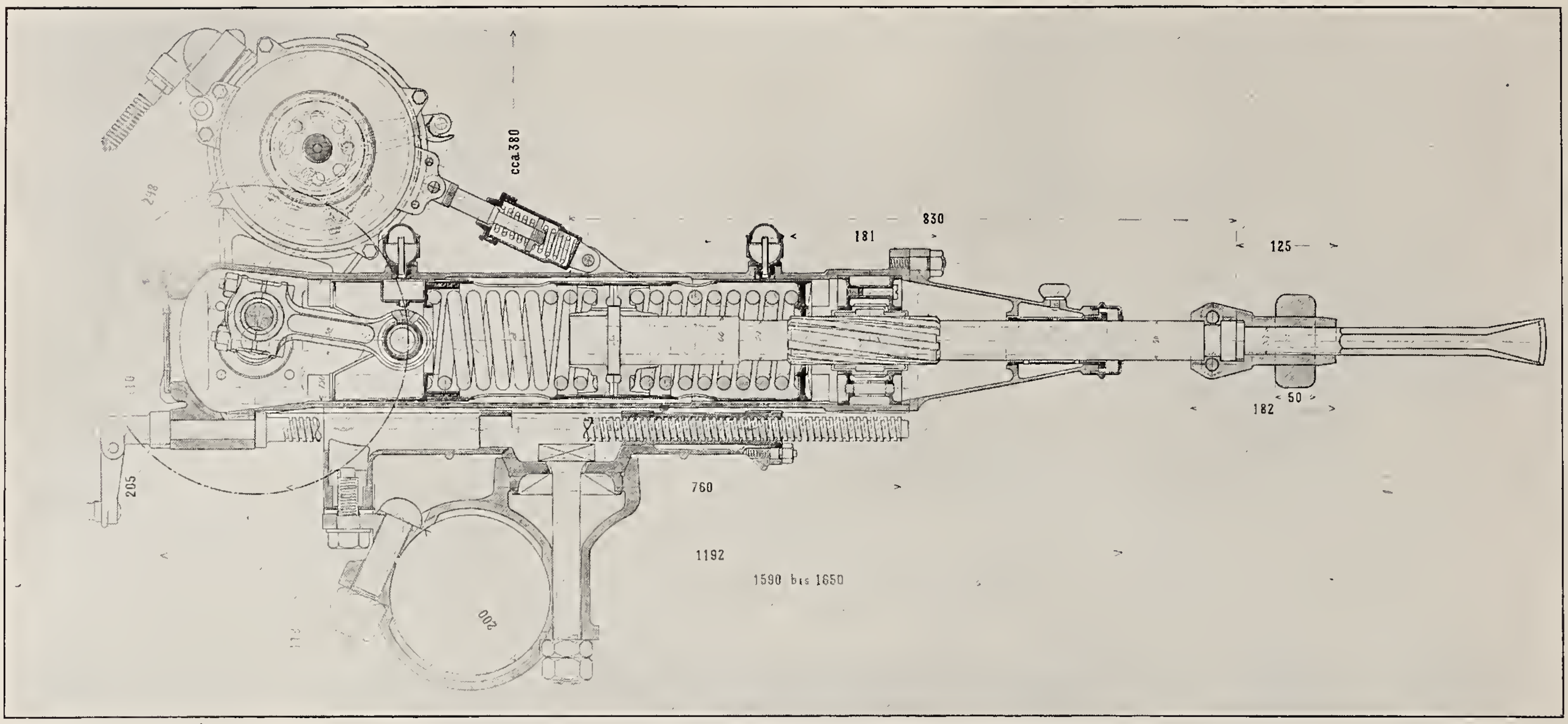
ONE OF THE TRIPLEX VENTILATING FAN SETS WITH ELECTRIC-MOTOR DRIVE



ONE OF THE ELECTRIC DRILLS AND TRUCKS COMPLETE

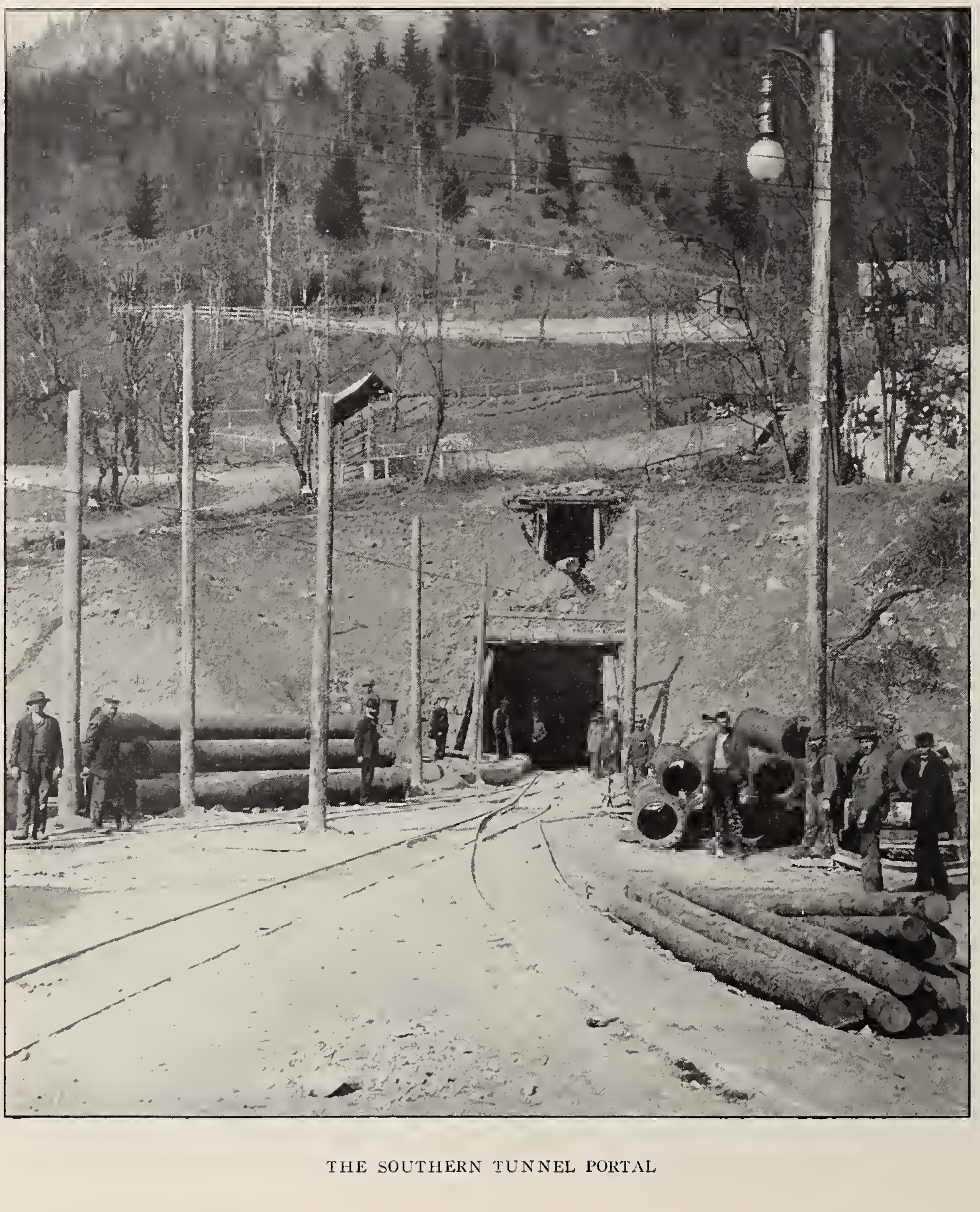


ONE OF THE DOUBLE LOCOMOTIVES USED IN CONSTRUCTION WORK



A LONGITUDINAL SECTION OF ONE OF THE ELECTRIC ROCK DRILLS

feet. When this length has been entirely unwound, a further length of cable is connected to it. In proportion as the tunnel is completed, the transformer is also moved forward every six weeks, and the high-tension cable is also lengthened.



THE SOUTHERN TUNNEL PORTAL

The whole of the electric plant in use was installed by the "Oesterreichischen Siemens-Schückert Werke," of Vienna, to which company the writer is indebted for the photographs here reproduced.

The Money Value of the Engineer

J. Swinburne, in an Address to the Students of the Institution of Electrical Engineers.

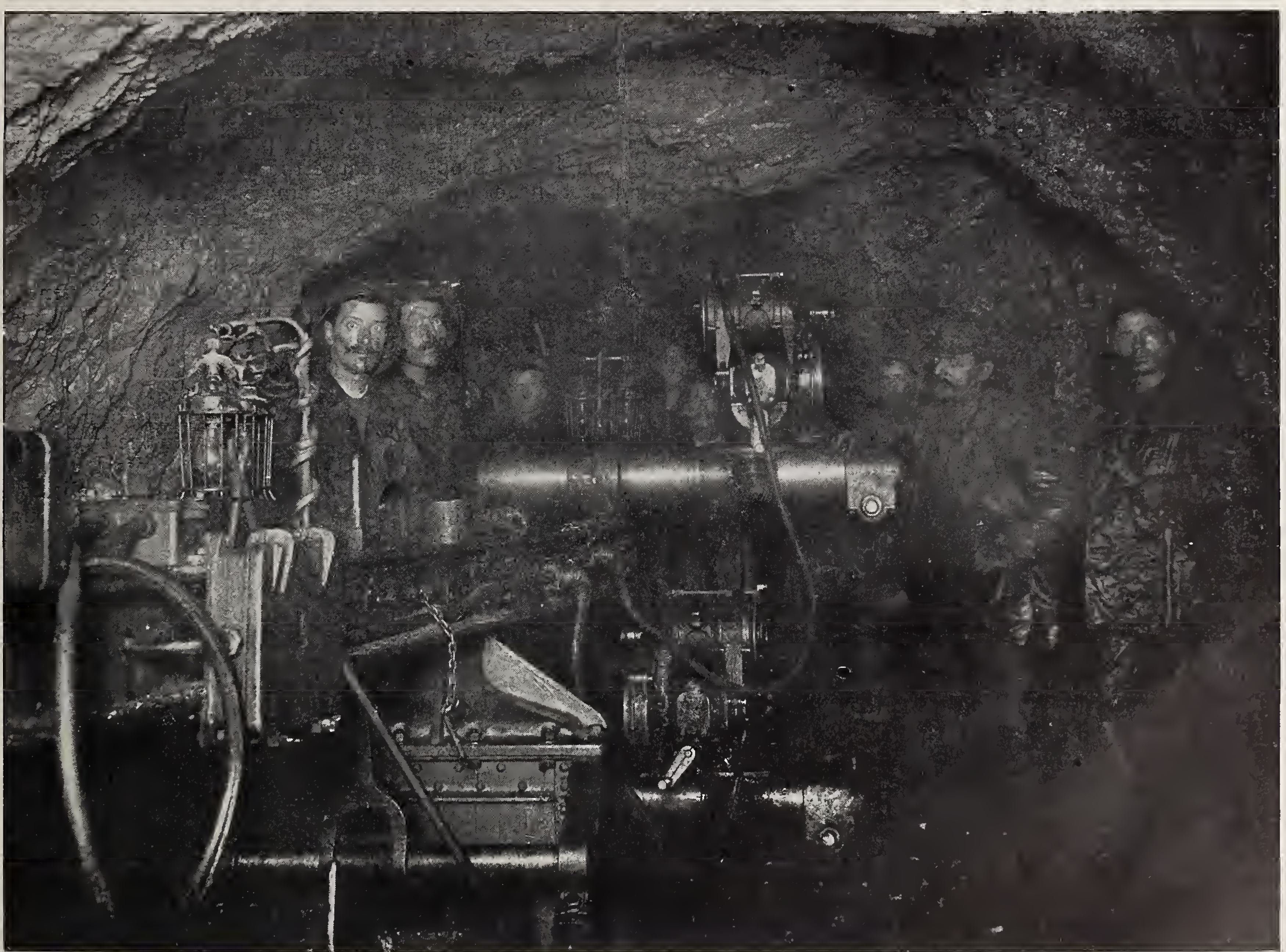
IN the charter of the Institution of Civil Engineers the engineer is defined as "Directing the Great Sources of Power in Nature for the Use and Convenience of Man." With all respect to this august body, and their often quoted definition, I would humbly suggest that it is inapt. It is really the definition of a scientific man. It is incomplete as applied to an engineer, because it does not take into account the sordid element of price. An American definition is much better:—"An engineer is a man who can do for one dollar what any fool can do for two." This is not poetical, and is useless for oratorical purposes; but it is right. It is no use being able to design most complicated alternating-current machinery, or being able to explain it with the help of a wilderness of clock faces and several issues of the technical journals, unless the machinery, when made, is cheaper than its rivals. Every design, every engineering manufacture and every piece of engineering is only a question of price. It is unpleasant, perhaps, but it is a hard fact, and we have got to face it. If one of us does £150 worth of work a year and earns £100, he is efficient; if he only does £90 worth, he is an inefficient machine and will come to grief. He is like a 90-K. W. alternator which takes 100 K. W. to excite, though the analogy is not close. If he does £15,000 worth of work and gets £10,000, he is an efficient machine of much larger size, and his efficiency is much more satisfactory to himself. I may mention, in passing, that an efficient man must do more work than he is paid for. This is not always realized. A man who only does what he is paid for would be of no use to the world at large. His efficiency is zero, his consumption being equal to his output. The man who does £15,000 worth of work and gets £10,000 consumes two-thirds of the work himself; so his efficiency is only 33 per cent., which is very high, even for an engineer.

We see, then, that the business man is the master; the engineer is his good slave; and the raw scientist is not good enough even to be the slave of the engineer; he has no market value at all, except as a teacher of more raw science. The raw scientist will remain at the bottom of the tree until he gets rid of the professional cant which pretends that raw science is pure, or nobler and superior to science as a whole; and the engineer will remain in the middle position as long as he takes the middle view and considers engineering as something superior to money considerations, and as long as he looks down on business and commercial methods.

Views like these put forward in addresses do not alter the world at large, and they are not expected to do so. They are put strongly to warn you, who are young, and therefore inclined to be enthusiastic, against one of the greatest difficulties in getting on; that is to say, a poetic idea that there is something degrading or deteriorating in taking a money view of everything. You may say, "We take higher views of life than that; there is something better for us in our careers than money grubbing." So there is; I heartily agree with you; and when you have grubbed some money and are at liberty to attend to higher things, I would like to be allowed to join you.

It is cant to profess contempt for money. The poet professes to work for fame, and so do the musician, the artist, the philosopher, the scholar or the man of letters. They generally like money; but apart from that they are merely satisfying their proper vanity, or love of approbation, by getting ahead of their fellows. But that is all you want to get on for. Money is nothing in itself, it is only a means, and making it is merely a way of going ahead of your fellows. People who cannot make money do not like it being used as a criterion, so they run it down. Everyone thinks the world ought to be judged by what he can do best himself.

Electricity in the growth of plants has been found useful for forcing and increasing the yield, but it is only recently that a foreign grower is said to have found that by the use of colored globes on arc lights the coloring of flowers can be altered. A red globe gives a more intense color and a yellow globe a more delicate color.



AT THE END OF ONE OF THE HEADINGS

The United States Patent Laws

Historically and Practically Considered

By CYRUS N. ANDERSON

A Paper Read at a Meeting of the Mechanical and Engineering Section of the Franklin Institute

SEVERAL years ago a writer in the "Iron Industry Gazette," an English publication, said: "Disparagement of patents is common and easy, but it should not be forgotten by those who sneer at inventions that, out of a total of eight billions of capital invested in manufacturing in the United States, patents form the basis for an investment of about six billions. Evidently, the United States system of encouraging invention that has resulted in the patenting of over 500,000 inventions is a system which is exceedingly wise and valuable. The only thing that has enabled manufacturers to make so wonderful a progress in the United States is its patent system."

Up to the present time, there have been granted in the United States nearly 800,000 patents and, while I have no recent figures, there is no doubt but that the proportion of capital invested in manufactures with patents as a basis is as great, if not greater, now than it was when the foregoing statement was made.

At a time when the right of property in patents, or rather in patented inventions, is so well recognized, it strikes one as a curious fact that there ever was or should have been a time when a right to such property was not recognized. Yet the fact is that in comparatively recent periods, considered in the light of the world's history, property rights in connection with inventions were not recognized, and if a man was possessed of an inventive turn of mind and was an inventive genius, and made inventions or improvements in machines or in mechanical devices or in the art of doing things, he had to stand by and see others enjoy equally with him the benefits of his intellectual thought and effort.

In the very earliest history, the right of property in tangible things was recognized, but an exclusive right in intellectual property, such as inventions and writings, was not regarded as a natural right, and the right to such property was only established as a result of advancing and improved civilization.

It seems that quite early in England the practice grew up under which the Crown, as a matter of grace and favor, but not of right, granted to the inventor of a new manufacture or a new art, the exclusive right for limited periods to his invention or improvement, and it is reported that in the fourteenth century, in the reign of Edward III, some wise subjects of the realm, alchemists they were, invented or discovered a philosopher's stone. A commission was appointed by the King, consisting of two aldermen and two friars, who, after an investigation, which, of course, was very carefully made, reported that the philosopher's stone possessed merit, and upon this report the King granted an exclusive right to the discoverers to manufacture and sell the philosopher's stone.

When the nature of intellectual property is considered, it seems somewhat anomalous that rights of property therein should not have been recognized from the very earliest times.

Prof. Shaler has said:—"When we come to weigh the rights of the several sorts of property which can be held by men, and in this judgment take only the absolute questions of justice, leaving out the limitations of expedience and prejudice, it will be seen clearly that intellectual property is, after all, the only possession in the world. The man who brings out of nothingness some child of his thoughts has rights therein which cannot belong to any source of property."

Mr. Fessenden, in his work on patents, published in 1821, says:—"In a moral as well as in a political point of view, the author of a new and useful invention has the best of all possible titles to a monopoly of the first fruits of his ingenuity. The invention is the work of his hands and the offspring of his intellect; and after he is allowed a temporary monopoly, becomes at the expiration of the patent a valuable donation to society."

At least as early as about the year 1600 the right of property in invention was well understood and had a well-established and defined standing in the common law. As indicating that in the common law of England at that time the reason for granting exclusive privileges to inventors, and that the rights of property in inventions were fairly understood, I will read you what was said by the court in the case of Darcy vs. Allin:—"Where any man, by his own charge and industry, or by his own wit or invention, doth bring any new trade into the realm, or any engine tending to the furtherance of a trade that was never used before; and that for the good of the realm: that in such cases the King may grant to him a monopoly patent for some reasonable time, until the subjects may learn the same, in consideration of the good that he doth bring by his invention to the commonwealth; otherwise not."

Sir Edward Coke said of patent privileges that:—"The reason wherefor such a privilege is good in law is because the inventor bringeth to and for the commonwealth a new manufacture by his invention, costs and charges, and therefore it is reason that he should have a privilege for his reward (and the encouragement of others in the like) for a convenient time."

It does not appear that there was any statutory law passed in England concerning the patenting of inventions until the year 1623, in the twenty-first year of the reign of James I, at which time the statute of monopolies was passed, which declared certain monopoplies to be void, and prohibited the grant of such monopolies in the future. One section of this statute, however, related to patents and read as follows:—

"Provided also, and be it declared and enacted:—That any declaration before mentioned shall not extend to any letters-patent and grants of privilege, for the term of fourteen years or under, hereafter to be made, of the sole working or making of any manner of new manufactures, within this realm, to the true and first inventor and inventors of such manufactures, which others, at the time of making such letters-patent and grant, shall not use, so as also they be not contrary to the law, nor mischievous to the State, by raising prices of commodities at home, or hurt of trade, or generally inconvenient; the said fourteen years to be accounted from the date of the first letters patent or grant of such privilege, hereafter to be made; but that the same shall be of such force as they should be, if this act had never been made and of none other."

I quote this section of the statute in full because it is the first English statute on the subject, and is the very foundation of our own laws on the subject of patents. These laws are the result of development and evolution.

Mr. Robinson, the author of one of our most elaborate treatises on the subject of the patent laws, has said that in this statute, as interpreted by the English courts, are found the sources of the patent laws of the United States.

The 150 years following the statute just referred to covered the Colonial period of the United States. During that period of our existence there was, as is well known to all, very little manufacturing within the present borders of the United States, and very little improvement in the manufacturing arts was made by the Colonists. The country was very thinly and sparsely settled; the Colonists, our forefathers, had duties to perform which were much more pressing upon them than the making of inventions or improvements in the method or art of doing things in the manufacturing world. The Colonists were making a continual fight for existence and constant effort to subdue the many obstacles incident to the development of a new country, and had no time to engage in the fascinating and frequently profitable pursuit of making improvements and inventions in existing devices in the manufacturing arts.

It is not surprising that under these conditions the Colonists made few inventions. But there was still another obstacle in the way of improvement by the Colonists of the manufacturing arts. This obstacle was the attitude of England toward the Colonists upon this matter. It was England's idea that the Colonists should supply raw articles of commerce, such as the products of the farm, and that England should furnish to the Colonists all such manufactured articles as might be needed or demanded by the Colonists. England's policy toward the Colonists was expressed by Sir William Pitt, when he said:—"It is the destiny of America to feed Great Britain, and the destiny of Great Britain to clothe America." Lord Chatham said, "I would not allow the Colonists to make so much as a hob nail for themselves."

Laws were enacted by England prohibiting every species of manufactures in the Colonies. When the Colonists began to make iron and nails for their use, the House of Commons resolved that "none of the plantations should manufacture iron nails of any kind out of any sows, pigs, whatsoever." And the House of Lords added, "No forge going by water, or other works, should be erected in any of the plantations for the making, working or converting of any sows, pigs, or cast iron into bar or rod iron."

By an act of 1750 the erection of buildings and mills for making iron was prohibited. There were corresponding restrictions imposed upon the Colonies with respect to all sorts of manufacturing arts. For instance, in 1684, Virginia passed an act encouraging the manufacture of the textile fabrics which was annulled by Parliament. The condition of manufactures in the Colonies has been well set forth by Senator Thomas C. Platt, of Connecticut, as follows:—

"Manufactures were practically unknown; * * * there were no machines as we now understand the term; * * * men knew how to plough and sow, hoe and chop, reap, mow and cradle, break flax and hackle it, thresh with the flail, winnow with the blanket or fan and to shell corn by hand. The women knew how to spin, card, weave and knit. Mechanical knowledge was monopolized by the blacksmith, the carpenter, the millwright and the village tinker. Production was a toilsome, weary task, limited by the capacity for muscular endurance."

It is probable that the first patent granted within the limits of the United States was by the general court of the Colony of Massachusetts, under date of May 6, 1646, to one Joseph Jenckes, of Lynn, for a scythe. In his petition or prayer, he prayed for protection for "Fowerteen yeeres, without disturbance by any other setting up the like inventions, so that his study and cost may not be in vayne or lost."

Before proceeding to a discussion of the laws relating to patents which have been enacted by the United States Government, I desire to call attention briefly to some of the objections which have been made to patents. The objection has been made that there is no such thing as intellectual property, and that ownership of such property restricts common rights. Also that the granting of a patent is the creation of a monopoly. Patents have been compared to letters of marque, which allow the holder to prey upon honest industry. It has been urged that patents increase the price of commodities, and that they encourage labor-saving inventions and take opportunities from the artisan.

It is needless to say to an audience of the present day that the last objection is utterly without foundation. Exactly the reverse has been proved adequately. It has been urged that patented inventions reduce or sink men to automata, and that the granting of a patent enables one man to say to another that he shall not carry on his business in the best way, and that by granting a patent the idea involved in the patent is tied up, and the course of thought in that direction is stayed. A Frenchman has advanced a picturesque objection that patents give undue advantage to their possessor by "making a golden bridge for him who enters the arena with arms more subtle and more finely tempered than those of his adversaries."

The foundation of all the patent-law legislation in the United States is the clause or phrase in the Constitution which vests in Congress power "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings or discoveries."

The first patent law of the United States was enacted in the year 1790, April the 10th. It followed in a general way the law then in existence in England authorizing the grant of patents without an examination of the prior art, as is now the case. The authority to grant patents was conferred upon the Secretary of State, the Secretary of War and the Attorney-General of the United States.

It appears that Mr. Jefferson, who was at that time Secretary of State, took great interest in the patent laws, and regarded them and the granting of a patent as of the very greatest importance, and he is generally referred to as the Father of the United States Patent Laws.

In the "Official Gazette" of the United States Patent Office, published September 24, 1877, an interesting description of the early practice under the Act of 1790 occurs. By Act of April 10, 1790, the first American Patent System was founded. Thomas Jefferson inspired it, and may be said to have been the Father of the American Patent Office. He took great pride in it, it is said, and gave personal consideration to every application that was made for a patent during the years between 1790 and 1793, while the power of revision and rejection granted by that act remained in force. It is related that the granting of a patent was held to be in these early times quite an event in the history of the State Department, where the clerical part of the work was then performed.

It is a matter of tradition, handed down to us from generation to generation, by those who love to speak of Mr. Jefferson, his virtues and his eccentricities, that when an application for patent was made under the first act, he would summon Henry Knox, of Massachusetts, who was Secretary of War, and Edmund Randolph, of Virginia, who was Attorney-General—these officers being designated by the act, with the Secretary of State, a tribunal to examine and grant patents—and that these three distinguished officials would examine the applications critically, scrutinize each point of the specification and claims carefully and rigorously. The result of this examination was that during the first year a majority of the applications filed failed to pass the ordeal, and only three patents were granted. In those days every step in the issuance of a patent was taken with great caution, Mr. Jefferson seeking always to impress upon the minds of his officers and the public that the granting of a patent was a matter of no ordinary importance.

It is not to be understood that the examination referred to an investigation of the prior art. The only examination required was of the petition, description, drawing, etc., of the application.

The next patent act was amendatory in its nature, and was passed in 1793. Among other changes, it imposed the duty of issuing patents upon the Secretary of State, subject, however, to the approval of the Attorney-General.

From 1793 down to 1836, various unimportant amendments to the patent laws were enacted. In the last mentioned year, however, the first comprehensive law was passed relating to the grant of patents. This law remained in force until 1870, and was in substance very much the same as our present laws.

By the enactment of 1836, a sub-department of the State Department was created, which was known as the Patent Office. Provision was made for the appointment of a Commissioner of Patents, and the Commissioner of Patents was required to make or to have made an examination of the alleged new invention or discovery to determine whether or not the same had been invented or discovered by any other person in the United States prior to the alleged invention thereof by the applicant, and to determine whether or not, in view of the prior art, the applicant was entitled to a patent.

Prior to this act examinations were not required, and if the applicant averred that his alleged invention was new and novel, the Commissioner or the Secretary of State was required to grant or issue a patent upon his application, provided the discovery or invention of the applicant was deemed of sufficient importance.

It will readily be seen that a patent granted under such circumstances was necessarily of very small commercial value, because it would not be reasonable to expect men to invest their capital in a species of property, good title to which and the value of which were so uncertain.

The Act of 1836 established patent property upon a higher plane than it had ever before occupied, and it is believed that the importance of this act to the people of the United States cannot be overestimated.

Senator Thomas C. Platt, speaking in 1884, referring to this act, said:—

"To my mind, the passage of the Act of 1836 creating the Patent Office marks the most important epoch in the history of our development—I think, the most important event in the history of our government from the Constitution until the Civil War. The establishment of the Patent Office marked the commencement of that marvelous development of the resources of the country which is the admiration and wonder of the world, a development which challenges all history for a parallel; and it is not too much to say that this unexampled progress has been not only dependent upon, but has been coincident with, the growth and development of the patent system of this country. Words fail in attempting to portray the advancement of this country for the last fifty years. We have had fifty years of progress, fifty years of inventions applied to the everyday wants of life, fifty years of patient encouragement, and fifty years of development in wealth, resources, grandeur, culture, power which is little short of miraculous. Population, production, business, wealth, comfort, culture, power, grandeur, these have all kept step with the expansion of the inventive genius of the country; and this progress has been made possible only by the inventions of its citizens. All history confirms us in the conclusion that it is the development by the mechanic arts of the industries of a country which brings to it greatness and power and glory. No purely agricultural, pastoral people ever achieved any high standing among the nations of the earth. It is only when the brain evolves and the cunning hand fashions labor-saving machines that a nation begins to throb with new energy and life expands with a new growth. It is only when thought wrings from nature her untold secret treasures that solid wealth and strength are accumulated by a people."

Under the patent laws now in force in the United States any person who has invented or discovered any new and useful art, machine, manufacture or composition of matter, or any new and useful improvement thereof, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than two years prior to his application, and not in public use or on sale in this country more than two years prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law and other due proceedings had, obtain a patent therefor.

It may be remarked here that the word "discovered" in this section of the statute means "invention."

It will be noted that foreigners have the same rights under this law as citizens of the United States.

The first requisite to the securing of a patent is the making of an invention. Just what invention is or what it takes to constitute an act of invention is a question that has been discussed by the courts and by text-book writers many, many times, and it is a question which cannot be answered by definition. I may say this, notwithstanding that definitions of the term "invention" will be found in many text-books, and in many decisions of the courts. Suffice it to say that invention comprehends a new idea of means and it must be something beyond the scope of merely mechanical effort.

Having made an invention, the next step in the process of securing a patent consists in the preparation of an application and the filing of the same in the Patent Office. This application comprises a petition to the Commissioner of Patents, requesting the grant of the patent for the invention disclosed in the application, an oath answering to the requirements of the statutes, a specification descriptive of the invention, and such specification must be concluded with a claim or claims specifically pointing out the improvement or invention. If no application has been made in a foreign country, the oath should set forth that the applicant is the original and first inventor of the invention disclosed in the application and described and claimed in the specification; that such invention was never known or used before his invention or discovery thereof; that such invention had not been patented or described in any printed publication in the United States of America or any foreign country before his invention or discovery thereof, or more than two years prior to his application; that the said invention had not been in public use or on sale in the United States for more than two years prior to his application, and that no application for foreign patent had been filed by him or his legal representatives or assigns in any foreign country prior to his application in the United States. If, however, applications for patents in countries foreign to the United States have been made at the time of the filing of an application in the United States, it is necessary for the applicant to name the foreign country or countries in which such applications have been made, giving the date of the filing of the same.

The claims are necessary to a complete specification. The specification must, of course, be signed by the applicant, who in nearly all cases is the inventor, and the application when forwarded to the Patent Office must be accompanied by the first government fee of $15. Where the application relates to an invention which can be graphically depicted, it is necessary to prepare and file drawings with and as a part of the application.

If any one of the parts above referred to are omitted, the application will not be accepted by the Patent Office, and the same will not be filed until all of the parts have been received by the Patent Office.

After an application has been received by the Patent Office, it goes to the application division, where it is classified, and is then forwarded to the division in the Patent Office in which is to be found the class of machine or art to which the invention belongs. Applications received in the office are examined in regular order, according to their filing dates.

Before the claims of an application are allowed, careful examination of the prior art is made, and only such claims are allowed as are distinguished from constructions disclosed by patents and other publications discovered by the examiner in his search of the art.

As a rule these examinations are carefully made, though, as you will readily understand, where several hundred examiners and assistants are employed, some of them are more careful in their work than others. The more care taken in the search and examination of the records in the Patent Office, the more likely it is that the patented claims will be valid.

It frequently becomes necessary to amend the claims, perhaps many times, before they can be brought into such shape that they are distinguished from the art.

There is one thing that should be understood by all applicants for patents, and that is that the claims of a patent are of the very greatest importance; in fact, I should regard the claims as the most important part of a patent. Unless the claims are well drawn and unless they cover well the invention forming the subject-matter of the patent, the patent loses much of its value.

The phraseology of the claims should be accurate. It is as necessary that the elements or parts entering into and forming the combination set forth in a claim should be stated and put together with exactness and precision as it is that the same elements be fitted together with exactness and precision in the machine itself.

As I have already said, the claims of a patent should be drawn with very great care, and should be made as accurate and as exact and as much to the point as it is possible.

I am sorry to say, however, that in many, many instances claims are vaguely and loosely drawn. This in some instances is due to a lack of knowledge of what the invention really is; in others it is a lack of ability to express ideas clearly in writing; in others it is perhaps a lack of effort; and in others it is perhaps due to a lack of proper time; but whatever the cause may be, failure to secure good claims is a misfortune so far as the patentee is concerned.

A writer in "The Forum," referring to the difficulty of claim writing, has said:—"It takes a very experienced hand to avoid defects which will nullify the patentee's proper advantage. An omission is fatal; an addition is fatal; and a vagueness is fatal."

Broadly considered, the claims of an application may be divided into generic and specific claims. If the invention disclosed in an application will support a broad or generic claim, such a claim should by all means be included. But in addition to such claim, specific claims also should be included, because it is very much easier to anticipate a broad claim in the prior art than it is to anticipate a specific claim, and it may happen, if the claims of the patent are ever subjected to litigation, that the patentee would be able to sustain the validity of the specific claim but would be unable to sustain the validity of the generic claim. In such case the patent, by reason of the presence of the specific claim, would still be of value to the patentee, while, on the contrary, if it had included only the generic or broad claim or claims, which had been anticipated, the value of the patent would be entirely destroyed.

It is not always so, but, generally speaking, a broad claim includes a small number of elements in combination, while a specific claim will include a greater number of elements in combination, and these elements may be still further affected and narrowed by qualifying limitations.

It sometimes happens that an inventor, who fully understands the details and principles of his invention, concludes that he is better fitted to write his specification and claims, that is to say, is better fitted to prepare his application for the Patent Office than some one who has had experience in the writing of specifications and the drawing of claims, and therefore undertakes to do this work. It is very unusual to find an inventor who has had sufficient experience to prepare the specification and claims of an application properly, and the chances are about one hundred to one against his succeeding in drawing claims which adequately protect his invention.

After the application has been placed in condition for allowance, it is allowed by the examiner, after which it goes to the Issue Division of the Patent Office. Then, upon the payment of the final fee of $20, the patent is printed, the grant is prepared and is signed by the Commissioner of Patents, and the patent is issued under the seal of the Patent Office.

Many inventors suppose that when they have secured their patents their troubles are over, but the fact is that if the invention is of any considerable value or worth, the patentee will be beset by a horde of infringers who will attempt to use the invention and secure the benefit of the inventor's thought and ingenuity.

The patentee can protect his rights only by bringing and prosecuting a suit in the Federal Courts and securing an injunction against infringers.

It seems strange that a person who would not think of trespassing upon the real property of another person, or who would not think of interfering with ordinary chattel property belonging to a stranger, will not hesitate to trespass upon the patented property of another, whenever it appears to him that such trespassing would inure to his advantage, considered from a business and financial standpoint.

Notwithstanding the fact that patented property is constantly being subjected to the attacks of infringers, such property is very valuable, and, as has already been pointed out, constitutes the basis of investment of many millions of dollars in the United States, and it has been asserted in a comparatively recent annual report of one of the Commissioners of Patents "that we mainly owe to our patent system such foothold as we have gained during the past fifty years in foreign lands for our manufactured products."

American Street and Electric Railway Statistics

THE Bureau of the Census has just published an exhaustive report on street and electric railways for the year ending June 30, 1902, prepared under the supervision of W. M. Steuart, chief statistician for manufacturers.

In June, 1903, a preliminary report on this subject was issued in the form of a Census bulletin, giving the principal statistics for all street and electric railways doing a public business in the United States.

The report just published contains, in addition to detailed statistics, more than 200 pages of text prepared by special agents, T. Commerford Martin, of New York City, and E. Dana Durand, of the Bureau of Corporations. This text discusses the development of the modern street railway system, the generation and distribution of electric current, car equipment and a variety of other features upon which the technical efficiency and economy of the street railway service depend. It also treats of methods of installing and operating interurban systems, handling passengers, freight, mail, express, etc. Statistics are presented showing the growth of mileage and traffic and the effect of development upon the distribution of the population.

Among the other subjects considered in this volume are capitalization, relation of expenditures to receipts, general financial results, terms of franchise, rates of fare, accidents, safety appliances, and the wages and conditions of labor.

The value and interest of the report are increased by the introduction of maps and illustrations, the former showing the network of electric railways in Ohio and Indiana, and the latter showing the appearance, development and equipment of cars and stations.

GROWTH OF STREET RAILWAYS

The first passenger car ever constructed for a street railway was used in New York City in the third decade of the last century. This car was drawn by horses over strap rails laid on stone ties. Improvements introduced during the next forty years were principally in details, but the introduction of the cable system in 1873 was a decided advance in motive power. At the present time, however, the use of the cable car is confined almost exclusively to the cities of Chicago, San Francisco and Kansas City, while the trolley, which was not used to any great extent prior to 1885, has practically superseded all other systems. In several instances even the steam railways have introduced electric motive power on their lines.

In view of the movement to abolish overhead wires in the large cities, the success of the open conduit system, which has been introduced in the more populous parts of New York and Washington, is worthy of note. In 1902 the number of miles operated by this system in these cities was 264.

INCREASE IN MILEAGE

During the twelve years from 1890 to 1902 the total single-track mileage for street and electric railways increased from 8123 to 22,577. This increase was due partly to the establishment of new railways, but principally to the extension of the lines already existing.

The mileage of the electric lines increased from 1262 to 21,907, while there was a decrease for the lines operated by other motive power, the decrease being from 488 to 241 miles for cable lines, from 711 to 170 miles for steam lines, and from 5662 to 259 miles for lines using animals for their motive power.

In proportion to its area, Massachusetts has much more electric railway mileage than any other State.

The average length of track per operating company increased from 10.56 miles to 27.63 miles during the same period.

The increase in mileage was accompanied by corresponding increases as follows: Cost of construction and equipment, from $389,357,289 to $2,167,634,077, or 456.7 per cent.; operating expenditures, from $62,011,185 to $142,312,597, or 129.5 per cent.; number of passenger cars, from 32,505 to 60,290, or 85.5 per cent.; number of fare passengers carried, from 2,023,010,202 to 4,774,211,904, or 136 per cent.; and number of employees, from 70,764 to 140,769, or 98.9 per cent.

CARS

There were 66,784 cars of all classes in the United States in 1902. Of this number, 60,290 were passenger cars and 6494 were cars used for express and other purposes. Of the passenger cars, 32,658 were closed, 24,259 were open, and 3134 were combination closed and open cars, while 239 were combination passenger and express cars. There were 1114 cars devoted solely to express, freight and mail business.

An interesting development in electric railway service is the construction and equipment of sleeping cars for use on long-distance lines in Ohio and Indiana.

The largest number of cars of all classes for any State was reported for New York, the number being 14,040.

About half of all the cars in the United States were equipped with heating apparatus, 19,021 being heated by electricity, and 11,138 by stoves, hot water or other contrivances. Many railways, however, have two sets of cars—one for use in summer and the other in winter—so that in winter the proportion of the cars in operation equipped with heating apparatus is larger than these statistics would at first glance indicate.

The report shows also that 62,369 cars, or 93.4 per cent. of the total number, were lighted. Of these, 55,703 were furnished with electric lights.

NUMBER OF RIDES AND FARES

The total number of passengers carried was 5,836,615,296, of which 1,062,403,392, or 18.2 per cent., were transfer passengers.

The average number of rides per inhabitant advanced from 32 in 1890 to 63 in 1902 for the country as a whole, while the advance for the urban population was from 98 to 168. The proportion of rides to the total population is greatest in the District of Columbia, where the whole population is urban, and is next greatest in Massachusetts, while New York ranks third. California has the highest proportion of rides to the urban population, largely as a result of the hilly streets in San Francisco, which compel general resort to this method of travel.

Five cents is the almost universal rate of fare for the urban lines in the United States, although more than one-third of the companies offer lower rates under certain conditions. Frequently six tickets are sold for 25 cents, but occasionally a larger number is required to be purchased in order to secure a low rate. Some companies give reduced fares to workingmen during certain hours of the day and to children going to and from school, while a few other companies carry children between certain ages at a reduced rate.

COMPETITION WITH STEAM ROADS

Considerable competition has arisen between the steam roads and the electric interurban lines. While the steam roads have the advantage of greater speed, the frequent service, convenient stops and low fares of the electric roads have, in many instances, seriously affected the local traffic of steam railways. Statistics show that in 1902 the street and electric lines of the United States carried more than seven times as many fare passengers as the steam railways. Such a comparison, however, means little, since steam railway journeys are, as a rule, much longer than those on street railways. In 1902 the average distance traveled by passengers on the steam roads was 30.3 miles. No definite average can be given for the distances traveled by passengers on the street lines, since no records have been kept by the street railway companies relative to this point. The receipts from passengers were $392,963,248 for steam railways, and $233,821,548 for street railways.

In 1902 the passenger earnings of the street railways were 94.5 per cent. of the total receipts; the remainder of the revenue was derived from the sale of electric current, from freight, mail and express service, and from advertising and other miscellaneous sources.

EMPLOYEES, SALARIES AND WAGES

The average number of salaried officials and clerks employed by the street railway companies of the United States in 1902 was 7128, and the average number of wage-earners was 133,641. The salaries paid amounted to $7,439,716, and the wages to $80,770,449. The wages alone formed 56.8 per cent. of the total operating expenses of the street railway companies.

By far the most important groups of employees are conductors and motormen. These two classes, which are approximately equal in number and in wages received, constituted about three-fifths of the total number of wage-earners. The most common rate of pay was $2 per day.

The highest wages were reported in Montana, and the lowest in Alabama, Arkansas, Georgia, North Carolina and Tennessee.

ACCIDENTS

The accident statistics show that during the year 1218 persons were killed and 47,429 were injured by street railway lines. Of the total number killed, 265 were passengers, 122 were employees, and 831 were persons on foot or riding in vehicles other than street cars; of the injured, 26,690 were passengers, 3699 were employees, and 17,040 were other persons. These numbers form only an inappreciable percentage of the total number of passengers carried. One passenger was killed for every 18,015,894 fare passengers carried, and one was injured for every 178,876 passengers. The rate of accident for the wage-earners was one killed out of 1095 and one injured out of 36. This rate is very much lower than the rate for steam railroads, for which one employee out of every 401 was killed and one out of every 24 was injured.

The reform in the direction of safety provisions for steam railway crossings has of late years been quite considerable in all large American cities, and has been carried on at an enormous expense, so that, of the steam railway crossings now unprotected, a large proportion are to be found in rural districts. The report states that in 1902 there were 4481 crossings, of which more than half were protected; 1967, however, were still without any form of protection, not even being supplied with bells or watchmen.

CONSOLIDATION OF STREET RAILWAY SYSTEMS

One of the most important factors in street railway progress has been the combination of formerly independent railways into great systems. Fifteen or twenty years ago most of our large cities were served by several separate animal-power railways, and there was usually no competition between these independent companies in the matter of fares. The introduction of mechanical traction, especially electric traction, developed a much stronger tendency toward consolidation than existed before. In most cases the establishment of a unified system made it possible to carry passengers more nearly where they wanted to go and to carry them longer distances; this augmented the traffic of the railways to such an extent that it proved decidedly profitable to the companies.

Legislation permitting municipalities to own and operate street railways has recently been enacted in a number of States. There is, however, no instance in the United States of municipal operation of a street railway. The leading instances of municipal ownership and private operation are the subways in Boston and New York.

EFFECT ON THE DISTRIBUTION OF POPULATION

It is apparent to everyone that the electric street railway is exerting a most important and beneficial effect on the territorial distribution of urban population, relieving the congestion in the centers of great cities and permitting growth far out into a belt of country which before the days of the trolley was inaccessible territory. Probably the possibilities which this new method of transportation introduces are only beginning to be realized.

This report gives some interesting illustrations of the extent to which the outer areas of cities have increased through the development of the street railway. For instance, the population in Manhattan Borough of New York City increased from 1,441,216 in 1890 to 1,850,093 in 1900, or 408,877. Of this increase, 231,556, or considerably more than one-half, took place in that part of the island lying north of Eighty-sixth street, the population in this section having practically doubled during the decade. This district is situated about 7 miles from the southern extremity of the city, and the great majority of its bread-winners do business down town and make daily use of the street railways.

In Bronx Borough the population increased from 88,908 to 200,507, the increase being mainly along the street and elevated railway lines. In Brooklyn and Queens Boroughs the increase in population was 39 and 76 per cent., respectively, and in each case the advance was mainly in the outlying wards.

Another conspicuous illustration of this influence is furnished by the city of Boston. Of the seven wards lying nearest to the business center of Boston, five showed a decrease in population, while in the outlying wards there was an increase of 93,395 inhabitants, or nearly five-sixths of the total increase of Boston. Moreover, the population of the immediately adjacent cities of Cambridge, Somerville, Chelsea and Brookline increased much more rapidly than that of the older parts of Boston. A very considerable proportion of the bread-winners, both of the outlying wards and of the adjacent cities, are employed in the business district of Boston and depend upon the electric railways for their transportation.

The change in the distribution of the population of Philadelphia since 1890 has been remarkable. Almost all of the wards in the heart of the city show a decrease in population, while several of the large outlying wards to the west and north of the business center have added greatly to the number of their inhabitants.

Chicago, Cleveland and other cities show this influence of railways in scattering population.

Even in medium-sized cities the street railways encourage the distribution of population, and thus reduce the evils of overcrowding and unsanitary surroundings.

Moreover, the electric railway has given a powerful impetus to suburban life, not only for residence, but also for manufacturing purposes. The effect of this influence is shown in the increased population of the suburbs of Boston and Philadelphia, two cities whose suburban residents are served largely by electric railways. Other cities showing this influence in a marked degree are St. Louis, Milwaukee and Cleveland.

OTHER SOCIOLOGICAL EFFECTS

The presence of a rapid and cheap means of passenger transportation permits manufacturing and commercial establishments to be located conveniently and economically, and allows the concentration of retail and wholesale trade and office business in specialized centers.

The change thus noted has had a marked influence upon the value of land, and upon rentals and building operations, for every extension of an electric railway line into new territory increases the selling and rental values of the real estate in the vicinity. Thus the clearly marked effect upon the community of the increase of electric railway facilities is to prevent overcrowding and to promote equalization of values.

The effect of street railways in concentrating business is evident, although there are no satisfactory statistics regarding the degree to which the business of cities has become concentrated in narrow areas. It has been estimated, however, that the daily movement of people into the central section of Chicago by means of the surface street railway alone is about 225,000, while a still larger proportion of the traffic of the elevated railways is to and from the same business center, which has an area of scarcely more than a square mile. It has also been estimated that the day population of Manhattan Island below Canal street, New York City, is about half a million greater than the night population. A large proportion of this enormous number of persons are carried to and from this section by street railways.

Street cars of the Public Service Corporation of New Jersey which have passed their days of usefulness are to be used in forming a settlement for pauper consumptive patients at Snake Hill, on the Hackensack Meadows, New Jersey.

St. Catherine's lighthouse, on the south coast of the Isle of Wight, has the most powerful electric light in Great Britain. It is of 15,000,000-candle-power.

Fires Due to Electricity and Other Causes

THE amount of damage done by fires caused by defective electric wires and lights in the State of Pennsylvania in 1902 is very small when compared with fires from other causes. In a paper by Washington Devereux, read before the Engineers' Club, of Philadelphia, the following figures were given:—

Ashes and hot coals, bonfires, candles, children playing with matches, $74,375; cigars, cigarettes, pipes, $132,625; railroad collisions, $199,600; defective flues and heating apparatus, $1,712,300; electric wires and lights, $447,795; explosions from gas, gasoline, etc., $346,045; engines and boilers, $44,650; forest fires, $157,950; friction in machinery, $218,230; furnaces, $127,705; gas jets, $128,405; chemicals, grease, oil, paint and varnish, $42,670; incendiarism, $1,790,875; lamp and lantern accidents, $180,210; lighting, $373,630; matches, $157,850; oil stoves, $212,086; sparks within buildings, $451,690; sparks from locomotives, $119,885; spontaneous combustion, $574,920; defective and overheated coal stoves, $660,405; tramps, $162,665; unknown origin, $3,875,260. The total amount of this damage was $12,191,876, making the loss due to defective electric wires and lights only 3.6 per cent. of the whole.

The usual tendency to attribute a fire of unknown origin to defective wiring was shown in the case of a large hotel in the city of Philadelphia, whose owner considered the advisability of introducing electric lighting. A fire of a very mysterious origin occurred. The electric wiring had been installed in accordance with the best-known methods of the day, but the molding which incased the electric conductors caught fire. The proprietor had heard many vague and mythical stories of the dangers of electricity and concluded the electric conductors were responsible for the fire, in spite of the fact that no current had ever passed over the wires. To solve the mystery he summoned to his aid a so-called electric expert, who declared that the wires had been charged with induced electric current from the electric light mains in the street, which passed within 50 feet of the building.

The chief inspector of the Fire Underwriters' Association was also consulted, and on inspection he found at various points along the molding candle grease, indicating the mode of illumination used to aid the workmen while installing the wiring. The inspector called for a small piece of candle, and lighting it placed it upon the molding, suggesting to the proprietor, "now we will go away and forget the lighted candle, and you will have another fire due to the electric induction." The common-sense solution won the day and the building was equipped with electric light throughout.

The Freedom of Electric Automobiles from Accidents

IN a paper on "The Future of the Electric Automobile," read in London before the Automobile Club, T. G. Chambers said that the electric carriage is as nearly proof against mishap as any machine can be. Taking the last six months' working of the Electromobile Company's Curzon street garage, the total involuntary stops, excepting those due to power exhaustion, were 61 in 159,258 carriage-miles. Of these stops 14 were due to a mechanical defect in the contact breaker, the possibility of which has since been entirely eliminated by an improved mechanism; 9 were due to tire troubles; 13 were due to the blowing of the main fuse, a matter immediately repairable by the driver. This leaves only 25 stops in about 160,000 carriage-miles necessitating the attention of a mechanic, or, on an average, 1 stop in every 6400 miles.

When it is remembered that at least half these carriages are in the hands of comparatively raw drivers, and practically all of them are in the hands of men without mechanical training, the reliability may be considered very great indeed. When the limitations of the accumulators are understood and recognized, little or no difficulty arises from power exhaustion. With an effective range of from 25 to 35 miles upon one charge, and with the adoption of interchangeable batteries, a carriage may be run all day, if only time be allowed for its return to a depot to take up a new battery, an operation which takes from two to three minutes. The far-reaching importance of this system of rapidly exchanging an exhausted battery for a fully charged one cannot be too much insisted upon. It will probably have a material effect upon the future of the electric carriage.

Statistics received by the Department of Commerce and Labor, through its Bureau of Statistics, indicate that the world's output of coal in 1903 was 864,000,000 gross tons, of which the United States produced 319,000,000 tons, as against 230,000,000 produced by Great Britain, 160,000,000 by Germany, 39,000,000 by Austria-Hungary and 35,000,000 by France.

Electrical and Mechanical Progress

A New Electric Pump

THE electrically operated pump illustrated on this page and made by the Dean Brothers Steam Pump Works, of Indianapolis, Ind., has two double-acting water cylinders with cranks set at right angles so as to produce four discharges at each revolution of the crankshaft. The crankshaft is made of steel and geared at both ends. The gears are all cut from the solid and accurately adjusted. The motor and pump are mounted on the same bed-plate, making a complete self-contained apparatus.

The pump shown will raise 500 gallons of water a minute 250 feet high. Every part is designed and fitted in the best possible manner. It is made in various sizes.

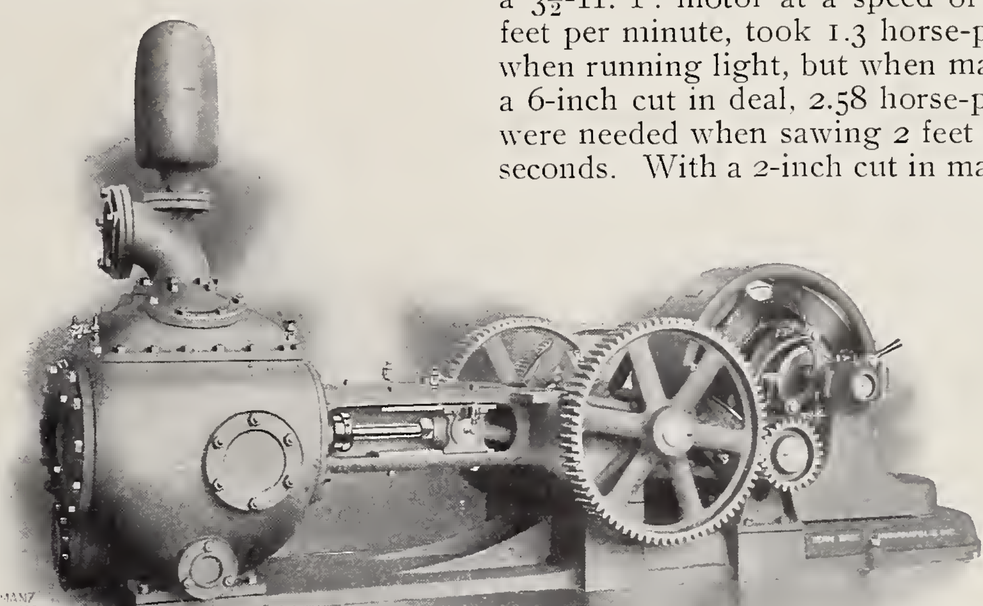
Driving Wood-Working Machines by Electric Motors

SOME interesting tests recently carried out in England to ascertain the power required by various wood-working machines, are recorded in "The Electrician," of London. All the machines were fitted with electric motors, some of the tests being made with an electromotive force of 460 volts and the remainder with an electromotive force of 214 volts. The ease and exactitude with which the power required by machines can be determined when they are electrically driven is well known, and offer inducements for carrying out such tests.

It was found in the trials that a circular saw, driven at about 1000 revolutions per minute by a 12-H. P. motor, and taking a cut at the rate of 6 feet per minute on 10-inch by 7-inch damp pitch-pine, required 13.8 horsepower. Another circular saw, 19 inches in diameter, driven by a 7-H. P. motor, required 2.14 horse-power when running light. When cutting deal with a 2-inch cut at the rate of 6 feet 2 inches in 10 seconds, 5 horse-power were required. With a $1\frac{1}{4}$-inch cut 4 feet 2 inches were sawed in 5 seconds, and required 4 horse-power; with the same cut, a length of 7 feet 3 inches was sawed in 8 seconds with a horse-power of 4.3; while with a 6-inch cut 5.2 horse-power were needed to saw a length of 2 feet in 20 seconds.

A 5-H. P. motor running at 1200 revolutions per minute, and driving a band-saw and a vertical-spindle machine by means of two belts taken off one pulley, developed, when driving the belts alone, 1.48 horse-power; and when driving the two belts and the band-saw running light, the power required was 2.14 horse-power. The speed of the band-saw was 4800 feet per minute, and that of the vertical spindle about 4000 revolutions per minute. Another band-saw, driven by a $3\frac{1}{2}$-H. P. motor at a speed of 3600 feet per minute, took 1.3 horse-power when running light, but when making a 6-inch cut in deal, 2.58 horse-power were needed when sawing 2 feet in 25 seconds. With a 2-inch cut in mahogany, 2.14 horse-power were required for sawing 1 foot in 4 seconds; for a $4\frac{3}{4}$-inch cut in oak it took 3 horse-power to saw at the rate of 1.5 foot in 15 seconds; while a $2\frac{3}{4}$-inch cut in beech took 2.86 horse-power when 1 foot was sawed in 15 seconds.

A tenoning machine, driven at 2700 revolutions per minute by a link belt from a 5-H .P. motor, took 3.4 horse-power when running light, and 5.86 horse-power when tenoning pitch-pine and removing $3\frac{1}{2}$ cubic inches of



A NEW ELECTRIC PUMP, BUILT BY THE DEAN BROTHERS STEAM PUMP WORKS, INDIANAPOLIS, IND.

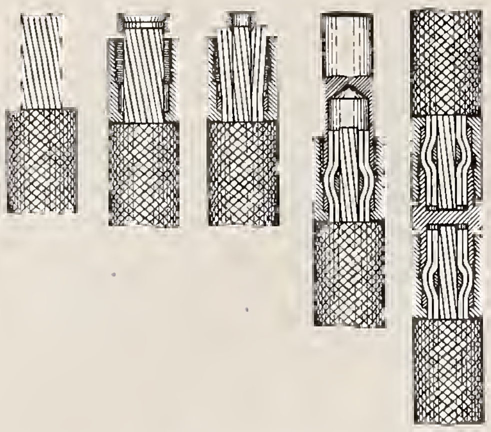


FIG. 1.—A NEW CABLE JOINT MADE BY DOSSERT & COMPANY, NEW YORK. THE SUCCESSIVE STEPS IN MAKING THE JOINT ARE HERE SHOWN

wood in 10 seconds. A planer, designed for 8-inch by 24-inch planks, and driven from a 5-H. P. motor, took 3.4 horse-power in making a $\frac{1}{8}$-inch undercut in pitch-pine 9 inches wide, and finished a plank 8.5 feet long in 25 seconds. A $\frac{1}{4}$-inch overcut from a plank of pitch-pine 5 inches wide required 3.2 horse-power when finishing a 6-foot length in 20 seconds. Another planer designed for 20-inch by 8-inch planks, and driven by a 5-H. P. motor, required 4.3 horse-power when making a 3-16-inch cut from a 9-inch wide deal plank at a speed of 7 feet 2 inches in 45 seconds; and it took 4.6 horse-power when making a cut 3-32 inch deep off an 18-inch wide deal plank at the rate of 3 feet 8 inches in 17 seconds.

An emery wheel used for grinding tools, and running at 1640 revolutions per minute, required 0.43 horse-power when not grinding; but when working on a straight moulding cutter, the current ranged from 0.616 to 1.25 horse-power. A 6-inch emery wheel driven at 1860 revolutions per minute from a $2\frac{1}{2}$-H. P. motor took 0.72 horse-power for the motor and belts only, 1.3 horse-power with the emery wheel running light, and 1.6 horse-power when grinding a moulding cutter.

Completion of the Simplon Tunnel

The piercing of the Simplon tunnel through the Alps, proposed as long as fifty years ago, but not commenced until late in 1898, was completed on February 24 of this year, and according to contract the tunnel is to be ready for traffic about the middle of May. It is the longest one through the Alps. From Briga in Switzerland, to Iselle on the Italian side, it measures $12\frac{1}{4}$ miles. The St. Gothard tunnel measures $9\frac{1}{4}$ miles, and the Mont Cenis a little over $7\frac{1}{2}$ miles. The cost of the Simplon tunnel is $15,000,000, borne jointly by the Italian and Swiss governments.

A New Cable Joint

The most disagreeable features of cable work, particularly in case of the larger sizes, are splices, taps and terminal connections. Messrs. Dossert & Company, of New York, have devised a joint to overcome these difficulties, and at the same time to make connections which shall be good electrically and mechanically, without the use of solder, at a cost claimed to be less than that of the ones formerly made.

The straight-away joint shown in the annexed illustrations is made of seven parts, six of which are in pairs. The duplicate parts are compression nuts, outside and inside rings. A nipple, threaded on each end to receive the nuts, completes the number.

Fig. 1 shows the way in which a joint is put together. The ends of the cable to be joined are thoroughly cleaned of insulation. The compression nut and outside ring are next slipped over the end of the cable and driven securely home by means of a large metal tube provided for the purpose. The outer strands of the cable are opened, the small inside ring is placed over the core and driven down as far as possible by means of a small metal tube. The next step is to mold the outer layer of strands into their original position, using a large tube for the purpose. These steps having been repeated for the other end of the cable, the joint is ready to be put together, and, to complete the connection, it only remains to screw the nuts securely on the nipple. The finished joint is shown in section at the right of the illustration.

It will be seen that the inside ring makes a bunch in the cable inside of the nut, and that when pressure is applied by screwing up the nuts on the nipple, contact is obtained between the connector and the two ends of the cable. The contact pressure obtainable is only limited by the strength of the nut to withstand splitting, and that of the threaded portion to resist stripping, and it is evident that the contact resulting is excellent.

After the joint has been completed a hexagonal sleeve may be slipped over it, as shown in Fig. 2; this locks it securely, eliminating any chance of the parts becoming unscrewed. The use of the sleeve, however, is necessary only in places where there is considerable vibration.

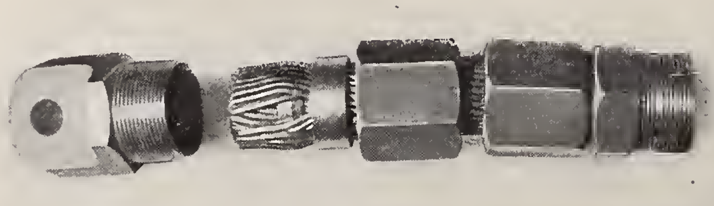


FIG. 3.—A 1,000,000-CIRCULAR MIL DOSSERT JOINT, WITH STRANDS CUT AWAY TO SHOW INSIDE AND OUTSIDE RINGS

FIG. 4.—ASSEMBLY AND PARTS OF DOSSERT CABLE TAP JOINT

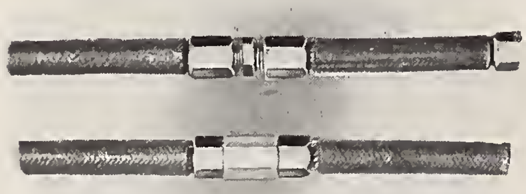
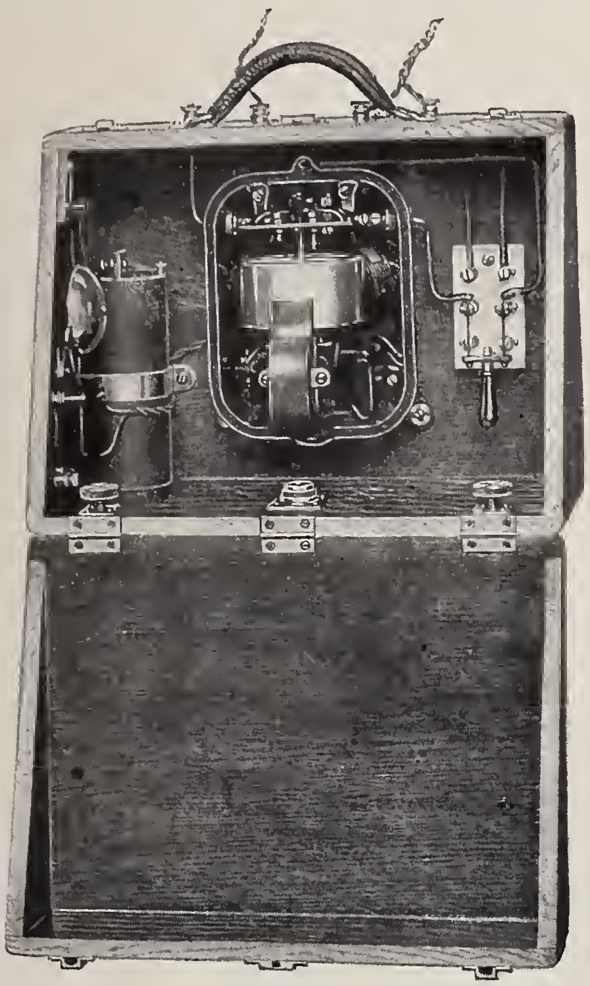


FIG. 2.—A DOSSERT JOINT WITH AND WITHOUT THE LOCKING SLEEVE

Fig. 3 is an illustration of a 1,000,000-circular mil joint, with half of a straight-away joint on one end and a lug connection on the other. The strands have been cut away so that the positions and functions of the inside and outside rings may be apparent. The nipples may be in the form of crosses or tees, or may be cast on to fittings of any description, so that cables may be securely fastened thereto.

One of the interesting applications of the joint is that to the cable tap. The joint is shown in detail and assembled in Fig. 4. A substantial hook is carefully machined to fit the cable, and the shank is drilled and threaded to form the nipple of the standard joint for the size of bleeder to be taken from the main feeder. A suitably shaped casting, which fits in the space between the cable and the base of the hook, is held in place by means of the compression nut, attaching the hook securely to the cable.

The attachment of the joint is easily and quickly made. The tap wire, or bleeder, is first fastened to the hook by



A PORTABLE WATTMETER CALIBRATOR OF THE RINGING TYPE, WITH THE CASE OPEN, MADE BY THE FORT WAYNE ELECTRIC WORKS, FORT WAYNE, IND.

means of the regular Dossert connector on the shank; after the insulation has been stripped from the main cable to a width equal to that of the hook, the clamp is placed over the wire and the small casting slipped in place and forced tightly against the cable by means of the nut. In this manner connectors of any size may be attached to a large cable.

All styles of connectors are also made in aluminium. They are very serviceable for this class of work, on account of the great difficulty in making soldered joints on aluminium conductors. Aluminium joints, as they are made at the present time, are always a source of trouble; in fact, aluminium cable has in many cases been discarded in favor of copper cable for this reason alone. With Dossert connectors, it is claimed, these difficulties disappear, and a cable made of aluminium can be installed with as much ease and in as workmanlike a manner as one of copper.

At a recent meeting of the National Board of Fire Underwriters, held in New York, the Dossert joint was favorably considered, the laboratory tests of the underwriters having proved entirely satisfactory. Pending its formal approval, directions were given by the board that permission to use Dossert joints without solder will be granted by local Boards of Fire Underwriters upon application, provided they are informed just where the joints are to be located. The New York Department of Water Supply, Gas and Electricity have approved the use of Dossert joints without solder in all places where soldered joints are now allowed.

Portable Wattmeter Calibrators

PORTABLE wattmeter calibrators, designed by the Fort Wayne Electric Works, of Fort Wayne, Ind., for calibrating meters without removing them from service, are shown in the annexed illustrations. These meters are used for periodic comparison of speeds with meters in service, the accuracy of the latter thus being determined.

Two types have been developed, the ringing calibrator and the registering calibrator. In the former, a standard wattmeter of proper capacity, voltage and frequency, but without registering mechanism, is mounted on the inside of a wooden carrying case. This is provided with leveling screws and a small spirit level set into the base. In the case beside the meter is a double-pole, double-throw switch, by means of which the series coils of the standard can be connected either in multiple or in series for double or normal rated current.

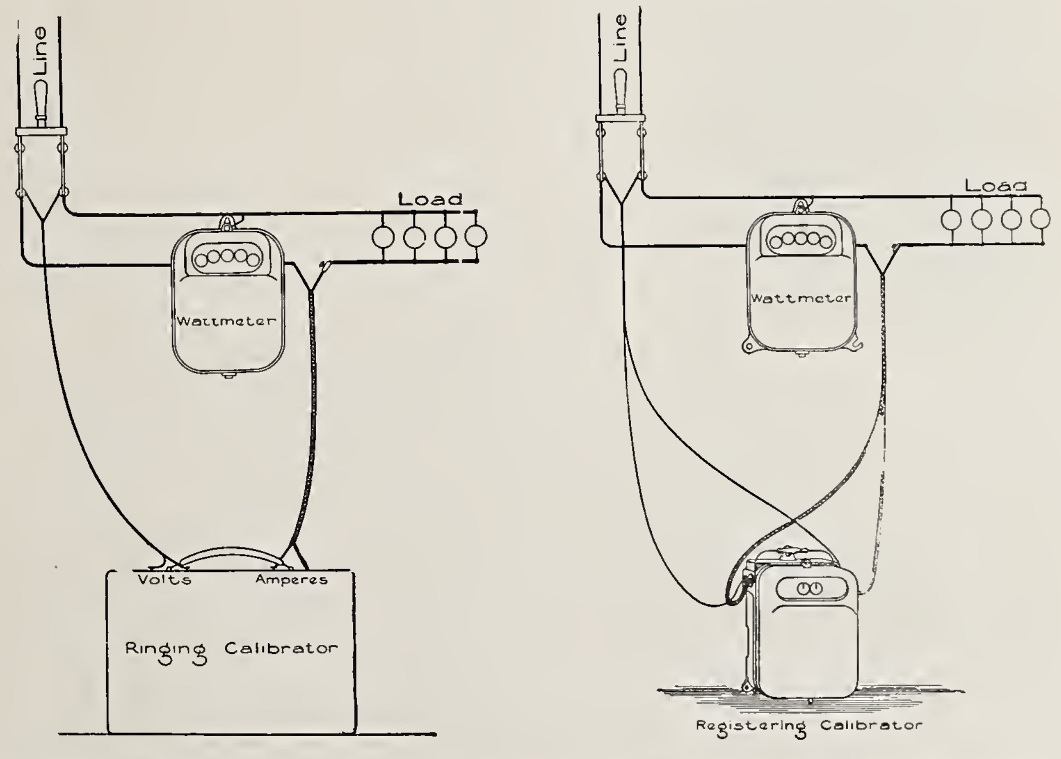
For normal calibration of 5-ampere meters with the switch down, the coils are in series; for double this current or 10-ampere meters, the switch is thrown up. This prepares the calibrator for use with 5 and 10-ampere me-

A PORTABLE WATTMETER CALIBRATOR OF THE REGISTERING TYPE, MADE BY THE FORT WAYNE ELECTRIC WORKS

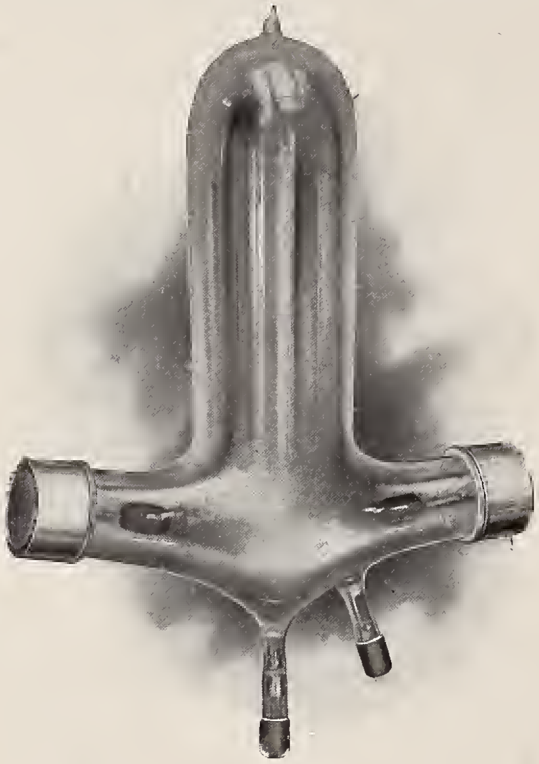
ters by direct comparison without a speed constant, the change in connections making no change in total ampere turns or speed.

The scope of the calibrator is further increased by using a speed constant of 2 for calibrating 15, 20 and 25-ampere meters. To calibrate 15, 20 or 25-ampere meters, the series coils of the calibrator are connected in multiple by throwing the switch up, in which case the calibrator will run twice as fast as these meters. It will be accurate under these conditions up to 15 amperes load.

For comparing the speeds of the two meters, a bell circuit is connected

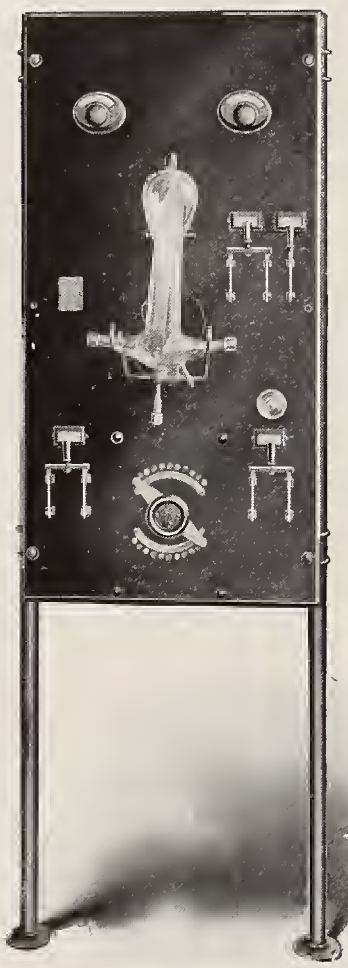


DIAGRAMS SHOWING CONNECTIONS FOR FORT WAYNE CALIBRATORS OF THE RINGING AND THE REGISTERING TYPES with the standard through a two-segment commutator on its armature shaft in place of the registering train. At every revolution of the standard armature, the bell circuit is closed



A MERCURY ARC RECTIFIER, MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., FOR USE IN CHARGING STORAGE BATTERIES

through a dry-cell battery mounted on the left side of the case, thus ringing the bell. This bell circuit may be permanently opened when not in use by a



PANEL OF THE GENERAL ELECTRIC COMPANY'S AUTOMOBILE-CHARGING OUTFIT, SHOWING THE RECTIFIER TUBE, SWITCHES, VOLTMETER AND AMMETER

two-point switch to prevent leakage of battery current, should the armature come to rest with the circuit closed by the commutator.

In calibrating a meter with the ringing calibrator the procedure is as follows:—

Level the case with the adjustment screws. Connect the current or heavy leads to the binding posts marked "Amperes" on the top of the case, with one lead replacing the load wire in the meter to be tested, and the other lead connected to the load wire thus replaced.

Connect the voltage or small leads to the binding posts marked "Volts" with the hooks on the other end connected across the fuse block or the switch on the line or service side of the meter to be tested. This is shown in the annexed diagram.

If the standard is properly connected in circuit the cup will rotate clockwise from above. Direction of rotation may be changed by reversing the voltage leads at the switch or fuse block. The case should now be closed to shield the armature or cup from air currents.

With a heavy load, the meter should be adjusted in step with the standard by means of its permanent magnet so the spot on the meter cup will always come to a certain point every time the standard bell rings for 5 or 10-ampere meters, or every other time for 15, 20 or 25-ampere meters. If the meter is slow, the magnet should be lowered, if fast, it should be raised.

For light load or one lamp, the adjustment is made with the starting coil arm. If the meter is slow, screw in the left screw, if fast, screw in the right side screw (when facing the meter).

The ringing calibrator is built for any standard voltage or frequency, and will calibrate either 5, 10, 15, 20 or 25-ampere meters of the same type, and of the same voltage and frequency as above described. It is equally suitable for calibrating meters of other manufacture having the same speed or an even multiple of its speed.

The carrying case is solidly built of quartered oak with mitered joints and is highly finished. It is also furnished in other finishes and woods. The overall dimensions are 15 x 11 x 8 inches.

The registering calibrator consists of a meter having the regular registering train replaced by a double reduction train and two dials instead of five, which register revolutions instead of kilowatts. This is a much simpler device than the ringing calibrator, but is much more restricted in its adaptability.

For carrying purposes a handle is attached to the meter frame. Two adjusting screws are provided on the bottom of the frame for leveling, the third support being on the case. The jewel bearing is extra long and projects through the case at the bottom so that the shaft can be raised or lowered without removing the case. The calibrator terminals can be reached by removing the terminal cap. Line connections are made as with the ringing calibrator.

The calibrator is leveled by a small level placed on a milled surface on the top of the base. The shaft is then lowered to the jewel, and, after the connections are made and the proper direction of rotation is verified through the dial window, the calibrator is ready for operation.

The dials will register 110 revolutions, which are equivalent to nearly 3 minutes running at full load. Therefore, if the revolutions of the meter to be tested are counted and compared with the difference in calibrator readings before and after counting, an exact comparison of speed is obtained. This can be done readily by one man. For first approximation one-half minute counting is sufficient, but for final accurate adjustment the time of comparison should be increased to two and one-half minutes.

A Mercury-Arc Rectifier for Charging Automobile Storage Batteries

A RECENT development as a part of electric vehicle-charging equipments made by the General Electric Company, of Schenectady, N. Y., is a mercury-arc rectifier for converting alternating into direct currents. The rectifier depends for its operation on the now well-known property of vapor tubes by which current is allowed to flow in one direction only, the electrodes acting as electric valves. An alternating current, then, may be "rectified" into a pulsating direct current by the suppression of the flow in one direction.

As will be seen in the annexed illustration, the outfit consists of a panel, a rectifier tube and holder and a compensating reactance, the last named being mounted either on the back of the panel or on the floor.

The rectifier tube is an exhausted glass vessel, with two anodes at the side, a cathode at the bottom, and a starting anode between the latter and one side anode. It is provided with metal caps for the terminals which protect the electrodes, thus reducing to a minimum the liability to breakage and burn out. The leads from the anodes are connected to the compensating reactance; the lead from the cathode forms the positive side of the direct-current circuit.

The holder consists of a moving member mounted on the face of the panel and provided with spring clips for holding the tube. Terminals for connecting the various parts of the tube to the panel are mounted on the latter. This is also provided with voltmeter, ammeter, double-pole switches for connecting to the vehicle and alternating-current mains and necessary double-pole and single-pole switches for starting and operating the rectifier. The compensating reactance is connected directly across the alternating-current supply mains. Leads are brought out from the reactance to a dial switch mounted on the front of the panel. By means of this switch the voltage and current may be varied within the limits of the rectifier. A tap is brought out from the reactance and forms the negative side of the direct-current circuit.

A great advantage claimed for the mercury-arc rectifier is that it gives a higher efficiency and power factor than a motor generator set, as well as a lower first and operating cost. The complete outfit occupies a floor space of approximately 24 inches by 18 inches. It is furnished in three capacities, 10, 20 and 30 amperes, and can be adapted to any commercial alternating-current voltage and any direct-current voltage necessary for charging vehicle batteries. It can be furnished for any commercial frequency.

High-Tension Strain Insulators

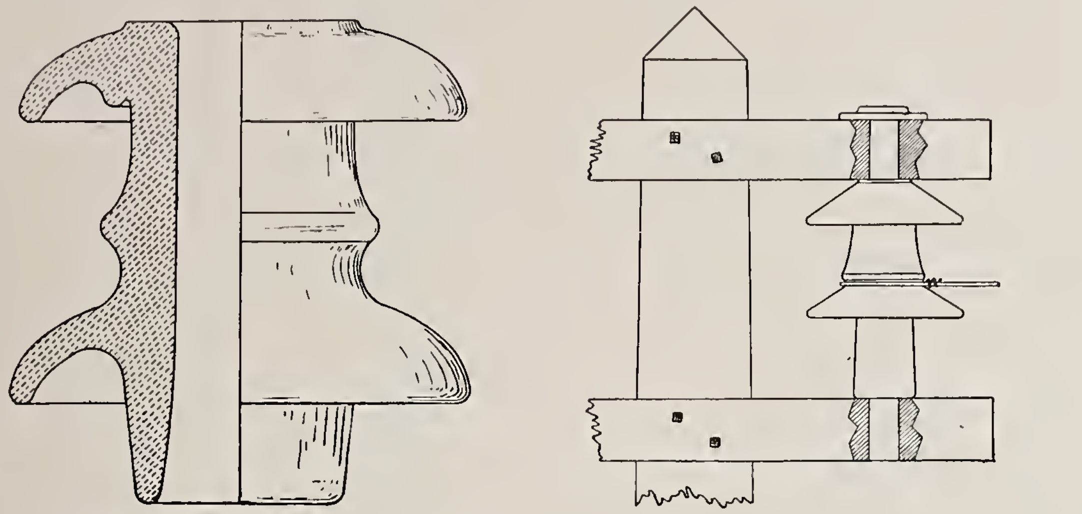
THE increase in the use of high-tension trolleys has created a demand for an insulator possessing mechanical and electrical qualities of a high order. To meet this demand the Locke Insulator Manufacturing Company, of Victor, N. Y., has brought out some new strain insulators for voltages up to 35,000. One of these, designed for 8000 volts and mesuring 6 inches in height and $5\frac{3}{4}$ inches in diameter, is shown in the annexed illustrations. A smaller design, for voltages of 5000 and under, has also been developed and found very useful in the construction of spans for trolley suspension, while a 60,000-volt pattern is now being developed.

These insulators are used for dead-ending, for curves or similar use in holding live wires of high voltage, under excessive tension, the ordinary pin being too weak. The pin of the strain insulator is supported at both top and bottom, and the pull is transferred directly to the pole.

Either wood or iron pins may be used. The former are straight grained and treated with paraffine; the latter are of extra heavy standard pipe, provided with a special fitting at the top to cover the holes in the pipe and cross-arm. The iron pins include fibre tubes as a cushion between the insulator and the pin. Both the wood and iron pins are designed for cross-arms $4\frac{1}{4}$ inches thick, but extra length is allowed for thicker arms.

The pin holes in the insulators are all of larger diameter at the top and bottom, the smaller diameter being directly opposite the wire groove, so that the porcelain is always under direct compression only, though the pins flex somewhat under heavy load.

The mechanical tests of larger designs of these insulators have shown their ability to stand a break-down load of 12,000 pounds with the insulator supported by a pin through the middle and the load applied around the middle wire groove.



AN 8000-VOLT STRAIN INSULATOR, MADE BY THE LOCKE INSULATOR MANUFACTURING COMPANY, VICTOR, N. Y. IT IS HERE SHOWN IN SECTION AND IN USE FOR DEAD-ENDING A LIVE WIRE

Electrically Tempering Tool Steel

IN telling of various ways of hardening and tempering high-speed tool steel, in a paper on "The Development and Use of High-Speed Tool Steel," read at the New York meeting, last fall, of the Iron and Steel Institute, and already noted in these pages, J. M. Gledhill presented several diagrams illustrating different electric tool-heating methods. These are reproduced herewith as of additional interest, and for the sake of convenience some of the previously printed data are also given here.

Fig. 1 shows the apparatus intended

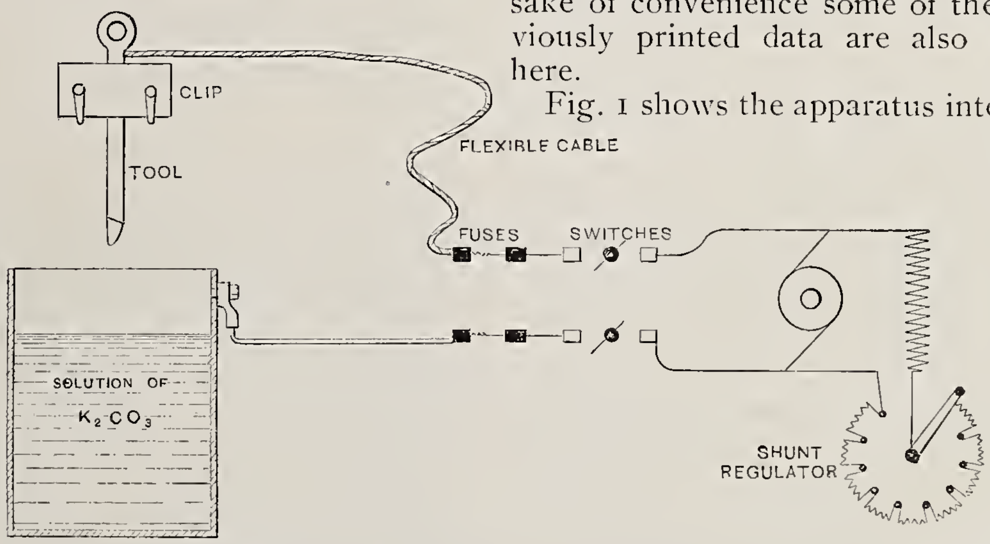


FIG. 1.—APPARATUS FOR HARDENING HIGH-SPEED TOOL STEEL

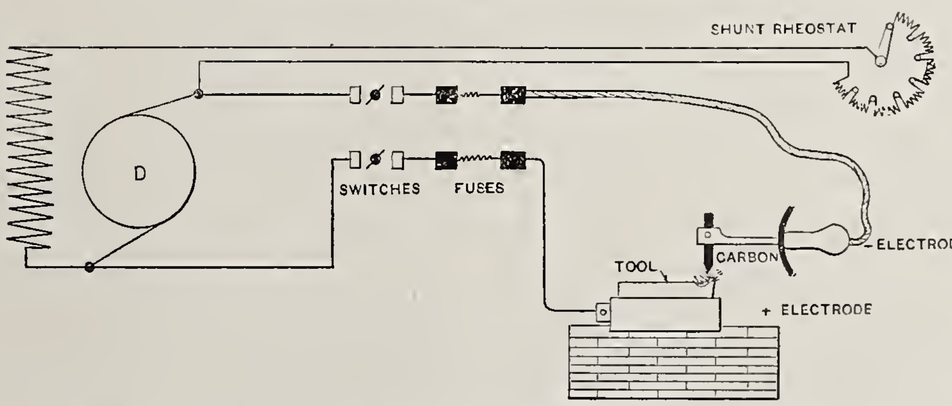


FIG. 2.—HEATING THE POINTS OF TOOLS BY THE ELECTRIC ARC
Electrically Tempering Tool Steel

specially for heating the points of tools. It comprises a cast-iron tank containing a strong solution of potassium carbonate, and a dynamo, the positive cable from which is connected to the metal clip holding the tool to be heated, while the negative cable is connected direct to the tank.

After switching on the current, the tool is gently lowered into the solution to the depth to which it is to be hardened. The dipping of the tool into the solution completes the electric circuit and at once produces intense heat at the immersed part. When it is seen that the tool is sufficiently heated, the current is switched off, and the solution then serves to rapidly chill and harden the point of the tool.

Another method of heating the points of tools is by means of the electric arc after the manner illustrated in Fig. 2. In Fig. 3 is shown the area of the tool subjected to the arc effect. The tool under treatment and the positive electrode are placed on a bed of non-conducting and non-combustible material and the arc is started gradually at a low voltage, being steadily increased, as required, by controlling the shunt-rheostat, care being taken not to obtain too great a heat and so fuse the end of the tool. The source of power in this case is a motor-generator consisting of a continuous-current shunt-wound motor at 220 volts, coupled to a continuous-current shunt-wound dynamo at from 50 to 150 volts. Arcs from 10 to 1000 amperes are then easily produced and simply and safely controlled by means of the shunt-rheostat.

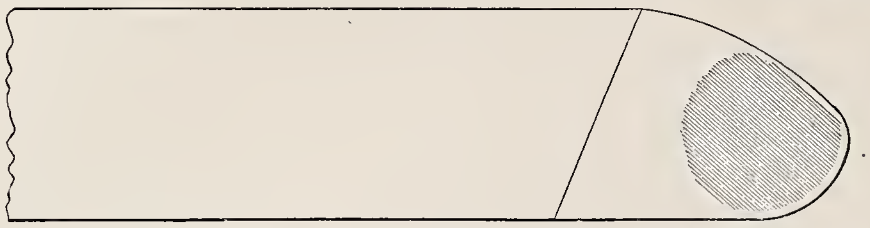


FIG. 3.—THE SHADED PART SHOWS THE AREA OF ELECTRICAL CONTACT. THE NEGATIVE ELECTRODE SHOULD BE KEPT MOVING OVER THIS SURFACE WITHOUT APPROACHING TOO NEAR THE CUTTING EDGE OF THE TOOL

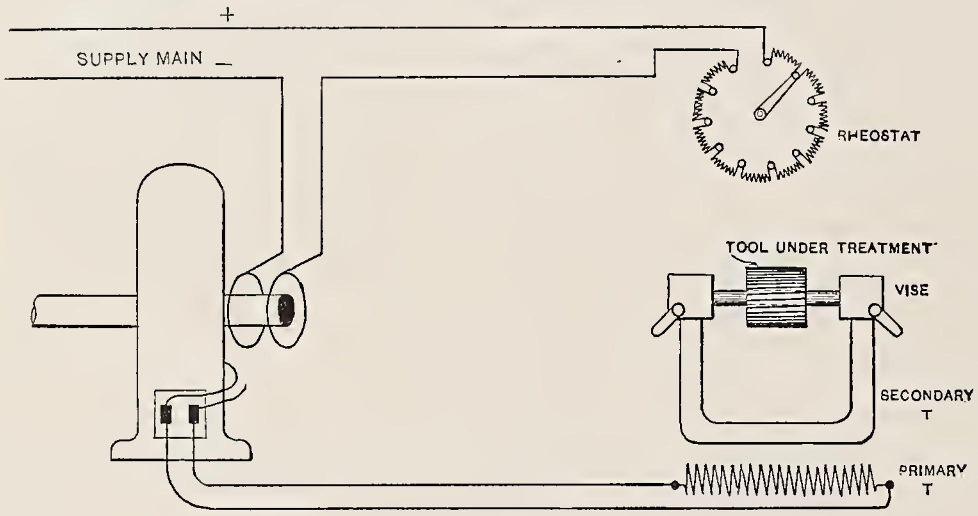


FIG. 4.—TEMPERING MILLING CUTTERS

Electrically Tempering Tool Steel

In the case of tempering such forms of tools as milling, gear, hobbing and other similar cutters; also large hollow taps, hollow reamers, and all other hollow tools made of high-speed steel, where it is required to have the outside or cutting portion hard, and the interior soft and tenacious, so as to be in the best condition to resist the great stresses put upon the tool by the resistance of the metal being cut, and which stresses tend to cause disruption of the cutter if the hardening extends too deep, the apparatus shown in Fig. 4 is used. Tempering of hollow cutters, etc., is sometimes carried out by the insertion of a heated rod within the cutter, and so drawing the temper, but this is not entirely satisfactory or scientific, and is liable to induce cracking by too sudden heat-application, and further because of the difficulty of maintaining the necessary heat and temperature required, and afterwards gradually lowering the heat until the proper degree of temper has been obtained.

In electrical tempering, the rod is placed inside the cutter quite cold, and the electric current gradually and steadily heats up the rod until the correct temperature is reached, when it can be held at such temperature as long as is necessary, and the current can be gradually reduced until the articles operated on are cold again, and consequently the risk of cracking by too sudden expansion and contraction is reduced very greatly.

The apparatus used is very simple, as will be seen by reference to the sketch. It consists of a continuous-current shunt-wound motor directly coupled to a single-phase alternating-current dynamo of the revolving-field type; giving 100 amperes at 350 volts and 50 cycles per second, the exciting current being taken from the works supply main.

By means of a transformer the generator current is stepped-down to 2 volts, the secondary coil of the transformer consisting of a single turn of copper of heavy cross section, its extremities being attached to heavy copper bars which carry the connecting vises holding the mandril upon which the cutter to be tempered is placed.

Although the resistance of the complete circuit is very low, still, owing to the comparatively high specific resistance of the iron mandril, the thermal effect of the current is used up in heating the mandril, which gradually attains the required temperature, slowly imparting its heat to the tool under treatment until the shade of the oxide on the tool satisfies the operator.

The method adopted to regulate the temperature of the mandril is by varying the exciting current of the alternator by means of the rheostat. An extremely fine variation and a perfect heat control are easily possible with this arrangement.

The Arnold Company

ANNOUNCEMENT was recently made of the change of name of the Arnold Electric Power Station Company to The Arnold Company, engineers, constructors, electrical, civil, mechanical, with offices as hitherto, in the Marquette Building, at Chicago. This change of name was prompted by the rapidly expanding business of the company, which has grown from that of consulting engineering through designing and constructing of central power plants, to that of consulting and designing engineers and constructors of properties, electrical, civil and mechanical.

The foundations of The Arnold Company business were laid by Bion J. Arnold in his consulting engineering work in the early nineties. The directness and originality with which Mr. Arnold attacked the propositions passing through his office at that time soon placed him among the foremost engineers, not only of Chicago, but of the East as well, and was the subject of very complimentary notices from European engineers.

It was soon found desirable to form

B. J. ARNOLD

a corporation under the name of the Arnold Electric Power Station Company, to carry out construction contracts that were being taken for power plants and shop equipments. Under the name the organization rapidly grew and its field of operations widened. Bion J. Arnold, as president, has general oversight of the company's operations; W. L. Arnold is vice-president, and R. G. Arnold is secretary and treasurer.

Mr. Arnold has been very ably assisted by George A. Damon, managing engineer, who is in direct charge of The Arnold Company's work. A full complement of office and field engineers, electrical, civil and mechanical, are in charge of the details of the various propositions. In the office the organization is completed by the draftsmen, stenographers and office assistants.

In some of the lines above noted The Arnold Company has achieved an enviable reputation. The equipment of industrial shops, and in particular of railroad shops, has received especial attention in a number of contracts covering such work. More recently not only the design, but as well the construction of the plant complete, including buildings and entire equipment, has been covered by one contract. The resulting arrangement has been most satisfactory to all concerned. The purchaser has to deal with but one contractor and has the assurance that the plant, when finished, will be complete in all particulars.

The same idea is carried out with all lines of The Arnold Company's work. In interurban propositions, not only the electrical equipment, but the road-bed and track work are arranged for under one agreement. In a recent water-power proposition, the preliminary and final reports were made by The Arnold Company, and on these the capital for the enterprise was raised. The design and the construction of the entire property, including dam, generator plant, sub-station and primary and secondary distributing systems were executed by The Arnold Company under one contract. In this case they will also operate the property for the first year.

Personal

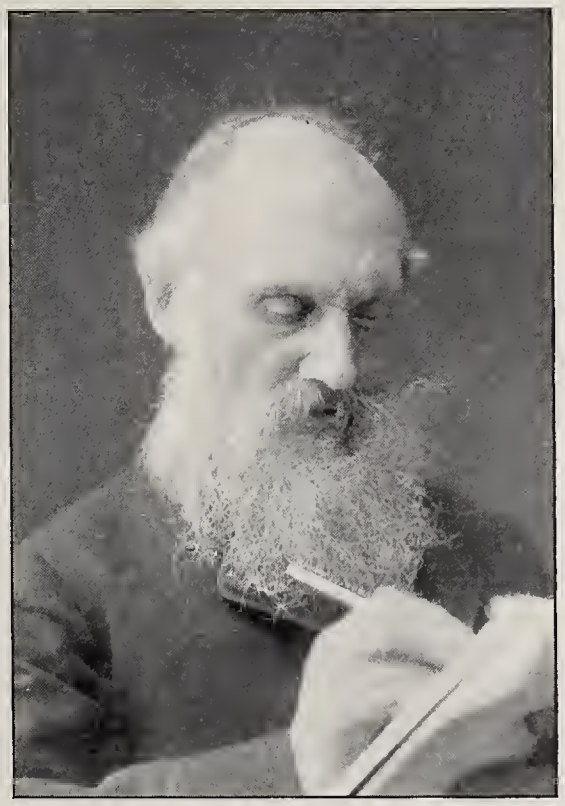
The first award of the John Fritz medal, which was established by the professional associates and friends of John Fritz, of Bethlehem, Pennsylvania, U. S. A., on August 21, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress, has been awarded to Lord Kelvin. The award was made by the following board, selected for the purpose:—

From the membership of the American Society of Civil Engineers:—Robert Moore, Alfred Noble, Chas. Warren Hunt and Charles Hermany.

From the membership of the American Institute of Mining Engineers:—E. G. Spilsbury, James Douglas, Charles Kirchhoff and E. E. Olcott.

From the membership of the American Society of Mechanical Engineers:—John E. Sweet, Robert W. Hunt, Samuel T. Wellman and James M. Dodge.

From the members of the American Institute of Electrical Engineers:—



LORD KELVIN

Carl Hering, Charles P. Steinmetz, Charles F. Scott and B. J. Arnold.

The medal is of gold, of value of about $100, and with it is presented a certificate of the award. The medal was awarded to Lord Kelvin for "Cable Telegraphy and other General Scientific Achievements."

Dr. F. A. C. Perrine has returned to New York from a trip to Mexico in connection with a new electric power transmission project.

John Van Vleck, mechanical engineer of the Interborough Rapid Transit Company, New York, will shortly go abroad to study British and Conti-

JOHN VAN VLECK

nental power house operation, along with the practice of superheated steam, recent developments in steam turbine construction, steam pipe for high-temperature steam, and allied subjects. He expects to return late in June.

Bion J. Arnold, the well-known consulting engineer, and member of the commission undertaking the electrification of the New York Central & Hudson River Railroad Company's lines, addressed the members of the Commercial Club, of Boston, Mass., on the evening of March 16. Mr. Arnold described the plans which had been completed for the two power houses, of about 60,000 H. P. each. He described the equipment of the sub-stations and the characteristics of the generating and distributing service. He called attention to the contract which had been made for the electric locomotives, and the tests which are being undertaken to demonstrate the entire usefulness of this apparatus. He described in detail the improvements planned for the Grand

Central Station, illustrating the address with numerous lantern slides.

F. S. Pearson, of New York, well known through his work in the electrical conduit equipment of the lines of the Metropolitan Street Railway Company of that city, is at present in personal charge of several large power propositions located at Niagara Falls, in the Province of Manitoba, Canada, and in Rio de Janeiro, Brazil, as well as one in Mexico.

F. S. PEARSON

P. G. Gossler, vice-president of J. G. White & Co., New York City, has left on a trip to Mexico in connection with the Monterey Electric Light & Power Company, Ltd., of which he is president. The Monterey Company holds the franchise of lighting the city of Monterey. The undertaking is controlled by J. G. White & Co. and the New York banking house of H. W. Halsey & Co.

H. T. Barron has joined the New York City office staff of the Green Fuel Economizer Company, of Matteawan, N. Y., in connection with the sale of blowers, heaters and ventilating fans. Mr. Barron is well known in heating and ventilating circles.

L. B. Stillwell has gone abroad on a pleasure trip and is expected to return about the middle of June. Previous to his departure late last month, he was appointed consulting electrical engineer of the Hudson River Companies, an organization controlling the several tunnels proposed and in progress underneath the Hudson River between New York and Jersey City, and the water front tunnel running from the Lackawanna Railroad station in Hoboken to Jersey City, connecting the Lackawanna, Erie, Pennsylvania and Jersey Central Railroad stations.

Adolphus A. Knudson has taken offices in the Mutual Life Building, New York, where he will continue his practice as consulting engineer, with electrolytic surveys upon piping systems, etc., as a specialty.

Charles A. Moore, of Manning, Maxwell & Moore, has resigned from the directorate of the Niles-Bement-Pond Company.

The Civil Engineers' Club, of Cleveland, Ohio, celebrated its silver anniversary on March 13 by a banquet at which the souvenirs were booklets containing a history of the club, the menu being printed on silvered paper and used as a wrapper for the booklet. The portraits of all the club's presidents in the latter are excellent. The officers for the ensuing year are:—President, B. L. Green; vice-president, Dr. D. C. Miller; secretary, J. C. Beardsley; treasurer, A. G. McKee; librarian, E. B. Wright; directors, D. C. Kingman and C. H. Wright.

H. D. Critchfield, general counsel and sales manager for the Automatic Electric Company, Chicago, returned to his desk on March 28, after a long and serious siege of illness. Mr. Critchfield was attacked by appendicitis in January and was operated on at the Chicago Hospital on February 1. While convalescing he was seized with pneumonia, from which he has just recovered.

Guglielmo Marconi and his bride arrived at New York on Saturday, April 1, on their honeymoon trip, six weeks of which they will spend in the United States and Canada. Mrs. Marconi is the fifth daughter of Lady Inchiquin, and was a popular débutante in London's society. The wedding, which occurred in London on March 16, was a notable social event.

Gardiner C. Sims has become the general manager of the Marine Engine & Machine Company, of Harrison, N. J., and 80 Broadway, New York. The company will build Armington & Sims engines, in addition to its other products, to meet the requirements of the market. The original and constituent characteristics of the Armington & Sims design are still the fundamental features of the engine, which has been steadily improved in detail as necessitated by modern steam practice since the introduction of the engine in 1872. The present patterns are all new, having been reproduced and perfected by Mr. Sims since the cessation of his service during the Spanish-American war. Mr. Sims is widely and favorably known in the electrical field, where his good pioneer work did so much to insure the success of incandescent lighting 25 years ago.

The Allis-Chalmers Company, of Milwaukee, Wis., U. S. A., will be represented hereafter in West Australia by F. R. Perrot, and in New Zealand by the firm of John Chambers & Son, Ltd. Mr. Perrot's headquarters are at Perth, West Australia, and those of John Chambers & Son, Ltd., are at Auckland.

William J. Clark has been elected president of the Perforated Music Roll Company, New York City. Mr. Clark, who is the well-known manager of the General Electric Company's foreign department, has had a most remarkable career. He was born in Derby, Conn., in 1855. From 1879 to 1887 he was postmaster at Birmingham, Conn. During this time his exceptional ability was so recognized that he was frequently called upon by the Postoffice Department to act as postoffice inspector. In this capacity he made many important investigations, among them the Star Route frauds, frauds in the Brooklyn postoffice, the famous mail robbery of the Chicago & St. Louis postoffice route in 1886, the Jersey City postoffice burglary and a number of other cases of a similar character. An evidence of his energy and cleverness in this service is shown by the fact that in running down over one hundred criminals, only three failed of conviction. In 1886 Mr. Clark began his street railway career by securing a charter to build a street railway connecting An-

WILLIAM J. CLARK

sonia, Derby and Birmingham, Conn. The following year he contracted with the Vandepoele Electric Company for the equipment of this line, the first of its kind in New England. This enterprise suggested the reorganization of the Vandepoele Company, and negotiations were conducted, culminating in the sale of the Vandepoele patents to the Thomson-Houston Company. Mr. Clark became connected with this concern in 1888 as general agent of the railway department. He remained in this position until the General Electric Company was formed by the consolidation of the Thomson-Houston and Edison General Electric companies in 1892, subsequently becoming general manager of the railway department. In the early nineties he effected a reorganization of the British Thomson-Houston Company. He held the title of managing director of this corporation until the completion of his work, when he returned to the United States. Mr. Clark's connection with the Perforated Music Roll Company will not alter in any way his present relations with the General Electric Company.

J. H. Hallberg has resigned his position as general superintendent of the electrical department of the Cincinnati Gas & Electric Company and has established an office at 45 Broadway, New York, as practical consulting electrical engineer and arc lighting expert. He has also accepted an appointment to the New York City Electric Lighting Commission, with which he will act in a general advisory capacity.

Arthur Williams, of the New York Edison Company, whose report on sign and decorative lighting attracted so much favorable notice at the last two conventions of the National Electric Light Association, has been appointed by President Davis to report on "Municipal Ownership" at the twenty-eighth convention, to be held at Denver-Colorado Springs, June 6-11. Mr. Williams has already collected a large amount of data regarding the management and operation of municipal plants, both in this country and abroad, and with his usual skill and thoroughness will make this report most complete and interesting. It will be a valuable addition to the literature on this subject already possessed by the association.

Chas. D. Knight has been appointed chief engineer of the American Electric & Controller Company, of No. 12 Dey street, New York City. Mr. Knight was formerly connected with the engineering departments of the General Electric Company, of Schenectady; the National Electric Company, of Milwaukee, and the Cutler-Hammer Manufacturing Company of the same place. Under his supervision the American Electric & Controller Company will manufacture a complete line of alternating and direct-current controllers, starters, automatic switches, solenoids, etc.

A. C. Bunker and W. C. Appleton, alternating current engineers, have become associated with the Crocker-Wheeler Company, Ampere, N. J., in the engineering and contract departments, respectively. Since the company took up the manufacture of alternating-current machinery, eight months ago, its activities in this field have rapidly increased and have necessitated a corresponding development in the engineering force. Mr. Bunker has been connected with the Stanley Electric Manufacturing Company on the Pacific Coast. Mr. Appleton has acted as engineering salesman for the General Electric Company in the Atlanta territory.

Frank W. Frueauff, of Denver, when recently in New York stated that the railroad people had been making an extensive canvass among possible delegates for the Denver-Colorado Springs convention of the National Electric Light Association. They report their belief that at least 3500 will be in attendance. This may be a bit optimistic, but there seems to be no question that the meeting will break all previous records in point of attendance as well as in point of general attractiveness.

LaRue Vredenburgh, who so ably handled the subject of advertising in his report presented at the Boston convention of the National Electric Light Association, will this year make a report on "The Commercial Side of Sign and Decorative Lighting," which will be presented at the Denver-Colorado Springs convention, to be held June 6-11. This is a subject of great interest to all the members of the association, and Mr. Vredenburgh's skill and experience will enable him to handle it in a most satisfactory and interesting manner.

Percival E. Fansler has joined the forces of Messrs. J. G. White & Co., of New York, as private secretary to Mr. White. Mr. Fansler graduated from Purdue University in 1901 with degree of B. S., and took up post graduate work, receiving the E. E. degree in 1903. He was appointed chief clerk of the Department of Electricity at the St. Louis Exposition in June, 1902, and in this position had charge of many of the details in connection with the department's work before, during and after the Exposition.

Obituary

Commodore C. C. Warren, founder of the Warren Electric Manufacturing Company, of Sandusky, Ohio, died on March 22. Commodore Warren was born in 1835 and started his business career as a merchant in a small town in Michigan. Later he became a bank clerk, finally going to Toledo, where he established the C. C. Warren Spice Company, which later became the Woolson Spice Company. While there he became interested in electrical work and engineering and devised the new form of electrical gen-

THE LATE COM. C. C. WARREN

erator, for the manufacture of which he established the present Warren Electric Manufacturing Company. Since that time the capacity of the plant has many times increased.

Henry Norcross Munn, editor of the "Scientific American," died suddenly on March 10 at his home, 281 Lexington avenue, New York. Mr. Munn was the son of Orson Desaix Munn and Julia Augusta Allen Munn. His wife was Anne E. Elder, and he leaves two children, Miss Augusta Munn and Orson Desaix Munn. Mr. Munn was a member of the firm of Munn & Co., of which his father was president, publishers of the "Scientific American," and the largest patent solicitors in the country. He was a member of the Union Club, New England Society, Riding and Driving Club, Essex County Club, New York Zoological Society and the Society of Colonial Wars. The funeral took place March 13.

Trade News

The Abner Doble Company, of San Francisco, reports a substantial and increasing business in tangential water wheels, particularly in large units, the percentage increase in horse-power of wheels sold by the company in 1904 over 1903 being 116 per cent. Among orders recently taken are the following:—For the Electra plant of the Standard Electric System the company is now building three 7500-H. P. Doble water wheels, each of the same general design and capacity as the Doble wheel installed during the last year in the de Sabla plant of the California Gas & Electric Corporation, and which has repeatedly developed 8000 H. P. on overload. One of the large Electra units will operate under a 1250-foot head at 400 revolutions per minute, the water being delivered through a 7-inch nozzle. The other two 7500-H. P. wheels will be directly connected to one 4000-K. W. generator, forming a double unit for utilizing water from two separate sources under different heads. The design of this unit is an unusual one, inasmuch as each wheel has sufficient capacity to drive the generator at full load. One of the wheels will be driven by a 6-inch jet under a head of 1465 feet, the water being taken directly from the main gravity conduit. The other wheel is to be driven by a 7-inch jet under a head of 1250 feet, the source of supply being a large reservoir at the end of the main conduit. This arrangement permits the operation of the generator at full load by running either wheel at its full capacity or by running both wheels under partial load, according to the conditions of the water supply. These operating conditions are made possible by the use of Doble needle regulating nozzles, which regulate the quantity of water delivered to each wheel. The speed of all three Electra wheels is unusually high, considering the size of the machines, but is permitted by the use of specially designed Doble bearings, similar to those so successfully introduced in the large de Sabla wheel. Each of the three Electra wheels will be operated from a Doble needle regulating and deflecting nozzle, the deflecting element in each case being controlled by a suitable hydraulic governor. A 200-H. P. Doble exciter wheel to operate under a head of 1465 feet at 720 revolutions per minute will also be furnished for the Electra plant.

Two 800-H. P. Doble main unit wheels and two 40-H. P. Doble exciter wheels have been built for the new Santa Ana No. 2 plant of the Edison Electric Company, of Los Angeles. These wheels will operate under a head of 305 feet, the speed of the 800-H. P. wheels being 176 revolutions per minute. Two 75-H. P. Doble exciter wheels have been built for the Pike's Peak Hydro-Electric Company, of Colorado, to operate at a speed of 975 revolutions per minute under a head of 2100 feet, the highest in the United States. A 300-H. P. double Doble wheel, equipped with two Doble needle regulating nozzles, has been ordered by the Hilo Electric Light Company, of Hawaii. For the Nevada City plant of the California Gas & Electric Corporation, three 570-H. P. Doble wheels have been supplied to operate under a head of 190 feet. The California Fish Commission ordered a Doble wheel to work under the low head of 23 feet. The Braden Copper Company, of Chile, has ordered four 340-H. P. Doble wheels for operation under 930 feet head, three for belt drive and one for direct connection to an electric generator. Doble 12-inch laboratory water motors have been built for the University of Illinois and the University of Texas. An interesting order recently received calls for a complete sawmill outfit to be installed in the Philippine Islands, the machinery to consist of a Doble water wheel operating under 400 feet head and directly connected to the mill. The order included the sawmill as well as the riveted steel pipe for the pipe line.

The South Side Elevated Railway Company, of Chicago, has contracted with the Westinghouse Electric & Manufacturing Company for complete equipments for seventy cars, which include 140 75-H. P. motors and multiple-control apparatus. The motors are of special design and are in line with the re-equipment of this system. The cars will be operated in trains of five, three of which will be motor cars. Orders recently placed by the Philadelphia Rapid Transit Company and the United Electric Light Company, of Springfield, Mass., are evidence that steam turbines and turbine generators are all that is claimed for them by the manufacturers. Both of these companies have been operating units of this type, and as soon as they can be built the former will install two 1500-K. W., 13,200-volt, turbine-driven generators, and the latter company a 1000-K. W. unit of the same type. A large shipment will be made to Mexico through G. & O. Braniff & Company, agents for the Westinghouse Company in Mexico. One order is for seventy-two machines, ranging in output from ¼ to 30 H. P. The Phillipsburg Gas, Light, Heat & Power Company will increase its station capacity by the addition of a 300-K. W. generator, a motor-generator set consisting of a 300-H. P. motor and a 200-K. W. generator, and two direct-current machines of smaller size. Four 75-K. W. 2200-volt transformers, lightning arresters, choke coils, regulating transformers, switchboard and arc lamps are also included in the order.

The Westinghouse Electric & Manufacturing Company are building for the People's Power Company, of Moline, Ill., two engine-type generators to be installed in their power station. The company is an old one in that section of the country, and has built up an extensive business in lighting and power work. The addition to their present equipment will be a 1100-K. W., two-phase alternator of the revolving-field type, operating at 2400 and 4800 volts, and a 600-K. W., 600-volt, direct-current machine. The alternating-current generator is a duplicate of a machine which the company put into service about a year ago. An order for three 300-K. W. alternating-current generators has also been placed with the Westinghouse Company by the Barber Lumber Company, of Boise, Idaho. These machines will generate current at 440 volts, which will be transformed to 23,000 volts for transmission. The necessary transformers, switchboards and lightning arresters are included in the apparatus to be furnished. Still another order, from the Mammoth Copper Mining Company, of Salt Lake City, is for a large addition to their electrical equipment. A total of nearly 800 horse-power in induction motors of different sizes, together with a motor-generator set, transformers, switchboard and three mining locomotives, is included in the order. The motors, two of which have a rated capacity of 200 H. P. each, and five of 50 H. P. each, will operate on three-phase, 2000-volt circuits. Electrical machinery is used very extensively in mining operations, and this order is merely indicative of the progress being made in this field.

The number of orders received by the Westinghouse companies for steam turbines and turbo-generators is convincing evidence of the firm belief which engineers place in this class of apparatus as a source of power. Many units have been installed, some of which have been in successful daily operation for years. This type of apparatus is installed in many places where it becomes necessary to increase the output of the station, and where it is not possible to increase the floor space. Three of these outfits have recently been ordered by the

Public Service Corporation of New Jersey, one having an output of 500 K. W. and two with ratings of 1000 K. W. each. The Truckee River General Electric Company, a large power-distributing company of California, operating many high potential lines, will add a 2000-K. W. alternating-current belt-driven generator. four 750-K. W. and four 625-K. W. transformers to their present equipment. Westinghouse low-equivalent lightning arresters and choke coils are being used for the protection of apparatus and more will be added.

The Allis-Chalmers Company is removing its general offices from Chicago to Milwaukee. This is another step in the direction of carrying out the plans of the present administration, which are gradually being brought to completion. One of the first conclusions arrived at by President B. H. Warren, after assuming office a year ago, was that for every reason connected with efficient administration of all branches of the work, from designing to manufacturing, and from selling to collecting and accounting, the chief offices of the company, covering all the ramifications of its business, should be concentrated in one place. That place was logically Milwaukee, because, although the company has four other works in three other cities, the largest works are in Milwaukee, and Milwaukee is where all the future expansion of the company's operations will take place. Besides, at the Milwaukee suburb of West Allis it has the land to build upon. Instead of being handled at long range as under the old system, the several departments will all be concentrated in one place, thus eliminating the necessity for constant traveling to and fro, effecting a great saving in time and expense, an enormous reduction in correspondence and, above all, the quickening of all movements of production. Plans for the workshop extensions at West Allis, which involve the construction of several more units, are practically complete and the extensions will be made in due course.

The Hecker-Jones-Jewell Milling Company, of New York City, is having constructed by the Allis-Chalmers Company, at the latter's West Allis shops, three vertical cross-compound Reynolds-Corliss engines, two arranged for rope drives and one for direct connection to a 425-K. W., 60-cycle, three-phase alternating-current Bullock generator, which is to be furnished by the Allis-Chalmers Company from its Cincinnati works. The high-pressure cylinders of the engines will measure, respectively, 30, 24 and 18 inches in diameter, and the low-pressure cylinders 64, 50 and 38 inches. Two will have a stroke of 48 inches and that of the smallest one will be 38 inches. The aggregate horse-power to be developed under normal steady load conditions is 3250. A direct-connected engine-driven exciter, switchboard, traveling crane and other machinery are included in the contract.

A. F. Gallum & Co. report that the new vertical cross-compound condensing engine built for them by the Allis-Chalmers Company for their tannery at Milwaukee is giving excellent satisfaction, having been in operation for some weeks. This engine, which has cylinders of 14 and 28 inches diameter and a 24-inch stroke, forms the driver of a 200-K. W. power unit, being direct connected to a Bullock generator, which was furnished at the same time by the Allis-Chalmers Company from its electric works at Cincinnati. Owing to the limited amount of floor space which could be alloted to the machinery, it was built in the most compact form possible. The engine occupies an area 19 feet long and 12 feet wide. Its capacity under normal load conditions is 275 H. P., but it is capable of producing 500 H. P., and it is now being operated at a speed of 150 revolutions to the minute.

The Wellman-Seaver-Morgan Company, with main office and works at Cleveland, Ohio, announces that Geo. B. Damon, who has been manager of their New York office, has been transferred to an important position in connection with the engineering and sales department at Cleveland, Ohio, and that W. A. Stadelman, for the past ten years manager of the Eastern office of the Brown Hoisting Machinery Company, has become the manager of the general Eastern office of the Wellman-Seaver-Morgan Company, with offices at 42 Broadway, New York City. All inquiries and matters requiring attention, convenient to the New York office of the Wellman-Seaver-Morgan Company, will have Mr. Stadelman's personal attention.

Growing business has prompted the Alberger Condenser Company, of New York, to open a branch office in Chicago, in the Home Insurance Building, 205 La Salle street.

At the annual stockholders' meeting of the Pittsburg Feed Water Heater Company, of Pittsburg, the following directors and officers were elected:—James Bonar, president; J. E. Schlieper, treasurer, and Joseph Cawley, secretary. The company reports business in its different types of heaters as being good at the present time.

The Dodge Coal Storage Company has acquired the business of the United Telpherage Company, of New York. Communications intended for the latter company should be addressed to "The United Telpherage Department" of the Dodge Coal Storage Company, 49 Dey street, New York.

The Standard Underground Cable Company, of Pittsburg, announce that on account of the general growth of their business on the Pacific Coast, they have decided to discontinue all agency arrangements for the sale of their products, and have opened their new offices in the Rialto Building, San Francisco, with A. B. Saurman as manager for the Pacific Coast territory. This includes Washington, Oregon, Idaho, California, Nevada, Arizona, British Columbia, Alaska and the Hawaiian Islands. Mr. Saurman has, in turn, been connected with the Standard Underground Cable Company in both construction and sales departments at Philadelphia and New York, and was later for several years manager of the Boston office. For the past two years his position has been that of manager of the Pacific Coast sales department. The Standard Underground Cable Company expects to make early announcements of location and personnel of sub-sales offices at Los Angeles and Portland. They also report that their factory at Oakland, Cal. (the only factory west of the Mississippi equipped with lead presses for cable work) has been unusually busy during the past six months, and that the future on the Pacific Coast points to its continued activity.

New Catalogues

A bulletin recently sent out by the Electric Storage Battery Company, of Philadelphia, Pa., describes the storage-battery installation in a sub-station of the Edison Electric Company, of Los Angeles, Cal. Illustrations are given of one of the batteries, the motor-driven end-cell switches and the switchboard, together with a diagram of the load curve.

Motors for crane, hoisting and similar service are illustrated and described in a new catalogue issued by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. Controllers are also shown, and diagrams of connections are given with characteristic curves of the various sizes. Another catalogue is devoted to direct-current bipolar motors, ranging in size from 1-6 to $1\frac{3}{4}$ H. P. "Wattmeters and How to Read

Them" is the title of a booklet also sent out by the company. The instructions are for users of electricity unfamiliar with the workings of electric meters, the meaning of kilowatt-hour being explained with the construction and action of the instrument. The booklet also contains illustrations of Sawyer-Man incandescent lamps and bases.

The National Electric Company, of Milwaukee, is sending out two cards, one bearing the illustration of two 1000-K. W. rotaries installed for the Milwaukee Light, Heat & Traction Company, and the other a car for the "Lima Limited" service of the Dayton & Troy Electric Railway.

A circular issued by the Rochester Electric Motor Company, of Rochester, N. Y., illustrates and describes motor-driven fans. A table of sizes is given, showing the horse-power, speed and cubic feet of air per minute.

A new bulletin sent out by Dodge & Day, of Philadelphia, illustrates and describes the changes made by this firm as engineers for the Jeanesville Iron Works Company, of Hazleton, Pa. The illustrations show the old and the new plants, the partially equipped engine-room, the new foundry, the new machine shop and other parts of this "modernized" plant.

Messrs. Queen & Co., of Philadelphia, are sending out a new circular devoted to condensers and self-induction apparatus. It shows a wide variety of condensers, from the most elaborate standards down to the small tin case condensers used extensively in telephone work. Standards of self-induction, both fixed and variable types, are illustrated and described. Curves are also given, showing the absorption and leakage of their standards.

A new catalogue of the DeLaval Steam Turbine Company, of Trenton, N. J., deals with centrifugal pumps. These are illustrated and described in detail, views being given of turbine and electric motor-driven machines. Results of tests by J. E. Denton and William Kent are given. The pamphlet also illustrates a turbine-driven blower, a direct-current generator and an alternator.

Centrifugal pumping machinery is illustrated and described in a new catalogue recently issued by the Morris Machine Works, of Baldwinsville, N. Y., builders of centrifugal pumping machinery and stationary and marine engines. The various types are shown arranged for belt-drive or direct-connected to steam engines, several sizes also being shown direct-connected to electric motors. A pair of 48-inch dredging pumps, the largest ever built for such service, are also illustrated. Several sizes of vertical stationary and marine engines are illustrated, tables of dimensions being also given.

"Church Lighting by Electricity" is the title of a pamphlet just from the press and issued by the Nernst Lamp Company, of Pittsburg. It is profusely and attractively illustrated and supplies excellent evidence of the fact that for such service, as well as other kinds of lighting, the Nernst lamp is rapidly coming into favor.

Direct-current motors for a variety of light work are illustrated and described in a new pamphlet sent out by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. They are of the bipolar type and range in size from 1-6 to $1\frac{3}{4}$ H. P. Another pamphlet sent out by the company is devoted to induction motors. The type illustrated differs from the original in that the element of speed variation by means of secondary resistance has been added.

A catalogue recently sent out by the Weber Gas & Gasoline Engine Company, of Kansas City, Mo., illustrates and describes suction gas plants and gas engines. Vertical cross sections of the latter are given and plans and elevations show the arrangement of the entire plant. Tables show the heating value of various fuels and afford a comparison of the costs of fuel for steam, oil and gas engines and of current for electric motors.

A new catalogue with the title "The Insulator Book" has been issued by the Locke Insulator Manufacturing Company, of Victor, N. Y. It includes a brief description of the company's laboratory for testing high-potential insulators and the methods of testing the various types illustrated. A recent development by the company is a line of high-tension trolley strain insulators, one of which is illustrated and described elsewhere in this issue. The list includes wall insulators, bushings for floor and other uses, high-tension cable and telephone insulators, and a number of forms of pins and brackets.

A story is told of a German in one of the Northwestern States who, after having some frozen water pipes thawed out, demurred at the charge. The manager of the company, who was present at the operation, turned to his assistants and said: : "Reverse those connections and freeze him up again." The bill was paid.

The Belgian Congo Telegraph

THE telegraph and telephone lines of the Belgian Congo region, says "The Scientific American," show some peculiarities both in the construction of the lines and their operation, owing to the climate and the character of the country. Where the lines run through the forests, the wires are placed as much as possible upon trees, and in other cases upon iron poles. The wire, which is of phosphor-bronze, is painted black, so as not to attract the attention of the natives. who lay hands upon all the copper they can find. The other brilliant objects of the line, such as the insulators, are also painted black.

A cutting 30 feet wide is made through the forest for the line, so that there is no risk of fire or from falling trees. Besides the telegraph offices of Leopoldville, Kwamouth and Coquithatville, there are nine telephone offices and six cabins. The latter are used for communicating with the steamboats on the river. The first hours after sunset are the best for telephoning, and it is possible to telephone direct from Matada to Kwamouth, or 380 miles. From the latter point to Boma, or 410 miles, the voice is still heard.

After 10 o'clock A. M. the heat makes it impossible to use the telephone, especially in the rainy season. This is due to the fact that a return wire is not used, and the use of the earth return is accompanied by great disturbances in the middle of the day. The greatest enemies of the telephone lines are the wild animals. In the rainy season atmospheric discharges often strike the wires, therefore the lines need to be constantly inspected and repaired. Within the last two years the government has been experimenting with a wireless telegraphy system between Boma and Ambrizette to connect the land lines with the submarine cable.

A course in chemical engineering, leading to the degree of chemical engineer, has been established at Columbia University, to go into operation at the beginning of the next academic year.

The data asked for by the National Electric Light Association, to be used for the annual revision of its "Municipal Lighting Statistics," are being returned this year with unusual promptness. This is one of the most useful publications of the association, and every year shows a growing disposition on the part of electric light companies to do their share toward keeping it accurate and up to date.

Cost of Niagara Electric Power Transmission

By ALTON D. ADAMS

ELECTRIC plants with an aggregate capacity of more than one-half a million horse-power are now completed or under construction at Niagara Falls, and only a small fraction of their possible output can be used locally.

The cost of transmitting large units of this power to distant cities must thus have a very important bearing on the problem of obtaining loads for these plants. Some of the generators at these plants develop energy at about 2200 and others at 12,000 volts, so that for any transmission of even moderate length, step-up transformers must be used, with the large power units here involved. With even as low a pressure as 12,000 volts, step-down transformers are usually required, so that the cost of terminal apparatus at both ends of a line will be nearly constant without regard to its length. It thus appears that the cost of the line itself is the uncertain factor that must determine whether a long transmission of Niagara power can be made to pay.

The transmission line is divisible into two distinct parts, the right of way, poles and insulators, which vary in total cost substantially with the line length, and the conductors, whose cost may vary in either of several ways with the voltage and distance. On the one hand, there is the well-known law that the weight of conductors in an electric circuit varies directly with the square of its length, all other factors remaining constant. This law tells us that for a given power, loss and voltage, the weight and cost of line conductors between Niagara Falls and a place 161 miles distant, or seven times the length of the older line to Buffalo, would require 49 times as much copper.

If the other law, that the power, loss and weight of conductors remain constant, provided that the voltage is increased directly with the distance, is used as a basis in the design of the longer line, impracticable results are reached at once. Each of the two 23-mile circuits between Niagara Falls and Buffalo is composed of three copper cables with a cross section of 350,000 circular mils, and is designed to transmit 7500 kilowatts at 22,000 volts with a loss of about 6 per cent.

If the length of one of these circuits is multiplied by 7, and its weight remains constant, the cross section of each conductor shrinks to only 50,000 circular mils, a size too small for the necessary mechanical strength, and too unreliable for so great a power. In order to hold the weight of conductors constant for this greater distance, with the same power and loss, the voltage must be multiplied by 7, thus raising it to 154,000, a figure nearly three times the highest pressure in actual use for electric transmission. An increase of the transmission distance to even 100 miles from the falls, if the voltage is held at 956 per mile of line, so as to keep the weight of conductors constant, will carry the pressure up to 95,600 volts, on the basis of the earlier Niagara Falls and Buffalo circuits. The rule of constant voltage thus leads to a prohibitive weight of conductors, and the rule of constant weight of conductors leads to a prohibitive voltage, at no great distance.

Somewhere between these two extremes must be found the practical rule for the increase of voltage and weight of conductors, as Niagara power is transmitted to greater distances. Just what this rule should be depends on so many factors that it is perhaps incapable of conclusive proof, but a working rule that can well be applied in many cases, and that corresponds with much of present transmission practice, may be suggested. This is that the voltage be varied with the square root of the distance.

With this rule as a basis, some suitable voltage may be taken as the minimum to be used on short transmissions, and then for longer transmissions the voltage may be increased with the square root of the distance, the power, loss and size of conductors remaining constant. Just what the minimum transmission voltage should be, and what should be the greatest length of line to which it is applied, admit of some difference of opinion, but the third transmission circuit between Niagara Falls and Buffalo may be taken provisionally as a basis.

This circuit is about 20 miles long, carries current at 22,000 volts, like the two older circuits, and is designed for the same loss of about 6 per cent. when transmitting 7500 kilowatts. Like the other two, this circuit is three-phase, but, unlike them, it is composed of aluminium conductors. Each of these conductors is a cable of 500,000 circular mils cross section, and is thus equivalent in conductivity to a copper wire of 300,000 circular mils.

With this Niagara Falls and Buffalo circuit, 20 miles long and operating at 22,000 volts and 7500 kilowatts, as a basis, an equal power may be transmitted to any distance at the same loss with wires of 300,000 circular mils, if the voltage is carried up with the square root of the line length. It may be shown at once that this rate of increase of voltage will not carry it beyond the limits of present practice until a very long transmission is reached.

If 60,000 volts be taken as the limit of present practice in the operating pressure of transmission lines, this limit is 2.72 times the voltage on the circuits between Niagara Falls and Buffalo. As the square root of 20 is approximately 4.5, the distance to which a three-phase circuit carrying 7500 kilowatts at 60,000 volts may be run with copper conductors of 300,000 circular mils cross section, without exceeding the loss on the Niagara line, is represented by $(4.5 \times 2.72)^2$, or substantially 150 miles. The application of this rule evidently brings the weight and cost of conductors, like the cost of insulators, pins, cross-arms, poles and right of way into direct proportion with the length of line if the loss remains constant.

A copper conductor of 300,000 circular mils section has a weight of 912 pounds per 1000 feet, or of 5016 pounds per mile of line, if the length of conductor per mile is taken at 5500 feet, to allow for sag. The three conductors of a three-phase circuit will thus weigh 15,048 pounds per mile of line, and at 15 cents per pound will cost $2,257.20. On the basis above considered, the investment in conductors increases directly with the length of line, and for a transmission of 7500 kilowatts on a line 150 miles long, with a loss equal to that on the circuits between Niagara Falls and Buffalo, the cost of conductors would reach $338,580.

Cross-arms and poles for the 10,000-horse-power or 7500-kilowatt circuit will vary somewhat in their cost with the use of one or two circuits per pole line. The older pole line between Niagara Falls and Buffalo carries both of the earlier circuits, and the second pole line, though it now has but one circuit, is designed for two. It is, as a rule, more desirable, however, to erect only one circuit per pole line in high-voltage transmission. Expense is by no means doubled by the use of only one circuit instead of two per line of poles, for the reason that with two circuits per pole line the poles must be larger and closer together, two cross-arms are required instead of one, and each of these must be larger and longer than would be necessary with one circuit per pole line. Insulators, pins, cross-arms and poles for a single circuit to transmit 7500 kilowatts at 60,000 volts will cost approximately $700 per mile, including the labor of erecting the conductors thereon.

Right of way is subject to greater cost variation than any other element of a transmission line, as it ranges from nothing to more than $1000 per mile, but $300 per mile of single line are sufficient to cover a wide range of cases. This latter sum brings the cost of pole line complete, including the erection of conductors, but not including the conductors themselves, up to $1000 per mile. This figure is for 35-foot poles set in gravel, sand or clay soil on open private land that is chiefly valuable for grazing or farming. If the land carries timber that must be cut away, or if holes for the poles must be cut in rock, the cost of right of way may be much greater than that just indicated. If, on the other hand, the pole line is located on a highway, the cost of securing a franchise may be more or less than $300 a mile.

According to the above estimate, the complete cost of the transmission line for 7500 kilowatts at 60,000 volts is $3257 per mile, or $488,580 for a line 150 miles long, using cables of the same conductivity per mile as those on the 20-mile circuit between Niagara Falls and Buffalo. It is to be held in mind also that the loss in this 150-mile line is the same as that in the 20-mile circuit to Buffalo.

The important question now is how much the investment in transmission line will add to the cost of energy per kilowatt-hour. As the line has been designed for a constant cost per mile regardless of its length, and as the loss is also constant, the cost of transmission per kilowatt-hour may be determined at so much per mile.

Before the figures for this cost can be reached, however, the number of kilowatt-hours to be delivered per year must be known. Here substantial aid can be drawn from the records of the transmission between Niagara Falls and Buffalo. During a very recent year the three circuits, already described, that connect the power houses at Niagara Falls with the terminal house in Buffalo, delivered 64,901,080 kilowatt-hours at the latter city, and the maximum load delivered by these three lines during the same year was 23,000 kilowatts. At the period of this maximum load, in December, the three transmission circuits were thus loaded, on an average, to a point just above the capacity for which they were designed.

If during the 8760 hours of the year in question the constant and uniform load carried at Buffalo by all three transmission circuits had been 7500 kilowatts, the total energy delivered would have amounted to 65,700,000 kilowatt-hours, or almost exactly the volume of energy that was in fact received at Buffalo in that year. From this it follows that the average load on each of these three circuits during the entire year was 2500 kilowatts, or one-third of its calculated capacity at the maximum percentage of loss for which it was designed. Here, then, is a concrete demonstration that a transmission line between a water-power plant and a large, distant city may, under favorable conditions, be operated continuously on an average with one-third of its full rated load.

Since a transmission line designed for a maximum of 7500 kilowatts may deliver substantially 22,000,000 kilowatt-hours per year, that cost of transmission which depends on investment in the line may be readily determined. As found above, the investment in a transmission line of 7500 kilowatts capacity with conductors equivalent to those on the 20-mile circuit between Niagara Falls and Buffalo, requires an investment of about $32.57 per mile. On such a line an annual allowance of 10 per cent. of its first cost to cover maintenance, interest and depreciation may fairly be made. This percentage on the investment per mile of line amounts to $325.70, and if the delivered energy amounts to 22,000,000 kilowatt-hours during the year, this investment charge per kilowatt-hour is 0.0015 cent.

As the size of conductors remains constant whatever the length of the transmission, the sum of the investment charges increases merely as that length. For a transmission 100 miles long the line charge rises to 0.15 cent per kilowatt-hour, if 22,000,000 kilowatt-hours are delivered during the year, and at 150 miles the line charge is 0.225 cent per kilowatt-hour. On the 100-mile line, allowing the voltage to increase as the square root of the distance, from 20 miles and 22,000 volts as a base, the pressure would be 48,800 volts. Evidently the item of 0.15 cent per kilowatt-hour for charges on line investment with a transmission of 100 miles, or 0.225 cent per kilowatt-hour for a 150-mile transmission, is not a serious impediment to the delivery of large amounts of energy over long distances.

As the cost of conductors alone on each of these lines was found to be $2257 per mile, the annual charges against these conductors for maintenance, depreciation and interest, if taken at 8 per cent, amount to $180 per mile, or to 0.0008 cent per kilowatt-hour for each mile of line, if 22,000,000 kilowatt-hours are delivered during the year. On the 100-mile line this charge against conductors alone would reach 0.08 cent, and on the 150-mile line 0.12 cent per kilowatt-hour.

Thus far the only method that has been considered for the limitation of the size and weight of conductors is that of raising the line voltage, and it has been shown that if the voltage rises faster than the square root of line length, starting with the Niagara case as a basis, the present limits of working pressures are soon passed. Another expedient remains, however, namely, that of increasing the percentage of loss in the conductors with the length of line. There is good reason for the increase of line loss with its length, for the charges on investment in the line necessarily grow with the length, and some increase in the loss of energy will amount to less than the charges on investment that would otherwise be necessary. When considering the cost of energy lost in a transmission line, it is important to remember that the average percentage of loss on all of the energy transmitted is much less than the maximum percentage of loss for which the line is designed.

This is due to the fact that the average load on the line is much less than the maximum load, and to the further fact that the energy loss in conductors varies as the square of the load, and the percentage of loss varies directly with the load. Thus, when the load on a line drops to one-half of the maximum, the loss of energy in the conductors sinks to one-fourth of its amount at maximum load and the percentage of loss is one-half of its full amount. It is by no means safe to assume from this that the average loss is to the maximum loss as is the average load to the maximum load, for it is possible with a low average load to have most of the energy delivered when the load is near its maximum.

Taking one case with another, however, it is a fair approximation to say that the average percentage of loss in a transmission line is about one-half of the percentage at maximum load. Assuming this statement as to loss to hold true of the transmission line between Niagara Falls and Buffalo, the average loss in the conductors is only 3 per cent., and this would also be true of a line 150 miles long with the same size of conductors, if the voltage was increased with the square root of the distance, as above indicated.

For this 150-mile transmission the annual charge of 8 per cent. on the investment in conductors was found to amount to 0.12 cent per kilowatt-hour. By an increase of the maximum loss to 12 per cent. on the 150-mile line, the size of each copper conductor will be reduced from 300,000 to 150,000 circular mils, the total weight of copper will be reduced one-half, and the annual charge against conductors will be only 0.06 cent for each of the 22,000,000 kilowatt-hours delivered during a year. With this reduction in the size of conductors the average percentage of loss will probably be about 6 per cent.

The loss of 12 per cent. at maximum load brings the cost of conductors down to $1128 per mile of line and the total cost of line per mile to $2128. On this basis the total cost of the 150-mile line reaches $319,200, and the annual charges against it at 10 per cent. amount to 0.14 cent per kilowatt-hour. All these figures make it very evident that an increase of voltage with the square root of the length and a moderate increase of line loss are sufficient to keep the cost of transmission lines within practicable limits over very long distances.

To sum up the more important points above:—An increase of voltage directly as line length soon carries it above the limits of present practice; an increase of voltage as the square root of line length assures a moderate cost of conductors with uniform loss on lines as long as any now in operation, and a constant cost per mile on lines of any length; if this increase of voltage is combined with some increase of line loss, present lengths of transmission may be much extended.

Electrical transmission for cotton mills, the electric motor drive and the removal of static electricity in spinning are among the electrical subjects to be discussed at the next meeting of the New England Cotton Manufacturers' Association, to be held at Boston, on Wednesday and Thursday, April 26 and 27.

Electrometallurgy of Iron and Steel

DISCUSSED BEFORE THE NEW YORK ELECTRICAL SOCIETY

A MEETING of the New York Electrical Society was held on March 15, 1905. President Frank J. Sprague was in the chair. Two comparatively short papers were presented at this meeting, one by Dr. E. F. Roeber on "Recent Developments in the Electrometallurgy of Iron and Steel." The other paper was by Dr. Paul L. T. Heroult, La Praz, France, on "Making and Refining Steel in the Electric Furnace."

Dr. Roeber's paper dealt chiefly with the manufacture of ferro-alloys in the electric furnace, especially those which, like ferro-titanium, require a higher temperature in their manufacture than is attainable in the blast furnace. The electric furnace also has the advantage that by its means a higher precentage alloy, of alloys like ferro-silicon, is obtainable than with the blast furnace. For example, in the electric furnace ferro-silicon is made with 75 per cent. silicon as against the alloy containing only 15 per cent. silicon obtainable with the blast furnace. The lecturer detailed at length the methods in use by different companies to produce alloys and metals free from carbon.

Dr. Roeber mentioned the work done in making absolutely pure iron on a large scale by electrolysis, samples of which iron were exhibited. This iron is much used and is of great utility where exceeding hardness and durability are concerned, as in the case of electrotyping where the form is used to run off large editions.

Dr. Heroult described the construction of his furnace in which two electrodes dipping into a slag on top of the molten metal are used, and through which the current passes from one electrode to the other. By varying the artificial slag, he is able to remove all the usual harmful impurities, such as phosphorus and sulphur. The cost of the whole treatment is small—below 50 cents per ton of steel if molten steel from the Bessemer converter or the open-hearth furnace is introduced into the electric furnace.

Messrs. J. T. Morehead, L. Ruhl, Drs. Leonard Waldo and C. A. Doremus took part in the discussion of the papers, and upon request, Dr. Heroult gave additional details of the operation of his furnace. A participant in the discussion made some calculations as to the amount of coal gas that was allowed to go to waste in the blast furnaces of the country. This amount, according to the figures presented, amounted to many billions of cubic feet of gas annually, more, he said, than the total amount used for illuminating purposes in the city of New York.

Other speakers pointed out that the escaping gas from blast furnaces was utilized in some parts of Europe.

After adjournment of the meeting those present inspected with much interest numerous specimens of alloys received from the Goldschmidt Thermit Company, the Roessler & Hasslacher Company and the Niagara Research Laboratories.

Electric Elevator Data

SOME useful electric elevator data are given in the March "Bulletin" of the New York Edison Company. They are based on tests made by the company with elevators in apartment hotel service to determine the cost of operation.

The number of miles per month traveled by various elevators under various conditions and the corresponding consumption of current per car-mile were carefully noted. From the data obtained, showing many conditions of operation, the following results may be taken as typical of elevators which are kept very busy:—

In one apartment hotel there are two passenger elevators, each having a capacity of 1600 pounds at a speed of 250 feet per minute, operated by a 20-H. P. motor; the height of the shaft is 316½ feet. There is also a freight elevator, with a capacity of 2250 pounds at a speed of 150 feet per minute, and operated by a 15-H. P. motor, the height of its shaft being 336 feet. The travel of the passenger elevators during a period of 31 days was 167.9 and 182.89 miles, respectively, and their consumption of current 338.8 and 368.8-K. W. hours, or a consumption per car-mile of 2.022 and 2.014-K. W. hours, respectively. The travel of the freight elevator during the same period was 32.5 miles; its consumption of current 73.2-K. W. hours, or a consumption of current of 2.25-K. W. hours per car-mile.

In another apartment hotel two passenger elevators were tested, each having a capacity of 2000 pounds at a speed of 150 feet per minute, and operated by a 10-H. P. motor. The length of the shaft of one was $254\frac{1}{2}$ feet, and that of the other, $218\frac{1}{2}$ feet; their mileage of travel during the month was 165.94 and 146.54 miles, their consumption of current 335.2 and 228.6-K. W. hours, respectively. The consumption of current of each per car-mile, therefore, averaged 2.02 and 1.55-K. W. hours.

Another passenger elevator in an apartment hotel, with a capacity of 1500 pounds, and a rate of speed 150 feet per minute, operated by a 10-H. P. motor, in a shaft 130 feet high, was tested. During a period of 32 days it traveled 106.25 miles, and its consumption of current was 254.6-K. W. hours, or 2.39-K. W. hours per car-mile. The following is a summary of these results:—

Capacity	Horse-power	Speed in Ft. per Min.	Height of Shaft in Ft.	Days Duration of Test	Miles Traveled During Test	K.W. Hrs. Consumed per Car Mile
1600	20	250	316.5	31	182.89	2.014
1600	20	250	316.5	31	167.9	2.02
2000	10	150	264.17	30	165.94	2.02
2000	10	150	218.5	31	146.54	1.55
1500	15	150	130.17	32	106.25	2.39

As would have been expected, this summary shows that the mileage and consumption of current per car-mile per month of an elevator depend largely upon its speed and the height of its shaft; the longer the shaft the greater the mileage; the greater the speed the larger the consumption of current. When the prospective consumption of an electric elevator is being estimated, therefore, comparisons with other buildings of totally different shape and character are fictitious.

The principal results to be deduced from these tests are that in apartment hotel service a busy elevator will travel from 50 to 80 miles per month for every 100 feet of shaft height, and consume approximately 2-K. W. hours per car-mile.

Another New Single-Phase Electric Railway

THE Bloomington, Pontiac & Joliet electric railway, which is equipped with the single-phase tracks and system of the General Electric Company, was put in operation on March 13 with a single car running between Pontiac and Odell, in Illinois, a distance of 10.4 miles. It is intended to operate the whole line as far as Dwight at 3000 volts without any feeders by simply connecting the power station at one end to two No. 2-0 trolley wires, with which the road is equipped. The cars are equipped with four 75-H. P., 25-cycle, series-compensated motors. Unlike the cars on the Schenectady-Ballston line, described recently in these pages, which operate on both direct and alternating current, the cars are equipped for alternating supply alone and with a method of control which varies the speed by varying the potential by means of a transformer.

Hydro-Electric Power at Greenfield, Mass.

THE town of Greenfield, Mass., important as the center of the tap and die industry of the country, promises to become practically independent of steam as a source of power. The Greenfield Electric Light & Power Company has put into operation 1200 H. P. developed from a reservoir recently completed a few miles from the town. The company furnishes the town with its electric lighting and is now in a position to furnish power for manufacturing. It has adopted a policy, which may very well be followed by other places, of making a low rate for small users of power. Instead of the usual wide difference in price per horse-power according to the amount purchased by the consumer, a uniform rate of $40 per horse-power per annum has been set, so that even the small industry which requires only one or two horse-power can get it at this price, which is very low as compared to the usual price in other similarly situated New England cities and towns. No small consumer can develop power by his own engine at anywhere near such a figure; probably the cost would be twice that amount.

Already a number of the prominent manufacturers of Greenfield have installed motors to be operated by this power, including the Wells Brothers Company, F. E. Wells & Son Company, the E. F. Reece Company and the Automatic Machine Company. As the total steam power used in Greenfield is only between 500 and 600 horse-power, it will be seen that the Electric Light & Power Company has ample power at its new dam. It is believed that the presence of this cheap power will have a tendency to attract new industries to the town, and this is one of the reasons for establishing the uniform rate.

Electric Driving of Stamp Batteries

ON this subject L. Wilms, M.Inst. C.E., M.I.E.E., chief electrical engineer of the East Rand Proprietary Mines, lately read a paper at a meeting of the South African Association of Engineers, Johannesburg. Mr. Wilms pointed out that the main feature in the driving of stamp batteries by electric motors is the proposition of generating cheap power in the bulk by means of a large central electric station, in place of the various engine rooms and boiler houses scattered over a group of mines under the control of one parent company. The author described the two electrically-driven 220-stamp mills now in the course of construction at the Angelo and Cason, the precedents in this respect for the Rand. He further gave some figures and detailed statements carefully compiled to demonstrate the saving effected in attendance, amortization, interest and in the coal bill. Tables were presented giving the cost of various items, such as coal, water, oil and stores, repairs and maintenance, staff, the interest and amortization for stations with an output of 2000 K. W., 3000 K. W. and 5000 K. W.

A New Atlantic Cable

THE Commercial Cable Company of New York have recently received bids for the construction and laying of a new Atlantic cable. This will be the fifth Atlantic cable owned by the company. It has been made necessary by the growth of business and the demand for more rapid service, chiefly by members of the London and New York Stock Exchanges.

The new cable will be larger than any now in use, the copper weighing 600 pounds a mile, and the armor will also be heavier. The length of the cable will be about 2300 miles and the cost about $2,300,000. In view of the fact that, besides owning four other Atlantic cables, the company has a traffic agreement with the German-American Cable Company and controls the Commercial Pacific Cable Company, with a line between San Francisco, Honolulu and points in the Orient, it does not seem as though the company were apprehensive of serious competition by the wireless telegraph.

Two prizes amounting to $350 have been offered by The Engineering News Publishing Company, of New York, for the best two papers on "The Manufacture of Concrete Blocks and Their Use in Building Construction." This is a subject of great importance to all technical men and of which, on account of its newness, comparatively little is known. It is, therefore, believed that the competition will be of great benefit to the engineering and architectural professions by making public the results of experiment and research.

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Modern Methods of Telephone and Telegraph Line Construction

COINCIDENT with the development of the telephone and the telegraph have been various improvements in methods of line construction. The American Telephone & Telegraph Company, of New York, was the pioneer in heavy and up-to-date long-line work, and it gave an opportunity for its construction men to develop new methods in the building of its lines and in the handling of the very expensive hard-drawn copper wire which the company was the first to use extensively. Some of the devices thus developed are shown in the several illustrations in this article.

The first line built by the company called for twenty-four hard-drawn copper wires. It was found that this large number was difficult to handle under the old system, and the construction forces were compelled to resort to more modern ideas. Particular care has to be exercised in handling this wire, as a slight injury or kink will ultimately result in a break. Under the old method, wires were reeled off by hand reels, two men to a reel, which made it necessary to cut the wires continually in order to get them over obstacles, such as trees and foreign wires. The large number of connecting sleeves for this purpose were expensive as well as troublesome, making progress slow.

In stretching ten wires it took twenty men to handle the reels alone, and several more to keep the wire clear and prepare it at the poles for the climbers. To overcome this, a combination of ten reels was constructed. The reels were placed on the ground at first and the wires were trailed out by men. This suggested the placing of the reels on a wagon and the attaching of all the wires to the end of a rope, to the other end of which a team of horses was attached.

This wagon is shown in Fig. 5, the horses being too far distant to be seen. The rope is usually 500 feet in length, and is placed over all obstacles as the horses proceed, giving the wires a free run. By this method the ten wires were reeled out at no greater expense than it formerly took for one wire, and two horses and a driver, two climbers and two groundmen did the work of about twenty-five men and increased the progress at least 50 per cent.

It was also found in running ten wires that great difficulty was encountered in pulling them up even, and very slow progress was made. From a combination which was developed whereby two wires could be pulled up with one set of blocks, was perfected a device, shown in Fig. 3, whereby ten wires could be pulled simultaneously with the one set of blocks. This was an important factor in reducing the cost, as well as expediting and getting the wires more even than was possible under the old methods of a single

FIG. I.—BLASTING OUT A POLE HOLE

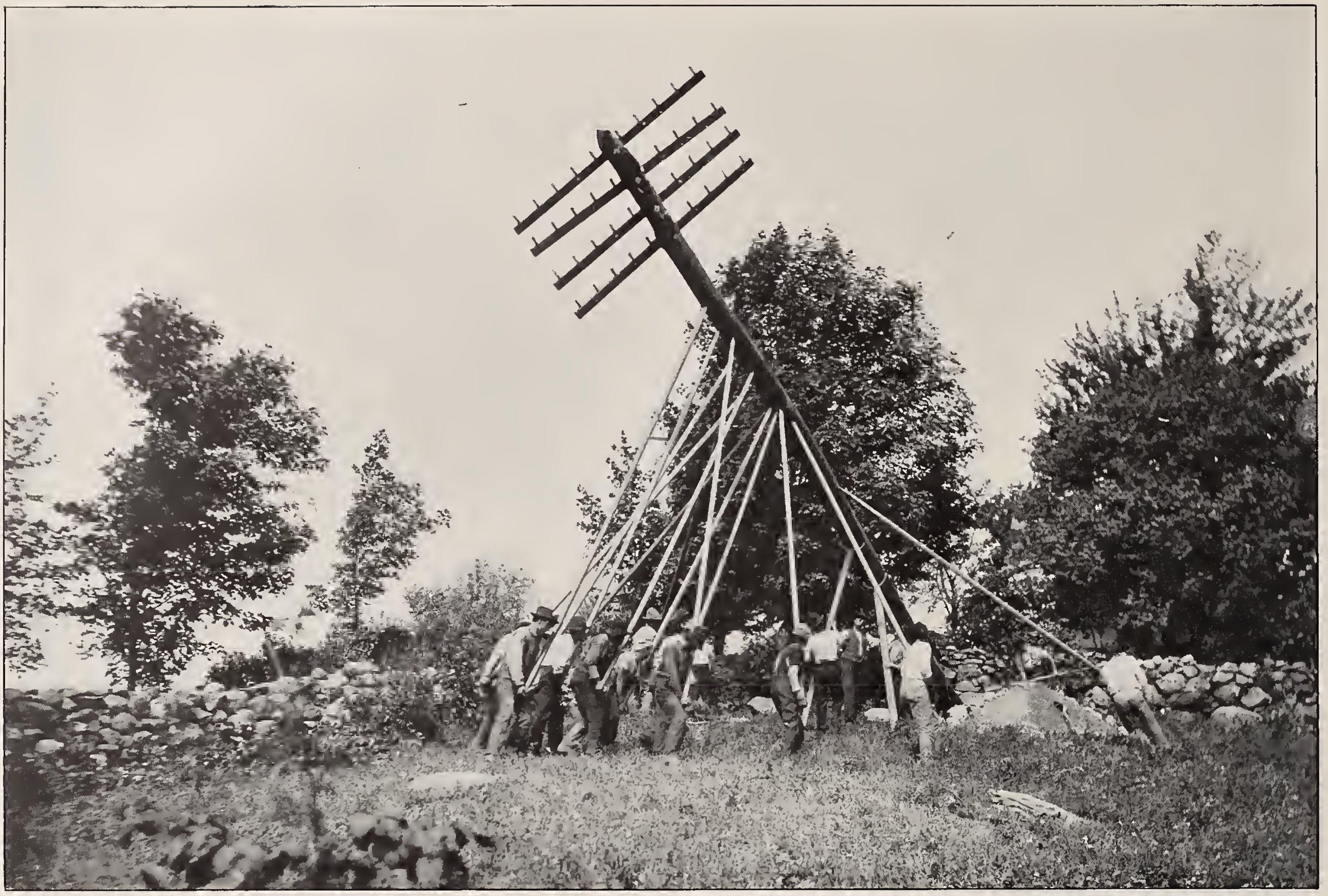


FIG. 2.—THE OLD WAY OF RAISING A POLE. THE SAVING IN MEN REQUIRED BY USING A DERRICK MAY BE CLEARLY SEEN BY COMPARING THIS WITH THE METHOD ILLUSTRATED IN FIG. 4

block to a wire. This led to the need of a proper clamp to hold the wire without injuring it, which was finally developed and is now in general use. By these means the cost of stretching ten wires has been greatly reduced, and a gang of fifteen men has been able to stretch 40 miles of No. 12 hard-drawn copper wire in one day.

After the adoption of the No. 8 hard-drawn copper wire it became necessary to increase the size of the poles. These have now reached the point where it is not economical to handle them in rough country with hand labor, and it was found that in the mountainous country it took, as a rule, twenty or more men to handle such poles, and even then slow progress was made.

All the pole derricks were inspected and were found impracticable, excepting for use in cities and level country, where there were not even ditches. A cheap and inexpensive derrick was then devised which could be fitted up quickly and applied to any ordinary timber wagon. This derrick is shown in Fig. 4, and consists principally of two 6-inch by 6-inch pieces of timber from 20 to 30 feet long, set upright, fastened together at the top in the shape of an inverted V, each upright being attached to the wagon by common eye-bolt sockets. The derrick can thus be swung to either side of the vertical at any angle necessary, and allows the poles to be set on either side of the wagon. A short outrigger is attached to the center of the wagon with check chains on either side, which are adjustable and hold the derrick at any angle. One pair of horses can haul it through the roughest country.

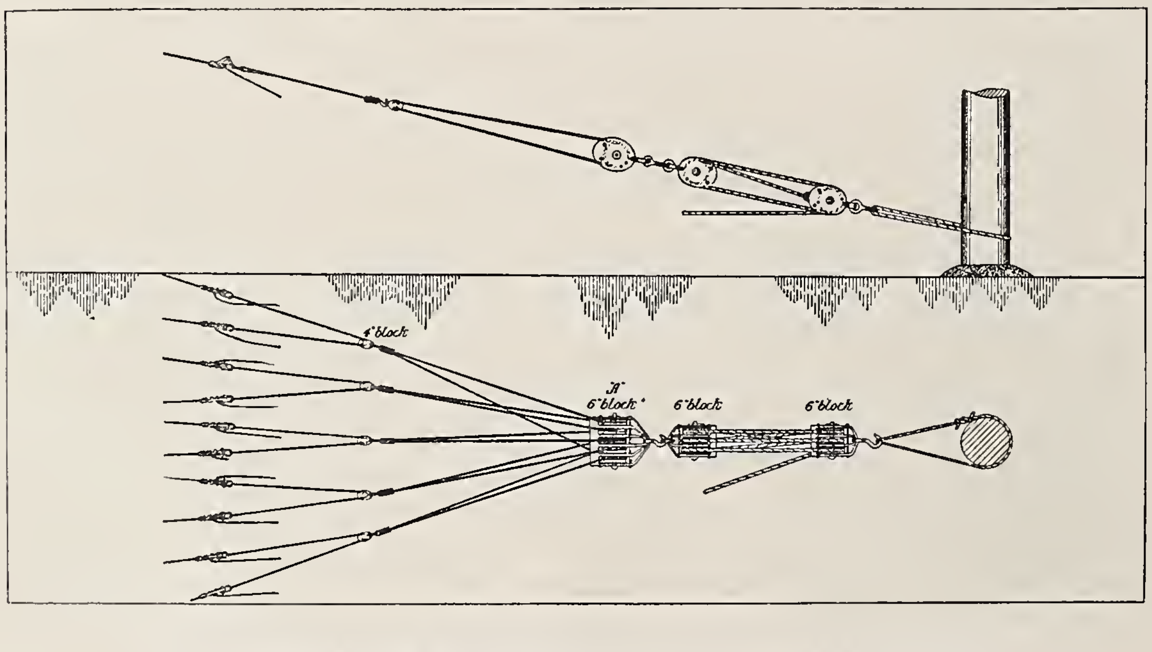


FIG. 3.—A DEVICE USED FOR DRAWING UP TEN WIRES SIMULTANEOUSLY

During the past season this derrick was used on about 100 miles of the roughest country in New England construction, where 90 per cent. of the poles were set on private property, and it was necessary to resort to the old practice of erecting poles with pikes for only seven poles. This derrick and a pair of horses, a driver and four men will raise poles that require

FIG. 4.—RAISING POLES BY DERRICK. FORMERLY TWENTY MEN WERE REQUIRED TO RAISE A POLE. NOW FIVE MEN AND TWO HORSES DO THE WORK

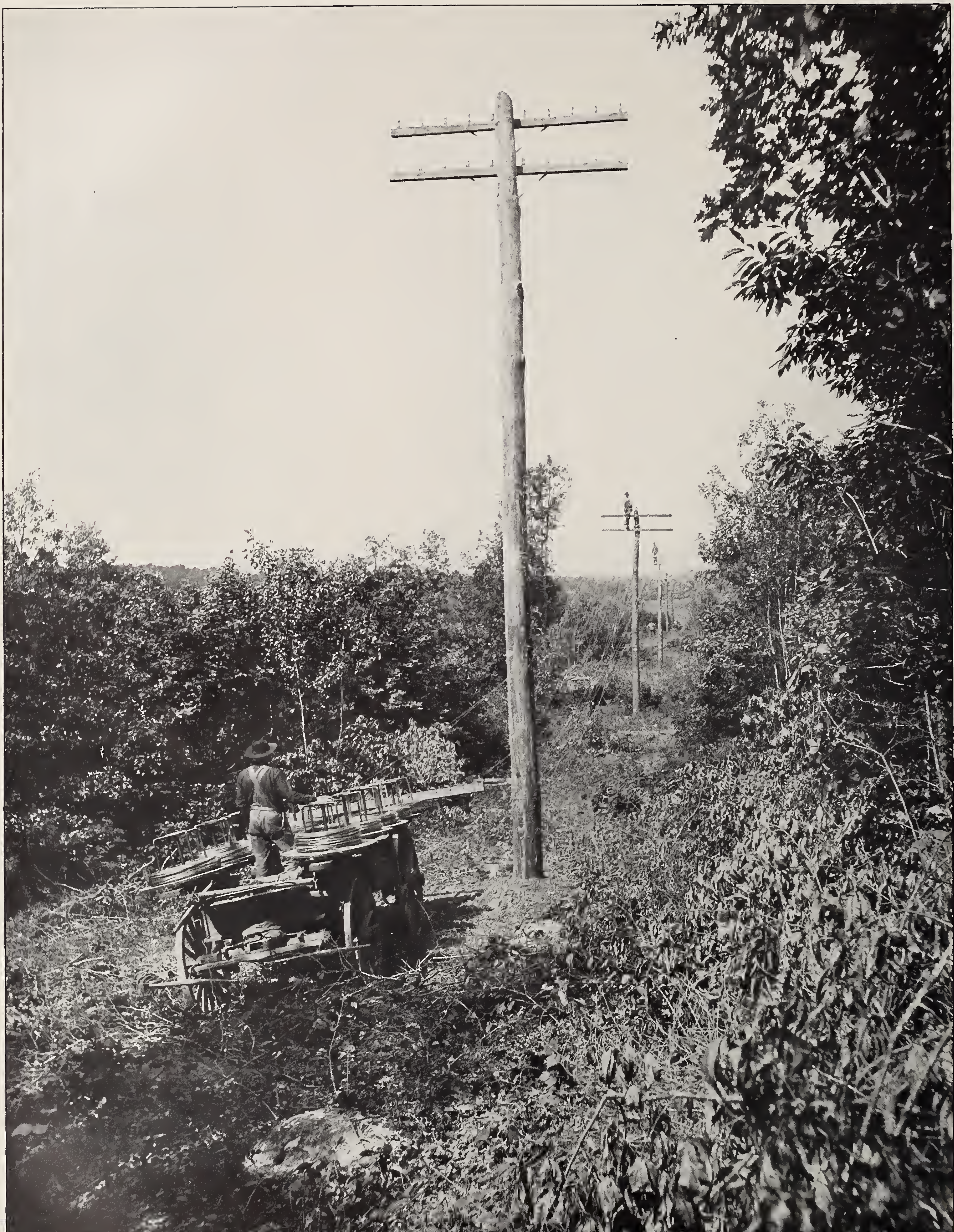


FIG. 5.—THE REEL WAGON. TEN WIRES ARE BEING DRAWN OFF THE REELS SIMULTANEOUSLY

twenty men in handling, and it will also enable the gang to make more rapid progress.

A method of surveying which the construction men employ in building a line consists in the setting up of twelve 10-foot stakes at the regular pole intervals. The contour of the line may thus be seen and any necessary corrections easily made, resulting in saving of poles and material.

Another factor in construction has been the use of dynamite for the blasting of holes. After digging the hole about 2 feet, a $1\frac{1}{2}$-inch hole is drilled the remainder of the distance with a common digging bar, and a small amount of dynamite is exploded in the bottom. This loosens up all the dirt, making it possible to shovel and spoon it out without still further loosening. Fig. 1 will give some idea of how well the dynamite does its work.

Commercial Electric Engineering

WRITING under the above head in the April number of "The Electric Club Journal," Chas. F. Scott, chief electrician of the Westinghouse Electric & Manufacturing Company, says:—

"'He must understand more about the customer's business than the customer himself, and he must know more as to what the apparatus will do than the designer himself.' Such was the reply of a man who was for a long time connected with the sales department of the Electric Company, when asked the principal qualifications essential in a commercial engineer. The man himself had handled many negotiations in which the engineering features were of great importance and he had, moreover, been in a position to observe the work of others.

"The engineering work of a large electric company may be divided under two general heads; the first is the design of apparatus and the issuing of specifications and data describing what it will do; the second is the selection and application of the apparatus to specific cases.

"The latter, which may be termed commercial engineering, is sometimes quite a simple matter; in other cases it is of the greatest difficulty and calls for the highest grade of engineering ability. It is not so much a knowledge of the theoretical elements involved in the design of the apparatus, a motor, for example, which is needed, as a good practical knowledge of what the motor can do. This practical knowledge needs to be based upon a definite knowledge of what the motor can do on shop test, and upon good judgment—based upon experience—in the selection of a definite motor to meet the requirements under particular conditions which may be uncertain and indefinite and varying in character, an estimate which is very hard to express in amperes or horse-power.

"But why should an electrical engineer or an electrical salesman know the customer's business, too? Electrical work is seldom purely electrical. Electricity is simply an agent. It enters into other things as a means of accomplishing results. Hence, it enters into them vitally and intimately. Every department of a railway or a factory which adopts electricity may in one way or another be modified by it. Electrical engineering is related to all other kinds of engineering, steam, hydraulic, pneumatic, mechanical, civil, chemical. In order that the commercial engineer may effectively apply his apparatus and show that it can produce results, he must be thoroughly familiar with the business of which his electrical machinery is to form a part, and which perchance it is to modify or revolutionize. Hence, the need of a fundamental all-around common-sense knowledge of all kinds of engineering and all kinds of operation. Hence, the education of the engineer should not be a mere collection of facts, but a development of engineering faculties. The education of the electrical engineer in college and in the apprenticeship course should lay a foundation in the fundamental principles of different branches of engineering and in a training which will enable these general principles and general knowledge to be correctly applied in particular cases. In no branch of engineering is a broad general knowledge and the ability to apply and use such knowledge for specific purposes more necessary than in electrical engineering."

Two wireless telegraph stations are to be established in Cuba by the Berlin Wireless Telegraph Company. One of these will be at Havana and the other on the Isle of Pines.

It is reported that the Chicago & Northwestern Railroad is considering the advisability of using electricity as the motive power on its suburban lines.

FIG. 6.—THE DERRICK BEING HAULED BETWEEN POLES

Costs of Electric Power Transmission

A Practical Application of Principles

By ALTON D. ADAMS

ELECTRICAL transmission of energy involves problems quite distinct from its development. A great water-power, or a location where fuel is cheap, may offer opportunity to generate electrical energy at an exceptionally low rate of cost. This energy may be used so close to the point of its development that the cost of transmission is too small for separate consideration.

An example of conditions where the important problems of transmission are absent exists in the numerous factories grouped about the great water-power plant at Niagara and drawing electrical energy from it. In such a case energy flows directly from the dynamos, driven by water-power, to the lamps, motors, chemical vats and electric heaters of consumers through the medium, perhaps, of local transformers. Here the costs and losses of transmitting or distributing equipments are minor matters, compared with the development of the energy.

If, now, energy from the water-power is to be transmitted over a distance of many miles, a new set of costs is to be met. In the first place, it will be necessary to raise the voltage of the transmitted energy much above the pressure at the dynamos in order to save in the weight and cost of conductors for the transmission line. This increase of voltage requires transformers with capacity equal to the maximum rate at which energy is to be delivered to the line. These transformers will add to the cost of the energy that they deliver in two ways, by the absorption of some energy to form heat, and by the sum of annual interest, maintenance, and depreciation charges on the price paid for them. Other additions to the cost of energy delivered by the transmission line must be made to cover the annual interest, maintenance, and depreciation charges on the amount of the line investment, and to pay for the energy changed to heat in the line.

Near the points where the energy is to be used, the transmission line must end in transformers to reduce the voltage to a safe figure for local distribution. This second set of transformers will further add to the cost of the delivered energy in the same ways as the former set.

From these facts it is evident that, to warrant an electrical transmission, the value of energy at the point of distribution should at least equal the value at the generating plant, plus the cost of the transmission. Knowing the cost of energy at one end of the transmission line and its value at the other, the difference between these two represents the maximum cost at which the transmission will pay.

Three main factors are concerned in the cost of electric power transmission, namely, the transformers, the pole line, and the wire or conductors. These factors enter into the cost of transmitted energy in very different degrees, according to the circumstances of each case. The maximum and average rates of energy transmission, the total voltage, the percentage of line loss, and the length of the line mainly determine the relative importance of the transformers, pole line, and conductors in the total cost of delivered energy.

First cost of transformers varies directly with the maximum rate of transmission, and is nearly independent of the voltage, the length of the transmission and the percentage of line loss. A pole line changes in first cost with the length of the transmission, but is nearly independent of the other factors. Line conductors, for a fixed maximum percentage of loss, vary in first cost directly with the square of the length of the transmission and with the rate of the transmission; but their first cost decreases as the percentage of line loss increases and as the square of the voltage of transmission increases.

If a given amount of power is to be transmitted, at a certain percentage of loss in the line and at a fixed voltage, over distances of 50, 100 and 200 miles, respectively, the foregoing principles lead to the following conclusions:—The capacity of transformers being fixed by the rate of transmission, will be the same for either distance, and their cost is, therefore, constant. Transformer losses, interest, depreciation, and repairs are also constant. The cost of pole line depending on its length will be twice as great at 100 and four times as great at 200 as at 50 miles. Interest, depreciation and repairs will also go up directly with the length of the pole lines.

Line conductors will cost four times as much for the 100 as for the 50-mile transmission, because their weight will be four times as great, and the annual interest and depreciation will go up at the same rate. For the transmission of 200 miles the cost of line conductors and their weight will be sixteen times as great as the cost at 50 miles. It follows that interest, depreciation and maintenance will be increased sixteen times with the 200-mile transmission over what they were at 50 miles, if voltage and line loss are constant.

A concrete example of the cost of electric power transmission over a given distance will illustrate the practical application of these principles. Let the problem be to deliver electrical energy in a city distant 100 miles from the generating plant! Transformers with approximately twice the capacity corresponding to the maximum rate of transmission must be provided, because one set is required at the generating and another at the delivery station. The cost of these transformers will be approximately $7.50 per horse-power for any large capacity.

Reliability is of the utmost importance in a great power transmission, and this requires a pole line of the most substantial construction. Such a line in a locality where wooden poles can be had at a moderate price will cost, with conductors in position, about $500 per mile, exclusive of the cost of the conductors themselves or of the right of way. The 100 miles of pole line in the present case should, therefore, be set down at a cost of $50,000.

A large delivery of power must be made to warrant the construction of so long and expensive a line, and 10,000 horse-power may be taken as the maximum rate of delivery. On the basis of two horse-power of transformer capacity for each horse-power of the maximum delivery rate, transformers with a capacity of 20,000 horse-power are necessary for the present transmission. At $7.50 per horse-power capacity, the first cost of these transformers is $150,000.

Before the weight and cost of line conductors can be determined, the voltage at which the transmission shall be carried out and the percentage of the energy to be lost in the conductors at periods of maximum load must be decided on. The voltage to be used is a matter of engineering judgment, based, in large part, on experience, and cannot be determined by calculation. In a transmission of 100 miles the cost of conductors is certain to be a very heavy item, and, as this cost decreases as the square of the voltage goes up, it is desirable to push the voltage as high as the requirement for reliable service permits.

A transmission line more than 200 miles long, from the mountains to San Francisco, Cal., has been in constant and successful use for about one year with 40,000 volts pressure. This line passes through wet as well as dry climate. It seems safe to conclude, therefore, that 40,000 volts may be used in most places with good results.

Having decided on the amount of power and the voltage and length of the transmission, the required weight of conductors will vary inversely as the percentage of energy lost as heat in the line. The best percentage of loss depends on a number of factors, some of which, such as the cost of energy at the generating plant, are peculiar to each case.

As a provisional figure, based, in part, on the practice elsewhere, the loss on the line here considered may be taken at 20 per cent. when transmitting the full load of 10,000 horse-power. If the line is constructed on this basis the percentage of loss will be proportionately less for any smaller load. Thus, when the line is transmitting only 5000 horse-power, the loss will amount to 10 per cent. During the greater portion of each day the demand for power is certain to be less than the maximum figure, so that a maximum loss of 20 per cent. will correspond to an average loss on all the power delivered to the line of probably less than 15 per cent.

In order to deliver 10,000 horse-power by the transformers at a receiving station from a generating plant 100 miles distant where the pressure is 40,000 volts, the copper conductors must have a weight of nearly 850,000 pounds, if the loss of energy in them is 20 per cent. of the energy delivered to the line. Taking these conductors at a medium price of 15 cents per pound, their cost amounts to $127,500.

The combined cost of the transformers, pole line and line conductors, as now estimated, amounts to $327,500. To this cost $12,500 may be fairly added to provide for transforming stations, switchboards and electric measuring instruments, bringing the total figure up to $340,000. No account is taken of the right of way for the pole line, because in many cases this would cost nothing, the public roads being used for the purpose; in other cases the cost might vary greatly with local conditions.

The efficiency of the transmission is measured by the ratio of the energy delivered by the transformers at the receiving station for local distribution, to the energy delivered by the generating plant to the transformers that supply energy to the line for transmission. If worked at full capacity the large transformers here considered would have an efficiency of nearly 98 per cent.; but as they must work, to some extent, on partial loads, the actual efficiency will hardly exceed 97 per cent.

The efficiency of the line conductors rises on partial loads, and may be safely taken at 85 per cent. for all of the energy transmitted, though it is only 80 per cent. on the maximum load. The combined efficiencies of the two sets of transformers and the line give the efficiency of the transmission, which equals the product of 0.97 × 0.85 × 0.97, or very nearly 80 per cent. In other words, the transformers at the water-power station absorb 1.25 times as much energy as the transformers at the receiving station deliver to distribution lines in the place of use.

Repairs, maintenance and depreciation of this complete transmission system are sufficiently provided for by an allowance of 10 per cent. yearly on its entire first cost. A further allowance of 5 per cent. on the investment takes care of the yearly interest charge. As the total first cost of the transmission system was found to be $340,000, the annual expense of interest, depreciation and repairs at 15 per cent. of this sum amounts to $51,000. Management, labor and incidental expenses in the operation of the system may be fairly set down at $15,000 per year, so that the total expense of operation, apart from the cost of energy, is $66,000 annually.

In order to find the bearing of this annual charge on the cost of power transmission the total amount of energy transmitted annually must be determined. The 10,000 horse-power delivered by the system at the sub-station is simply the maximum rate at which energy may be supplied, and the element of time must be introduced in order to compute the amount of transmitted energy. If the system could be kept at work during twenty-four hours a day at full capacity, the delivered energy would be represented by the product of the numbers which stand for the capacity and for the total number of hours yearly.

Unfortunately, however, the demands for electric light and power vary through a wide range in the course of each twenty-four hours, and the period of maximum demand extends over only a small part of each day. The problem is, therefore, to find what relation the average load that may be had during the twenty-four hours bears to the capacity required to carry this maximum load. As the answer to this question depends on the power requirements of various classes of consumers, it can be obtained only by experience. It has been found that electric stations, working twenty-four hours daily on mixed loads of lamps and stationary motors, can deliver energy to an amount represented by the necessary maximum capacity during about 2400 hours per year. Applying this rule to the present case, the transformers at the sub-station, if loaded to their maximum capacity of 10,000 horse-power by the heaviest demands of consumers, may be expected to deliver energy to the amount of 2400 × 10,000 = 24,000,000 horse-power-hours yearly.

The total cost of operation for this transmission system was found above to be $66,000 per annum, exclusive of the cost of energy at the generating plant. This sum, divided by 24,000,000, shows the cost of energy transmission to be 0.275 cent per horse-power-hour, exclusive of the first cost of the energy. On the basis of 3000 hours, the ordinary working time per year, the yearly cost of this transmission is $8.25 per horse-power. To obtain the total cost of transmission, the figures just given must be increased by the value of the energy lost in transformers and in the line conductors. In order to find this value, the cost of energy at the generating plant must be known.

The cost of electrical energy at the switchboard in a water-power station is subject to wide variations, owing to the different investments necessary in the hydraulic work per unit of power developed. With very large powers, such as are here considered, a horse-power-hour of electrical energy may be developed for materially less than 0.5. As the average efficiency of the present transmission has been found to be 80 per cent. of the energy delivered by the generators, it is evident that five horse-power-hours must be drawn from the generators for every four horse-power-hours supplied by the transformers at the sub-station for distribution. In other words, one-fourth horse-power-hour is wasted for each horse-power-hour delivered.

The cost of one-fourth of a horse-power hour, or 0.5 × 0.25 = 0.125 cent, must thus be added to the figures for transmission cost already found, that is, 0.275 cent per horse-power-hour, to obtain the total cost of transmission. The sum of these two items of cost amounts to 0.275 + 0.125 = 0.4 cent per horse-power-hour, as the entire transmission expense. For a working year of 3000 hours the expense of power transmission is thus, 3000 × 0.4 = $12 per horse-power. If to this expense per horse-power-hour for transmission is added the cost of energy at the generating station, the total cost of delivered energy is 0.4 + 0.5 = 0.9 cent per horse-power-hour, or 0.9 × 3000 = $27 per horse-power for a working year of 3000 hours.

It may now be asked how the cost of transmission just found will increase if the distance be extended. As an illustration, assume the length of the transmission to be 150 instead of 100 miles. Let the amount of energy delivered by the sub-station, the loss in line conductors and the energy drawn from the generating plant remain the same as before. Evidently the cost of the pole line will be increased 50 per cent., that is, from $50,000 to $75,000. Transformers, having the same capacity, will not be changed from the previous estimate of $150,000. Sub-station, switchboard and instruments will also remain at the same cost of $12,500. If the voltage of the transmission remain constant, as well as the line loss at maximum load, the weight and cost of copper conductors must increase with the square of the distances of transmission. For 150 miles the weight of copper will thus be 2.25 times the weight required for the 100-mile transmission, or 850,000 × 2.25 = 1,912,500 pounds. At 15 cents per pound, as before, the cost of this copper is $286,875. The complete investment for the transmission system over 150 miles is thus $449,375. Interest, maintenance and depreciation at 15 per cent. of this sum amount to $67,406 yearly.

As there are now 50 miles more of line to be cared for, the expense of operation may be increased to $16,500 yearly, making the total cost of transmission $83,906 per annum, exclusive of the value of lost energy. It was found above that a delivery of 24,000,000 horse-power-hours yearly might fairly be expected from a transmission system with 10,000 horse-power maximum capacity. With this delivery of energy the cost of transmission per horse-power-hour is 0.35 cent, nearly, exclusive of the cost of energy lost in the transformers and the line. This loss of energy was found above to be 0.125 cent per horse-power-hour of delivered energy, making the total cost of transmission 0.475 cent per horse-power-hour, or $14.25 per horse-power per year of 3000 working hours. Adding 0.5 cent per horse-power-hour as the cost of energy at the generating plant, the total cost of the delivered energy is 0.975 cent per horse-power-hour, or $29.25 per horse-power during a working year of 3000 hours. This last cost is only $2.25 greater per horse-power-year than that found above for a transmission of 100 miles. It will be noted that the value of the energy lost in this transmission is only 0.125 cent per delivered horse-power-hour, while the other expenses, mostly interest, maintenance, and depreciation on the investment, amount to 0.35 cent. The investment in copper could probably be reduced somewhat with advantage, thus raising the amount and cost of energy lost in the line, but reducing the other costs of transmission by a larger amount, so that the total cost would be lowered.

There is another course that promises much better than an increase in the loss assigned to conductors, however, and that course lies in the direction of still righer voltage. The transformers for the two great transmission systems that extend over a distance of about 200 miles, from the Sierra Nevada Mountains to San Francisco, in California, are designed to deliver energy to the line at either 40,000 or 60,000 volts, as desired. Though the regular operation, up to a recent date, has been at the lower pressure, successful experiments have been made with 80,000 volts on the lines, and the intention is to raise the regular working pressure to 60,000 volts as soon as the load increases so that the line loss would be large enough to make the higher voltage desirable.

The lower valleys of the Sacramento and the San Joaquin Rivers, which are crossed by these California systems, as well as the shores of San Francisco Bay, have as much annual precipitation and as moist an atmosphere as do most parts of the United States and Canada. There seems to be no good reason, therefore, to prevent the general use of 60,000 volts elsewhere if this pressure proves satisfactory in the parts of California named.

The distance over which energy may be transmitted at a given rate, with a fixed percentage of loss and a constant weight of copper, goes up directly with the voltage employed. This rule follows because, while the weight of conductors to transmit energy at a given rate, with a certain percentage of loss and constant voltage, increases as the square of the distance, the weight of conductors decreases as the square of the voltage when all the other factors are constant.

Applying these principles to the 150-mile transmission, it is evident that an increase of the voltage to 60,000 will allow the weight of conductors to remain exactly where it was for the transmission of 100 miles, the rate of working and the line loss being equal for the two cases.

The only additional items of expense in the 150-mile transmission, on the basis of 60,000 volts, are the $25,000 for pole line, and the $1500 for operating expenses. Allowing 15 per cent. on the $25,000 to cover interest, depreciation and maintenance, as before, gives an item of $3750, which, plus $1500 additional operating expense, makes a total yearly increase in the costs of transmission of $5250 over that found for the transmission of 100 miles. This last sum amounts to 65.6 cents per horse-power per year of 3000 working hours when divided up among the 24,000,000 horse-power-hours delivered yearly by the transmission system.

The cost of transmission is thus raised to $12.65, and the total cost of delivered energy to $27.65 per year of 3000 hours on the 150-mile system with 60,000 volts.

Submarine Telephones for Naval Use

A SUBMARINE telephone is now being tested at the Boston Navy Yard by Capt. James R. Selfridge, U. S. N., who says it is the "most valuable aid to navigation that the world has ever seen." A bill has been passed by Congress for the establishing of a system of submarine signals along the Atlantic Coast, from Delaware Breakwater to Portland, for the prevention of shipwrecks and for signaling to naval vessels.

At the recent annual meeting of the Ohio Gas Light Association, I. Butterworth, editor of the "Progress Department," said that street lighting by gas is unquestionably on the increase, both in the United States and Europe. After citing statistics he concluded with this interesting remark:—"The development of systems for the long-distance lighting and extinguishing of street lamps by increasing and decreasing pressure, or by means of clockwork seems to further warrant the belief that street lighting by gas will eventually largely displace electric street lighting throughout the world."

Lighting the New York Subway

By WILLIAM H. RADCLIFFE

IN the operation of a rapid transit subway, reliance must necessarily be placed almost entirely upon artificial illumination. The choice of illuminants for such a purpose quickly narrows down to electric light, which owing to its steadiness, reliability, and non-vitiating property, together with the low attending fire risk, is particularly adapted to this class of work. Of electric light, that provided by incandescent lamps is preferable for subway lighting to arc light and the other forms in which electricity is used for illuminating purposes, on account of its comparatively low cost, low maintenance and easy subdivision into small units.

Although the choice of illuminants for the subway was a simple matter, the best form in which to use the lamps, their proper grouping and spacing, and the most efficient reflectors to employ with them had each to be considered with respect to the general results to be obtained. The problem was therefore quite complicated and entailed a careful study of the various available systems, together with exact photometric tests of every lighting element employed. In the solution of the problem care had to be taken to avoid dazzling effects, unpleasant and injurious to the eyes. Satisfactory results would have been difficult to obtain from arc lamps on account of the low ceilings in many parts of the subway, which necessitated placing the lights but little above the eyes of the passengers.

It was found that meridian and ordinary frosted incandescent electric lamps fulfilled the requirements to a certain extent. Of these, the former cost more than the latter, their life of economical usefulness is somewhat shorter, and their cost of maintenance is considerable. Ordinary frosted incandescent lamps cost about 20 per cent. more than those with plain glass bulbs. They are originally less efficient, and rapidly become less so, owing to adherent accumulations of dust and dirt in the frosting on the outside of the bulbs.

A system was finally chosen for the stations which permitted the use chiefly of plain unfrosted lamps. These lamps were covered, where possible, with glass bulbs frosted on the inside so as to avoid the rapid deterioration of the light from the adherent dust and dirt on the outside frosting. The three following arrangements were adopted for the stations, plain lamp bulbs being used in all cases.

FIG. I.—A SUBWAY STATION SHOWING ARRANGEMENT OF LAMPS ENCLOSED IN FROSTED GLASS BALLS

FIG. 2.—A SUBWAY STATION SHOWING ARRANGEMENT OF LAMPS FITTED WITH BELL-SHAPED PRISMATIC GLASS REFLECTORS AND ENCLOSED IN FROSTED GLASS BALLS

1. Incandescent lamps covered with 7-inch balls frosted on the inside, and attached directly below the ceiling as in Fig. 1.

2. Incandescent lamps covered with bell-shaped prismatic glass reflectors having removable frosted glass balls, and suspended on metal brackets as shown in Fig. 2. The reflectors compensated in a great measure for the loss of light due to the frosting.

3. Incandescent lamps provided with flattened prismed glass reflectors having a white coating on the prismed side, and covered with 4-inch removable frosted balls as illustrated in Fig. 3. The reflectors were placed just within the ceiling.

The white coating of the prismed glass reflector as employed in the arrangement last mentioned was a new departure, and was the result of an exhaustive series of experiments conducted by Major E. L. Zalinski, U. S. A. (retired). Without materially interfering with the direct reflection of the glass prisms, the white superimposed coating added to the general illumination by producing a diffusive action of the light, and broadened its distribution so that a larger area could be effectively illuminated with a given lamp or number of lamps; in fact, the available efficiency was increased by not less than 20 per cent. The light given with this diffusing reflector in use also appears less dazzling than when ordinary prismed glass reflectors were used, and the reflectors themselves are, in the open, much more ornate in appearance.

The results secured by employing the white superimposed coating may be seen by comparing the distribution curves *A* and *B* in Fig. 6. Curve *A* was obtained from three 16 candle-power incandescent lamps grouped under a $13\frac{1}{2}$-inch clear glass prismatic reflector, and curve *B* was obtained from the same lamps and reflector when the latter was coated on the back (the prismed side) with a white coating. These curves show the distribution of the light at different angles, and it is obvious from them that reflectors having the white superimposed coating permit the effective illumination of a larger area without increasing the quantity of current consumed.

As illustrative of the increased efficiency secured by the diffusing reflector, the following data are presented as made by the Electrical Testing Laboratories of New York. Measurements were made on a 5-inch meridian lamp when using its so-called prismo glass reflector, and also with the same lamp when using a 9-inch diffusing reflector.

Angles	Apparent Candle Power— Lamp Alone	Lamp with Prismo Reflector	Lamp with 9-inch Diffusing Reflector
90 degrees (horizontal)	28.8	31.0	15.8
75 "	28.5	32.0	32.8
60 "	28.2	33.5	40.5
45 "	27.5	35.5	45.0
30 "	25.4	38.1	48.7
15 "	23.0	39.8	52.0
0 " (nadir)....	22.1	42.1	53.8

From these results the Rousseau diagram shown in Fig. 5 has been prepared, in which curve *C* is for the lamp alone, curve *B* for the lamp with prismo reflector, and curve *A* for the lamp with 9-inch diffusing reflector. The mean zonular candle-power values for the 60 degree and the 75 degree zones computed from this diagram are tabulated on the next page.

MEAN ZONULAR CANDLE POWER

Source of Light	60 Degree Zone Mean Candle Power	60 Degree Zone Comparative Efficiency	75 Degree Zone Mean Candle Power	75 Degree Zone Comparative Efficiency
Lamp alone	27.0	(Basic value)	27.2	(Basic value)
Lamp and prismo reflector	37.0	157 per cent.	35.2	129 per cent.
Lamp and 9-inch diffusing reflector	46.5	172 "	43.1	158 "
Increase over prismo value by using 9-inch diffusing reflector	....	25 "	....	22 "

It is to be noted that this gain is chiefly in the higher angles, giving a better sidewise distribution—a gain which cannot be secured by any variation in the shape of the reflector. The foregoing results have been described relatively to the larger diameter of the diffusing reflector, but measurements made with the clear glass reflector and with the same reflector coated, give a marked superiority for the diffusing one. For general illumination a high intrinsic brilliancy is not desirable, but rather a uniform distribution of the light. A person looking directly at the light from a bare incandescent lamp may think it provides a better illumination than the light from a group of these lamps, properly diffused, but as soon as he attempts reading thereby he finds his mistake. Naked lights are therefore to be avoided since they produce a glaring intensity instead of an effective illumination.

In this connection it is interesting to note that efforts to secure a broadened distribution of the light by any modification of the shape of prismatic reflectors have failed. When reflectors were flattened with this in view, the depth of the curve of illumination was very much lessened, but without broadening it, and therefore the effectively illuminated area was not increased. This may readily be seen by comparing the curves in Fig. 4, which give the distributional illumination at different angles from the vertical axis obtained from a 16-candle power incandescent lamp when provided with reflectors made from the same mold, of 84, 90, 100, 120 and 130 degrees, respectively.

As to the spacing of the lamps in the subway, those for lighting the stations average 15 feet between centers, and are each of 16 or 32 candle-power. Those for lighting the tunnel are spaced 60 feet apart, but as there are two rows on opposite sides of the tunnel, and the lamps are staggered, the real distance between them is about 30 feet. The tunnel lamps are ordinary incandescent lamps of 10 or 16 candle-power each, and are used without reflectors. They provide sufficient light to enable the employees to see their way clearly for all track and inspection work, but are not so brilliant as to interfere with the recognition of the signal lamps of the block signal system in use. Enameled steel plates, just large enough to screen the light of these lamps from the eyes of the motormen, are clamped about the

FIG. 3.—A SUBWAY STATION SHOWING ARRANGEMENT OF LAMPS ENCLOSED IN REMOVABLE FROSTED GLASS BALLS, AND PROVIDED WITH FLATTENED PRISMED GLASS REFLECTORS HAVING A WHITE COATING ON THE PRISMED SIDE

lamp sockets so that they project down over the side of the lamps toward the nearer approaching trains.

In some of the subway stations the outer edges of the platforms are curved as in Fig. 7, on account of the course taken by the track; this construction prevents the platforms of the cars running as closely to the platforms of the stations as would be the case if the latter were straight. In order to prevent passengers stepping through these openings when entering or leaving trains, there is placed below each curved station platform a row of 10 or 16 candle-power incandescent lamps which are intended to light up the opening and thus make it more discernible to the passengers stepping across it.

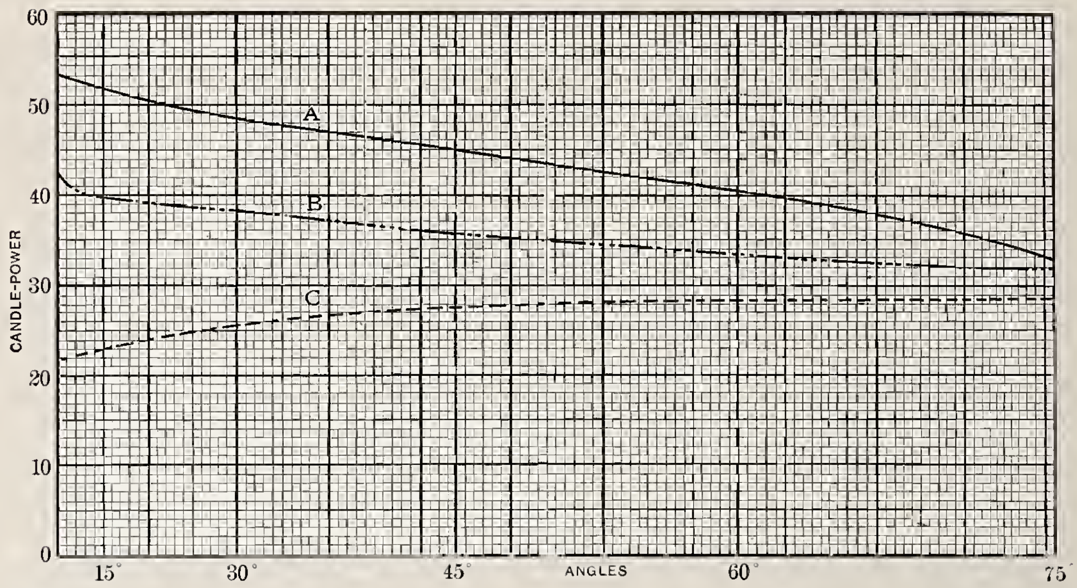


FIG. 5.—ROUSSEAU DIAGRAM SHOWING DISTRIBUTION OF LIGHT ABOUT A 120-WATT MERIDIAN LAMP USED ALONE AND WITH EACH OF TWO REFLECTORS

For lighting the subway tunnel and stations there are provided in the power house at Fifty-Ninth street, New York, three 1250-K. W. alternators. These machines are entirely independent of the power supply for operating the cars, and are connected with the lamps through their own system of primary cables, transformers and secondary conductors. The secondary conductors to which the station lamps are directly connected have a pressure of 120 volts; this is about 5 volts higher than the pressure at first used, it being found that owing to the position of certain of the lamps they did not provide sufficient light at 115 volts, and the pressure was therefore raised to increase their brilliancy. For the tunnel lamps a pressure of 600 volts is used, and this supplies series groups of five lamps each.

In order that a temporary shutdown of the station lighting system may be provided for, emergency lamps connected to the contact rail power circuit are installed on the ticket booths, upon the columns in front of the platforms, and on the stairways leading to the stations. By means of these lamps sufficient light can be provided to enable passengers to see the edges of the station platforms and the stairways without the use of the regular lighting system.

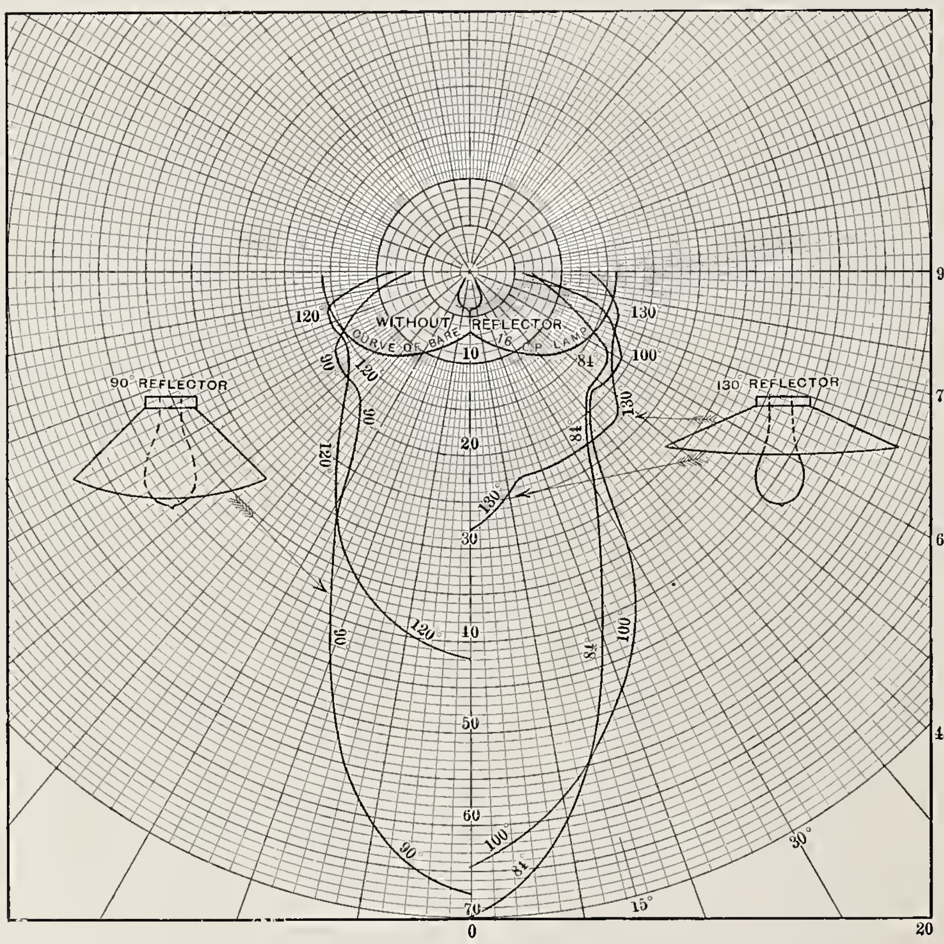


FIG. 4.—CURVES SHOWING DISTRIBUTIONAL ILLUMINATION FROM A 16 C.-P. LAMP WITH FIVE PRISM GLASS REFLECTORS HAVING DIFFERENT ANGLES OF OPENING

Many precautions are taken to insure the continual lighting of the tunnel lamps, their circuits being so arranged that four separate and abnormal conditions must necessarily exist before these lights would entirely fail.

To accomplish the lighting of the subway there are used at the stations about 4600 115-volt incandescent lamps, of which there are 1800 16 candle-power lamps, and 2800 32 candle-power lamps. In the tunnel, approximately 4300 600-volt incandescent lamps are employed, of which 2500 are of 10 candle-power each, and 1800 of 16 candle-power each.

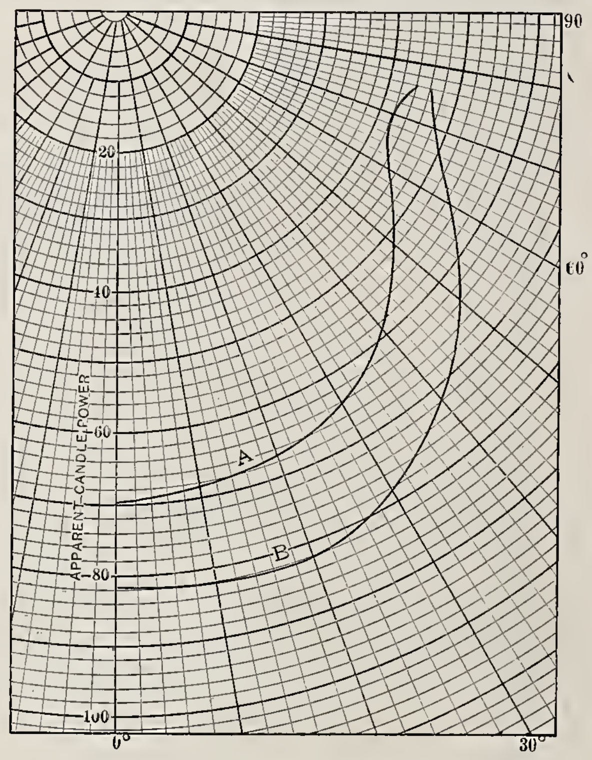


FIG. 6.—CURVES SHOWING DISTRIBUTION OF LIGHT ABOUT THREE-LAMP CLUSTERS WITH CLEAR GLASS AND COATED GLASS REFLECTORS

Experimental works for the sterilization of water by the use of electrically ozonized air were recently started at the municipal water works of Paris.

FIG. 7.—A SUBWAY STATION SHOWING A CURVED PLATFORM, BELOW WHICH LAMPS ARE PLACED TO LIGHT UP THE OPENING BETWEEN ITS OUTER EDGE AND THE CAR PLATFORMS

Chicago's Municipal Electric Railway Prospects

MUNICIPAL-ownership advocates in Chicago have often referred to the waterworks as a bright particular example of the beneficent working of their pet theory. However, the "Chicago Daily Tribune" finds that the actual facts in the case do not justify the loud claims made by the public-ownership people. The situation, it says, may be summarized thus:—

The water-service equipment is antiquated and inadequate.

In at least a third of the city there is difficulty in supplying water above the second floor of dwellings.

The service is mismanaged in a manner that no private concern would tolerate and to a degree which makes its profit more a matter of luck than care.

On account of diversion of the profits of the department and aldermanic complacency the service is 20 years behind the times.

Collections of assessments are more than $800,000 in arrears.

The improvement of the service is and has been for years hindered by political considerations.

The department is the victim of mechanical and supply contractors.

To this Mayor Dunne, according to the same newspaper, makes this answer:—"Oh, I have no doubt the water department has been mismanaged. But, even if it has, the municipal operation of the department has been a good thing for the people. Water is cheaper in Chicago than in any other city in this country. If the municipal ownership of street cars is mismanaged with the same beneficial results as those obtained in the water department, we shall have reason to congratulate ourselves."

The Cost of Electric Rock Drilling

TESTS of electric rock drills were made recently in British Columbia to determine the consumption of power in electric drilling in mines. The tests were extensive enough to give good averages. An 86-inch hole, 2 inches in diameter, was drilled in 19.08 minutes. The total consumption was 940 watt-hours, or 131 watt-hours per foot. The cost was 10 cents per kilowatt-hour, which, at the rate of 131 watts per foot drilled, would bring the cost down to less than 2 cents per foot. The minimum cost of drilling with steam of compressed air is about 10 cents per foot.

Coal for the New York Subway

THE importance of coal in the operation of the New York Subway can be better realized when it is considered that with the furnaces at the big power plant between Fifty-Eighth and Fifty-Ninth streets, on the Hudson River, running normally, they turn 1000 tons of anthracite into electric current daily.

Great inconvenience would be caused by any interference with this supply of fuel. In order to keep ahead of the demands of the power house furnaces, it is necessary, says the "New York Tribune," to unload an 800-ton barge about every day, and from the time the coal is shoveled into a bucket in the hold of the barge lying alongside the pier until it is shoveled up from the floor of the boiler room and thrown into the furnaces, the hand of man performs no labor in its actual movement.

The operation of moving the coal is as follows: The fuel is shoveled from the hold of the barge at the pier into a bucket which is raised and the coal dumped into a hopper, from which it is fed to a 30-inch belt conveyor and carried to a second hopper to be weighed. When the scales indicate that a hopper contains two tons, the stream of coal is shifted to another hopper and the coal in the first falls on one of a series of belts, which carries the fuel through a subway and up an incline to the bins the entire length of the power house over the boilers, 1300 feet distant.

It takes three and a half minutes for the coal to make the trip from the barge to the bins. Trippers on the conveyors running on each side of the power house direct the stream of coal to any particular bin desired. From the bottom of each bin are metal tubes, through which the coal is carried to points convenient for shoveling it into the furnaces, or direct to automatic stokers with which part of the boilers are equipped, as the case may be. The coal handling feature of the large power station is probably one of the most complete plants of its kind in use.

Mercury vapor lamps have been adopted for lighting the press room of "The New York Times" in its new building at Forty-second street and Long Acre Square, New York. Cooper Hewitt lamps light four large presses and two autoplate machines included within 17,000 square feet of floor space in a room 21 feet high. The lamps have tubes 1 inch in diameter and are $27\frac{1}{4}$ inches long, with a light-giving length of $20\frac{3}{4}$ inches.

Natural Sources of Energy

The Probable Extensive Development of Solar Power

By Dr. LOUIS BELL

MUCH has been written during the last decade concerning the failure of the earth's fuel supply and the vision of frigid despair that lurks behind the portals of the not distant future. True enough, we of the present day have used our supplies like reckless vandals, avaricious and purblind, robbing our children and our children's children without scruple. There is no stopping the greedy hordes in their frantic money hunt, and it is the part of wisdom to cast about for means of saving from the general disaster as much as possible.

The case really is not quite so bad as it looks, but at the best it is bad enough. The present coal supply of the world will, at the present quickening pace, last perhaps a few hundred years with the aid of such new mines as may turn up in out-of-the-way places; but once gone, it will be gone forever, and the paltry wood supply which is renewed year by year cannot give material help.

The supply of good and easily available coal is even now showing us the beginning of the end, and the American anthracite strike last year proved how small a shortage in the normal coal supply may cause widespread distress. Deep mining and heavy transportation charges mean costly fuel long before the total supply nears its end, and it is not too much to say that from the present time on we must expect to see the price of fuel on a pretty steady and steep upward gradient. The ultimate outcome is a case rather for speculation than for prophecy. That men and nations will put up a strong fight against the inevitable is obvious, but ultimate defeat is certain. We are drawing, without thought for the morrow, on a store which is plainly limited.

But even so, the case is not a desperate one for humanity if viewed philosophically. In the last resort the fight before us is not for civilization, as such; but merely for the preservation of the status quo. Compared with the present consumption of coal, for example, the fuel used in the golden age of Athens is an evanescent quantity. Civilization does not consist entirely of tall chimneys and automatic machinery, but we naturally wish to preserve these, together with the rest. Nor are manufactures the sole source of happiness and wealth; but we would fain save them, among other things, from the penalty of unthinking avarice. If worst came to worst, men could migrate, as they have in case of need ever since the dawn of time, seeking in this instance a climate where there would be small need of fuel. Cities and empires are really but flickering shadows on the clouds of space.

"They say the Lion and the Lizard keep
The courts where Jamshyd gloried and drank deep."

London and Paris and New York have no better guarantee of permanence than had Persepolis, and when the northern land becomes untenable for lack of fuel, men will build anew elsewhere.

The practical problem that presents itself to the student of economics is, first, how to make the most of the fuel that remains, and second, how to supplement it so as to most increase the area of the earth's surface which will remain tenable when the fuel supply fails. The first end is to be reached by deliberate and persistent efforts to increase the efficiency with which fuel is utilized. Until recently fuel has been so cheap that the stimulus to economy was far from acute; but from now on the reward of economy will progressively increase.

Already much has been accomplished, for the power derived to-day from a pound of coal is nearly three times as great as it was fifty or sixty years ago. But in spite of this the inroads into the coal measures are yearly heavier, and further success in this line of economy will be more and more difficult. Perhaps the best promise at present comes from the gas engine, which can be made to double the present efficiency of steam engines; but even this gain will serve only to delay the end a little. The generation and distribution of electric power from plants of enormous capacity and great efficiency will afford great help by enabling mankind to utilize to advantage fuel now hardly worth transportation, and much of this work is likely to be done within the next few decades.

Still greater saving can be accomplished by a thorough revision of current methods of heating. The ordinary means of heating buildings are uneconomical to the last degree, and it is not too much to say that their efficiency can be doubled by close attention to conditions and by more skillful methods of constructing buildings. We have already reached the pass where of two methods of obtaining power and heat, of equal total cost, but one involving more fixed charges and the other more fuel expense, the former should be unhesitatingly chosen. Parity of cost this year means a saving a few years hence when coal will be higher than at present.

In spite of every effort of this sort, there remains the irrevocable fact that we are consuming our capital, and that at a rate which has steadily increased, in spite of former improvements, and will continue so to do. Hence, it is necessary to seek out whatever means can be found for obtaining power and heat as such from sources that do not involve further demands on coal.

Obviously the first recourse is to water-power in the ordinary form, and how successfully it has been taken is a matter that needs little comment. Falls like Niagara, good for at least three or four million horse-power, are magnificent sources of power; but they are quite insignificant features of the world's aggregate water-power. The bulk of it is in small falls, giving a few hundred or a few thousand horse-power each. Every one of those, properly utilized, stops a call for fuel, and in favored districts it is even now quite feasible to remove the whole region from our present discussion.

But as a matter of fact, all the electrical transmission yet accomplished is only a drop in the bucket. If all that has been done in the past decade were crowded into a single year's development, it would not noticeably check the steady increase in the demand for coal even for that single season. Comparatively few power transmissions supersede the use of fuel; they go rather to building up new industries and supplying new luxuries, and they cut as yet but small figure even in this rôle. Even with the rapid present increase in electrical work there is little prospect that hydraulic development will materially check the demand for coal, let alone reducing it.

Nothing but the dire stress of rising price of fuel will force enough capital into hydraulic plants to produce a perceptible effect. And while there is in the aggregate enough water-power in some places to set coal a-begging, most of it is in such locations and in so small units that its utilization would mean a complete rearrangement of social and industrial tendencies.

Moreover, at the present rate of forest destruction, the complete denudation of vast tracts of country is a matter of comparatively few years, so that the available water-power will be greatly lessened. The effect of such destruction is already beginning to be felt on a growing number of streams, and one only has to look at Southern California to realize the ultimate outcome in enormous variations of flow that make full utilization of the streams very difficult. It is not easy to get exact data on the effect of denudation on the variations of stream flow; but it is probably within bounds to say that with a given drainage area and rainfall, the practical capacity of a stream in available power would be lessened 50 per cent. by the complete denudation of the watershed.

The practical aspect of the water-power question, then, is that while the aggregate amount available is enough to supply fully all present and many future demands for power, present industrial growth is so rapid and is so thoroughly grounded in laws that ignore the fuel question, that hydraulic power is at present of very little importance as an auxiliary. It can, and will, become of great importance as the fuel stress gets more severe; but it will involve very great changes in the distribution of capital and population, even with all the aid that long-distance electrical transmission can give.

In order to preserve the status quo it is not sufficient merely to replace the use of fuel for power purposes, but to find means of keeping down its expenditure for heating purposes. This is a far more difficult matter than the former, for it portends an inefficient cycle of operations. The transformations of energy that lead to mechanical power are, in case of heat engines, conspicuously inefficient; and if the power so derived be converted back to heat, the total losses are very great.

Hydraulic plants, worked on a very large scale, can be made to accomplish electrical heating at a price comparable with coal at prices not greatly in excess of those now ruling; but this branch of work has been barely touched up to the present time. The inevitable result of scarce fuel will be to increase it, but at the cost of throwing enormous extra work on existing water-powers, and the steady tendency must be to cause emigration to regions where less artificial heat is needed than at the present centers of the world's activity, and to concentrate the new civilization in such of these regions as are supplied with natural sources of energy.

Of such sources, aside from water falls, the only ones available are tides, wind and solar radiation. The first mentioned have been utilized in a very small way; their larger use has been considered dubious. In the first place, tides of a height readily available are local in their occurrence; and, second, tides are essentially periodic, so that their direct power is available only in two short daily periods occurring in cyclic order during each part of the twenty-four hours as the month is rounded out. Hence the first problem of tide utilization is storage of power.

It is possible by the use of multiple reservoirs to extend the use of the tides throughout the twenty-four hours. A three-pond system accomplishes this end at considerable cost in complication of waterways and variations in head, and even a two-pond system helps to a steady use of tidal power for part of the day. There is, too, great variation in the rate of flow in the tides in different localities, the most favorable case being that in which the tide rises and falls most rapidly. But the main trouble with the tides is that the total rise and fall is relatively small, compelling one to deal with low, as well as variable, heads and to provide enormous reservoirs to store even enough water for use in two daily five-hour runs. In very few places would it be possible to rely on more than 6 feet mean working head.

This means that if the storage pond were 6 feet deep, each square mile of reservoir would store water for about 5000 H. P. for a five-hour run. Even this is an unusually favorable case, and it is evident at once that hydraulic works on this scale imply a very large investment for the power obtained.

The only tidal powers to be taken seriously as able to count in large work are such as exist in exceptional spots, like the Bay of Fundy, where the tides run 40 feet high under normal conditions. There it should be possible to obtain, for two five-hour runs, more than 50,000 H. P. per square mile of reservoir. It may seem fanciful to consider the utilization of this power, and so it is with coal at its present price. But with steam coal at $20 a ton or more, as it may well be within the experience of some even now living, the case will stand very differently. If one stops to consider the effect on human industries of coal at such a price, it is evident enough that desperate remedies would be in order.

A glance at a map will show that the inner extremity of the Bay of Fundy is almost a tidal lake, known as the Basin of Minas. At its outlet rise two great headlands, less than three miles apart, while the norrower tide-race between them takes the full current for the basin within. This covers an area of more than 400 square miles, so that it is safe to say that through that narrow gap more than 200,000,000 H. P.-hours run daily to waste. To utilize it would require an engineering feat more tremendous than anything yet attempted by man, but in years to come the game may be worth the candle.

Using tidal power implies either intermittent power supply or storage. The latter is not at all an impossible alternative even with the means now at hand. For example, let us take a tidal power yielding 100,000 H. P. in two five-hour intervals. To deliver continuous ten-hour power, a storage battery would be required having a capacity of about 350,000 K. W.-hours. This could be put up probably for about $3,500,000, on which, reckoning interest and upkeep at 10 per cent., the annual charge would be $350,000. Such a plant could probably sell its full output, and the charge per year due to storage is evidently only a small sum, quite possible under the assumed conditions, even considering the probability that the price of material would rise considerably under the condition of greatly increased cost of fuel.

The writer, however, inclines to the opinion that when the fuel stress gets so severe as to call for the utilization of tidal and other difficult hydraulic powers, industry and population will tend to drift southward to a more genial climate where the struggle against Nature will be on easier terms.

The utilization of wind-power is even less attractive than that of tidal-power, since the supply is a very erratic variable, save in the region of the trade winds. Wind-power in a small way is a great convenience, but it cuts only a small figure as a protection to the fuel supply in general. The largest windmills are of only a few horse-power, and run at so variable a speed that, except for purposes like pumping, they are decidedly inconvenient. Still they have their uses as adjuncts in a general scheme of power supply.

There have been propositions to erect batteries of windmills driving dynamos and to so concentrate their power by storage as to obtain a continuous and considerable supply. Doubtless this could be done, but hardly to advantage, except in localities where the wind blows fresh and true, with some approximation to regularity. Along the sea coast in certain regions these conditions exist, although seldom to an extent warranting much reliance on wind-power.

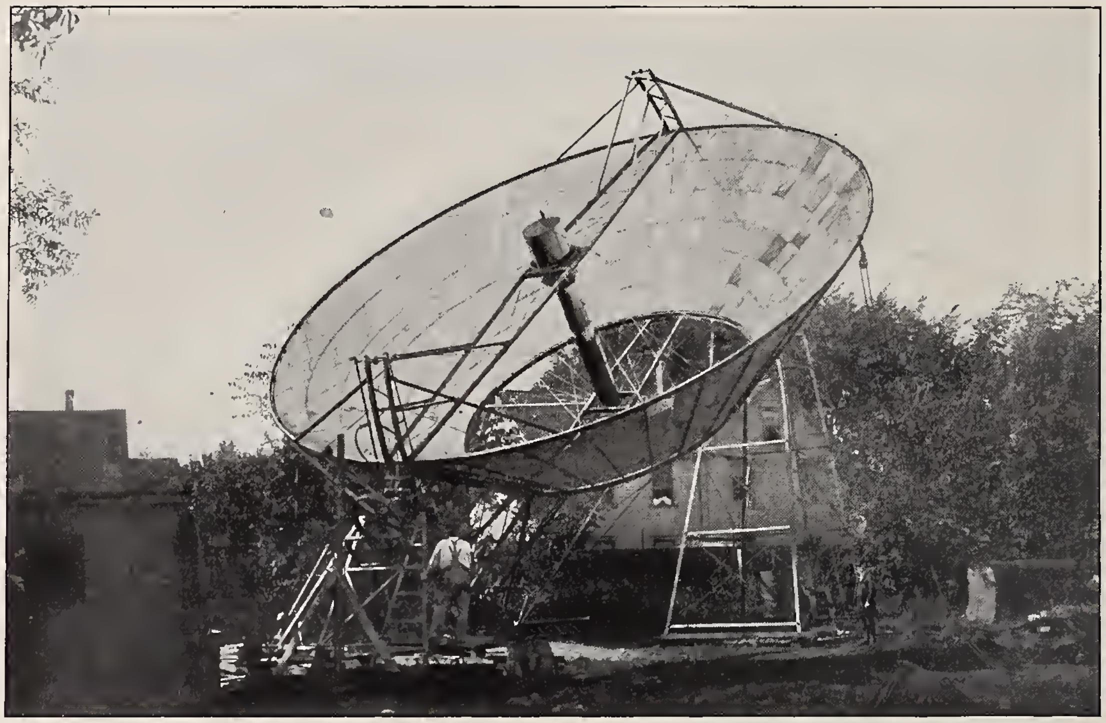
As compared with transmitted hydraulic power, the utilization of wind has little to commend it, for it is relatively costly and inconvenient. Like the earth's internal heat, there is plenty of it as a whole, but little that can be put to good use.

There remains as a possible recourse the enormous energy received from solar radiation. Although this is the great ultimate foundation of terrestial energy, it is not altogether easy to utilize directly. The total amount of radiant energy received by the earth may be roughly reckoned at the equivalent of no less than 10,000 H. P. per acre, obviously more than enough to satisfy the extreme requirements of industry.

John Ericsson was the first engineer to take up seriously as a practical problem the task of utilizing this enormous store. With his customary dogged persistence he did not rest until he had produced a solar engine that would do serious work. The result he attained was the production of one horse-power per hundred square feet of exposed normal reflector surface,—a figure that has since been reached by other investigators, and which may, therefore, be taken as a safe basis of reckoning.

The method used by Ericsson, and by those who have followed him, was to concentrate the solar rays upon the boiler of an engine by means of a huge concave mirror, thus compelling the sun to furnish the fuel and serve as stoker. And the process worked well, both with the great inventor's hot air engine and with the ordinary steam engine. Clearly such a mirror, containing one or several hundred square feet of surface, could not economically or conveniently be made of a single sheet of glass, and as a matter of practice it has been found best to build up the reflector of plain strips of silvered glass, individually set in an appropriate framework. These strips do not bring the rays to an exact focus, but still easily concentrate them all on an object the size of the boiler employed. The composite mirror must evidently move so as to follow the sun in its daily course, and this is easily accomplished by clockwork.

A recent practical type of such apparatus is shown on this page. It consists primarily of a mirror structure forming the frustum of a short, hollow cone with its base turned sunwards. The cone is lined with strips of silvered glass, perhaps 2 feet long and 6 or 8 inches wide, set in a light steel framework by means of bolts and soft washers. The frame is supported between two skeleton piers on a polar axis capable of being moved in declination along the arcs shown projecting a little above the mirror, so as to follow the seasonal changes in the sun's altitude. This adjustment is readily made by hand every few days as required.



A 10 H. P. SOLAR BOILER AT SOUTH PASADENA, CALIFORNIA. THE BOILER CONSISTS OF ONE-INCH COPPER PIPE, BLACKENED, ARRANGED IN A 14-INCH DIAMETER SPIRAL. THE BOILER PRESSURE IS 200 LBS. PER SQUARE INCH. THE MIRROR CONTAINS 1000 SQUARE FEET OF SURFACE

The diurnal motion is given by clock-work. This is not continuous, as in clock-driven telescopes, but by steps every minute or two, the driving mechanism being locked during the intervals to reduce the danger of vibration from wind.

The boiler is a coiled water-tube affair of 1-inch blackened copper pipe, equipped with a superheater and placed axially in the center of the mirror. In the particular example shown, the mirror is 36 feet in diameter, and contains about 1000 square feet of silvered surface. The boiler carries 200 pounds pressure in full sunshine and is good for 10 H. P. Flexible couplings enable the steam to be readily led to the engine. The whole structure can be stripped, "knocked down," and put together in any sort of out-of-the-way place with no tool beyond a monkey wrench. There are no very heavy parts, so that the problem of transportation in a difficult country is comparatively simple.

The absorption of solar heat by the atmosphere is so great that when the sun is near the horizon such apparatus cannot be worked at full power, but in clear sunshine it is fully available for at least eight hours a day. Getting up steam after the sun is fairly at work is about an hour's task, and then the engine will drive steadily on until the approach of sunset.

Obviously a machine of this description, however excellent, cannot be used for general power purposes with good results, except in regions where there is reasonably steady sunshine. In the world's several arid districts, for example, such as what was formerly known as the Great American Desert, solar power is of consequence. In these a solar engine could be used nearly or quite 300 days per year, while cloudiness for more than a single day at a time would be quite unusual, as during the so-called rainy season many of the showers occur during the night. For irrigation work and other discontinuous employment sun power could, therefore, be freely used, and at a cost generally less than that of power generated by fuel.

The cost of power so obtained from sunlight is merely the cost of attendance and minor supplies plus the charge for investment and upkeep. The fixed charges, assuming a 10 H. P. unit like that shown, should not exceed, say, $3 per month per H. P., and the attendance would amount perhaps to $4 or $5 per H. P. more, so that the total annual expense would be, perhaps, $75 per H. P. per year, or about 3 cents per H. P.-hour, based on eight working hours per day.

This is considerably below the cost of power obtained from small steam or oil engines, and compares favorably with the prices commonly charged for electric power in small units where electric power is available. In operating two or more solar generators together, the attendance charge would be materially reduced. Single generators much larger than that described would be somewhat unwieldy, but two or more could readily be connected to a single engine or pump.

Sun-power is, therefore, readily available over very large areas in units of moderate size; but if the demand be for a general power supply, the case is less easy. Of course, solar engines could be used to drive dynamos from which power could be stored for continuous use; but about 30 per cent. of the energy would be lost in the extra transformations. In spite of this, sun-power must be regarded as even now practicable on a considerable scale within the favored areas.

There is a huge arid area in Northern Africa which could be thus utilized for industries requiring power, as Ericsson pointed out years ago. He estimated that the enormous amount of nearly 10,000,000 square miles of the earth's surface was available for solar power, and experience has shown that nearly all this semi-desert region can be reclaimed by irrigation,—space enough to support the whole of the earth's present population.

Without indulging in speculation of this sort, it is reasonably certain that very large areas, now sparsely populated, can be made available and furnished with all necessary power by utilizing the sun's rays, together with what water-power may exist.

It must be remembered that, if need be, solar heat can be made directly available for cooking, so as to render fuel for this purpose quite unnecessary, except as an occasional auxiliary. Even this minor use could be averted by a very moderate amount of electrical energy stored from solar engines. A few years ago very successful experiments were made in India on cooking by sun-power, and it is beyond question that the thing is not only feasible, but quite easy of accomplishment. Imagine an apparatus on the general plan of the one shown on page 336, but much smaller and with cooking compartments in place of the boiler, and solar cooking becomes a simple matter. It might be a bit difficult to arrange for frying in this way, but that would be reckoned by many as a positive advantage.

Incidentally, it should be mentioned that even now solar heat is being utilized for heating water for various household purposes. The apparatus for this purpose is absurdly simple, merely a sectional boiler of thin blackened copper, exposed on the sunny side of the roof under a glass cover very like a hot-house frame, and suitably piped for supply and demand. An hour's exposure to full sunlight raises the water to a temperature from 30 degrees to 60 degrees F. above that of the air, and as the heaters actually in use contain from 40 to 120 gallons, according to size, there is an ample supply of hot water through the hours of daylight. Solar water heaters of this kind have been installed on the roofs of many houses in Southern districts. They work admirably, and even in less favorable places have been found useful.

Given a mild climate where there is no need of elaborate heating devices for keeping comfortable, and all ordinary domestic needs are easily satisfied if the region is one where sunshine is available, and the demands of power-using industries can be readily met where hydraulic power is available, irrespective of solar power, or, in the sunshine belt, by solar power auxiliary to water-power, or even alone. No matter how completely the stored fuel supply is exhausted, the earth from the equator 30 degrees north and south can, by means even now at hand, be thoroughly habitable under the general conditions of our existing civilization. To latitude 40 degrees the conditions are somewhat less favorable, but the status quo can be generally preserved by skillful combination of existing sources of power. In higher latitudes there is trouble ahead, and while in some quarters of the earth the climate comes to the rescue, in others herculean engineering efforts will be needed to provide power for warmth, light, and industry.

The exhaustion of coal, or its extreme scarcity, will, therefore, bear hard on the north temperate zones, in which at present much of the world's industry is centered. Only resort to the most desperate efforts can render these available for the support of a large population beyond latitude 45 degrees. As soon as the hardness of the struggle and the competition of more favored climates has forced a migration sufficient to diminish greatly the density of population, the natural fuel supply will tend to increase and check further migration.

We are steadily exhausting the stored fuel supply that makes the world's present centers of population and industry tenable. Tides, wind, and sun may be called to the rescue; but these remedies are a desperate resort in a really unfriendly climate, and will hardly suffice to check the migration to regions of less strenuous needs. This shifting of population and industry will be none the less inevitable because it chances to be slow. Every fresh remedy for lack of fuel will make the process more easy and gradual; but when the fuel is used up, the sheer force of competition will ensure the dominance of the regions which make small demands for uneconomic uses of power.

A New German Electrical Combination

ANOTHER addition to the list of amalgamations in the German electrical industry, which has already witnessed consolidation of the Siemens and Schuckert works on the one hand with a share capital of $22,500,000, and of the Allgemeine and Union Electricity Companies on the other with a similar amount of capital, is proposed to be made by a fusion of the Felten & Guilleaume Company, of Mulheim, and the Lahmeyer Electricity Company, of Frankfort-on-Maine.

An official announcement on the subject states that, subject to the consent of the stockholders at forthcoming meetings, the directors of both companies have entered into an arrangement for the transfer to the Mulheim Company of the manufacturing departments of the Frankfort Company. The Lahmeyer Company will thus be left to continue the financial side of its business in relation to various electrical undertakings in which it is interested, while the capital of the Felten & Guilleaume Company will be increased from $9,000,000 to $13,750,000 for the purpose of absorbing the former's dynamo and other manufacturing departments, and also for strengthening the working capital. The fresh capital will be issued at a premium, and the title of the new concern will be the United Felten & Guilleaume-Lahmeyer Works Company.

A scheme for a train ferry across the English Channel is now before Parliament. It is proposed to construct a marine station at Dover for the transfer of the carriages from the railway. The carriages will be shunted on arrival onto an electric lift, and, after the lift has been lowered to the proper level, they will be hauled on board the boat over a short, movable bridge by means of electrical windlasses, the whole operation taking a maximum of four minutes. For the sea passage, four vessels are to be provided.

The Cooper Hewitt Single-Phase Vapor Converter

A SINGLE-PHASE vapor converter, intended to take the place of the ordinary alternating-current direct-current motor-generator set for the conversion of alternating to direct current, is now being put on the market by the Cooper Hewitt Electric Company, of New York. It is designed especially for charging storage batteries and for electrolytic work, though, it is claimed, it will operate well also on a resistance load, such as incandescent lamps.

Two views are given in Figs. 2 and 3 of the accompanying illustrations of the outfit complete, which is made up of the converter bulb,—an exhausted glass globe about 9 inches in diameter, containing the electrodes, and mounted in a metal ring supported on knife edges to allow the tilting motion for starting; an inductance coil mounted below the bulb, resembling in appearance a small transformer, and serving to steady the direct current; an adjustable inductance coil mounted behind the converter and serving to control the current strength; and a marbleized slate panel carrying a direct-current ammeter and a direct-current voltmeter and the handle of the regulator, as well as two double-pole switches controlling the alternating and direct currents. The entire apparatus occupies a space about 15 inches wide, 20 inches long and 20 inches deep. It can be placed on the floor or mounted against a wall.

The maximum capacity of the converter is 50 amperes continuous running, and the current is adjustable as low as 6 amperes. It may be adapted to any direct-current voltage up to 115 volts. Its efficiency at 30 amperes and 115 volts is approximately 80 per cent. This tends to increase as the current falls off. The apparatus is designed for any single-phase constant potential supply circuits of 60 cycles.

It operates without expert attention. As there are practically no movable parts, there is little chance of anything getting out of order, and therefore no special care is necessary. It will be found a very simple and feasible means of charging electric vehicles. Its cost is lower and its efficiency is higher than is the case with a motor-generator set, and no attendant is required. The apparatus, being protected by fuses, may be left running over night, provided the batteries be not overcharged thereby.

In explanation of the manner of operation of the vapor converter which may be acceptable to many readers in connection with the foregoing particulars, we cannot do better than quote from a pamphlet issued by the Cooper Hewitt Company, entitled "The Cooper Hewitt Mercury Vapor Converter and Allied Apparatus." This is a reprint of an article contributed several months ago to "The Technical World" by P. H. Thomas, S. B., chief electrician of the Cooper Hewitt Company, and from it also Figs. 1 and 4 to 8 have been reproduced.

Mr. Thomas, after explaining, in a popular way, the characteristics of alternating as distinguished from direct currents, briefly describes the Hewitt apparatus as consisting of a large glass bulb or globe, with a small puddle of mercury at the bottom constituting the negative electrode, and having at the top two or more electrodes of iron or other material. These electrodes are of various shapes, and usually not over 1 or 2 inches in size. Platinum lead wires run from all the electrodes to the outside line wires, through the glass, which makes a perfectly air-tight joint with this metal. The bulb is exhausted as perfectly as possible of all gases except mercury vapor. A converter of this type is shown in Fig. 4. In some cases it is desirable to make the electrodes all of mercury. Such a converter, with four positives and a negative, is shown in Fig. 5.

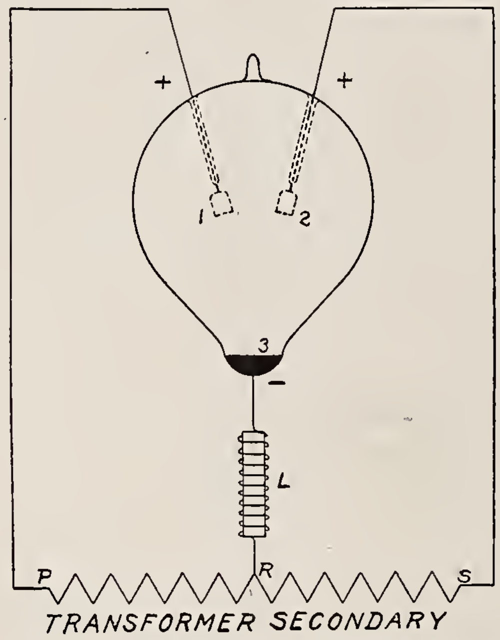


FIG. 1.—CONVERTER FOR SINGLE-PHASE ALTERNATING CURRENT

On account of the nature of the negative electrode resistance, if we connect a Hewitt mercury vapor apparatus across suitable direct-current mains, and start it by breaking down the negative electrode resistance, current will flow steadily until it is stopped by means external to the apparatus, this being the proper operation of the apparatus on direct current for giving light.

Suppose, however, we suddenly change the direct current to alternating current. At the instant of change, nothing new occurs. There is no difference in the operation of the apparatus, since we shall assume there is at the instant no change in the current. Then, referring to Fig. 6, at point *A*, where, we shall assume, the alternating current begins, it will be observed that the value of current begins to decrease, until finally a zero point is reached at *B*. At this time, of course, current ceases to flow.

Meanwhile the alternating electromotive force or voltage is reversed and begins to increase in strength. This reversal of direction makes the other electrode of the apparatus the negative, and, if we provide no means of overcoming its initial negative electrode resistance, no current can flow. The same condition will exist also when the alternating force has again become zero, and flows in its original direction, as indicated at the point *C* (Fig. 6). If the electrode resistance were broken down again at this point *C*, the lamp would start again, and would run until the current again became zero at the point *D*. It is thus evident that this apparatus cannot run continuously of itself on alternating current.

Suppose, however, instead of the ordinary lamp, which has but two electrodes, we use an apparatus like that shown in Fig. 7, which has two electrodes at one end and one at the other. Suppose we pass direct current between electrodes 1 and 3 in such a direction that 3 is the negative or cathode. Then, as in the mercury vapor lamp, current will continue to flow between these electrodes, and the negative electrode resistance of electrode 3 will be practically eliminated by this current.

Suppose, now, we apply, in addition to this direct current, the alternating electromotive force of Fig. 6 between electrodes 2 and 3. When the alternating electromotive force is at the point *A*, current will flow from 2 to 3,

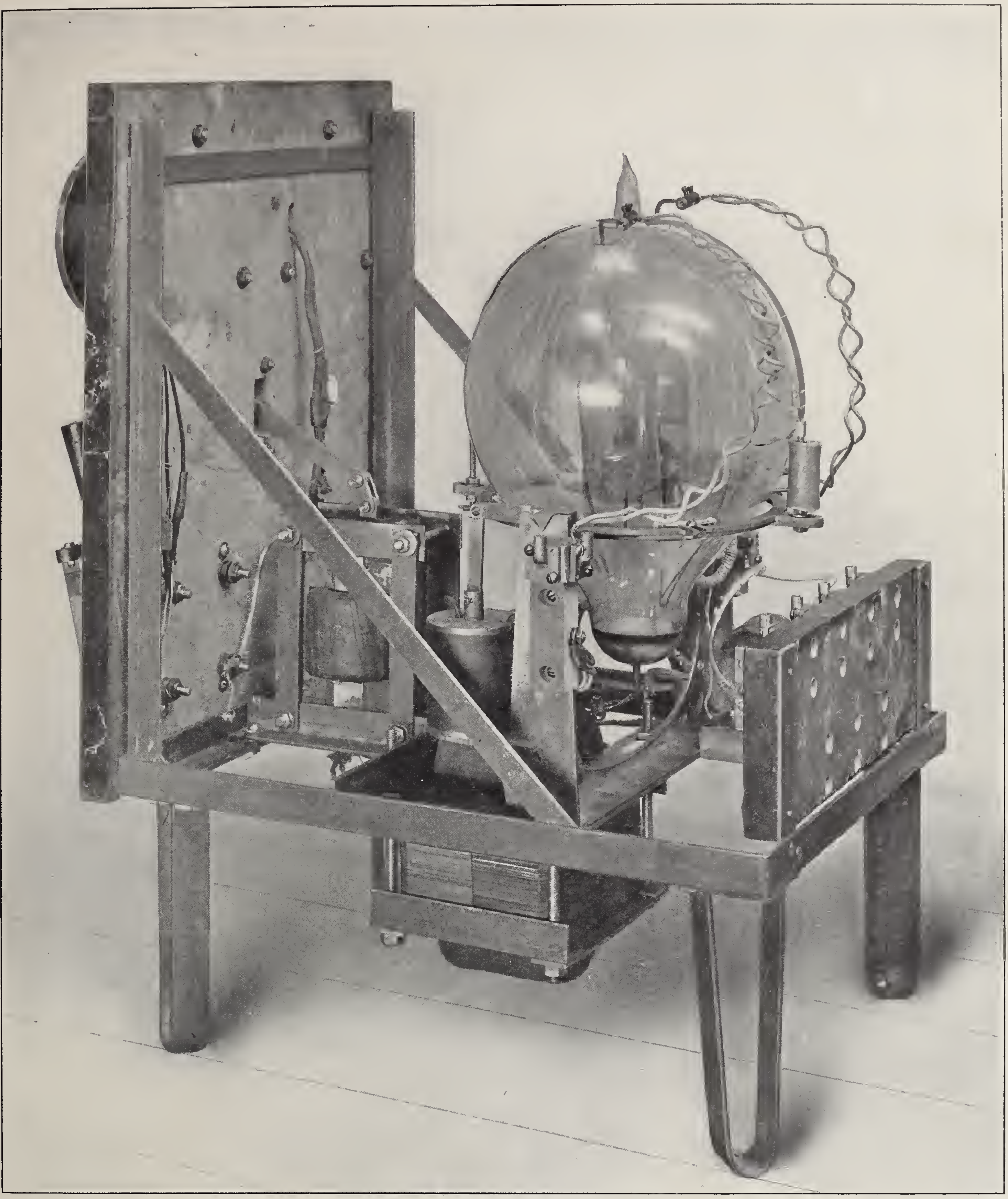


FIG. 2.—SINGLE-PHASE COOPER HEWITT VAPOR CONVERTER OUTFIT, MADE BY THE COOPER HEWITT ELECTRIC COMPANY, NEW YORK

since 3, being the negative for the alternating current as well as for the direct, has no negative electrode resistance, on account of direct current which flows to it from electrode 1. As the alternating electromotive force changes to the opposite direction, it attempts to flow from 3 to 2; but, since in this case electrode 2 is its negative, and since its intial electrode resistance is not broken down, the reverse alternation of the alternating current cannot start. When the alternating electromotive force returns to its first direction again, however, 3 is its negative, and current will flow as before.

Thus only those alternations of the supply which have the direction from 2 to 3 can pass, and we have succeeded in getting one kind of direct current from an alternating source.

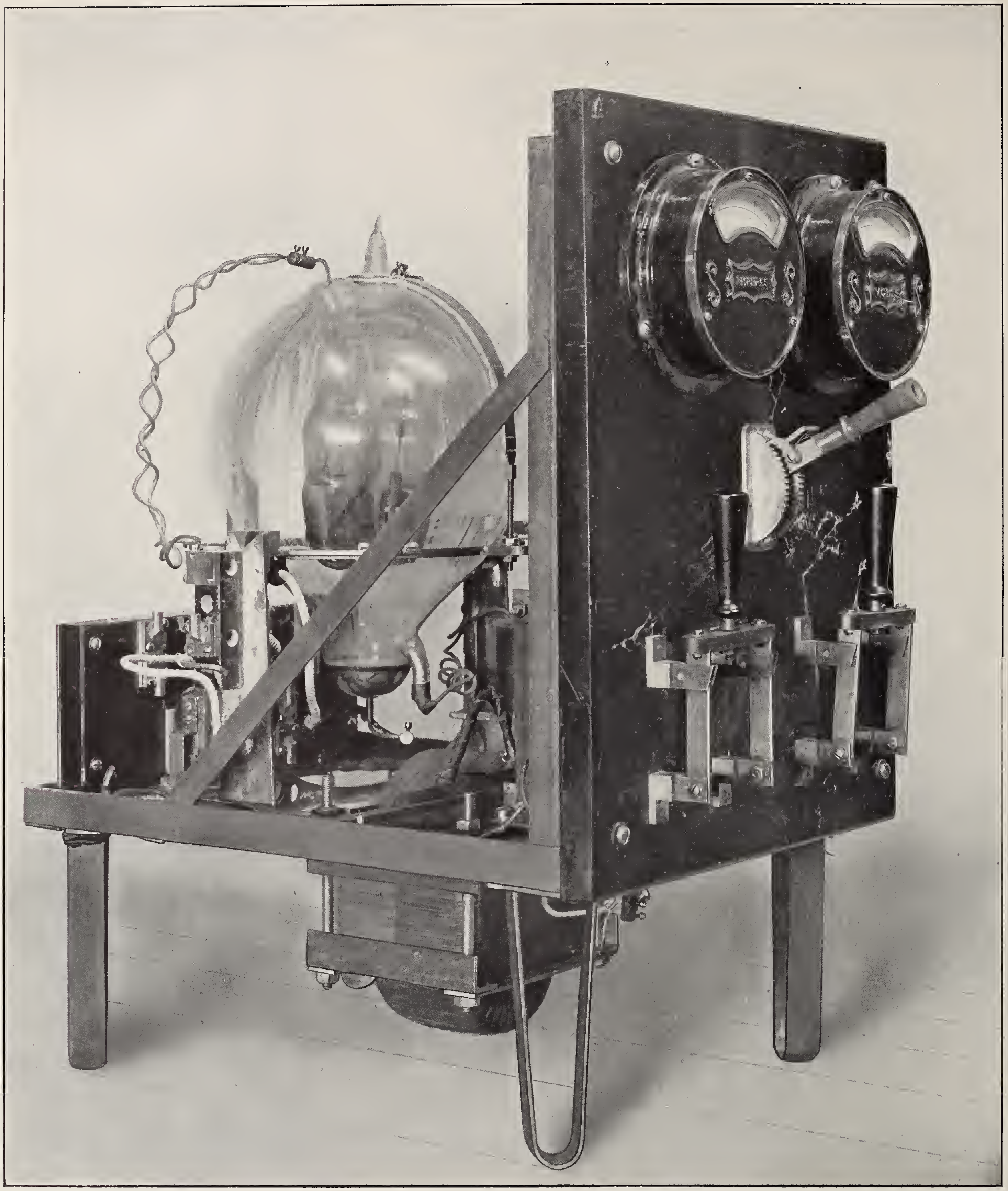


FIG. 3.—ANOTHER VIEW OF THE COOPER HEWITT CONVERTER OUTFIT, SHOWING THE FRONT OF THE SWITCHBOARD

The intermittent character of this current is shown at *a* in Fig. 8. This is perhaps the simplest form of converter. The direct current, however, though all in the same direction, is intermittent, and not well adapted for some kinds of work.

Take another case. Suppose we have a second alternating current exactly opposite to the first, and suppose we have a fourth terminal in Fig. 7 similar to Fig. 4, and that the new alternating current is sent from the new electrode to 3. The relation of the two alternating electromotive forces is shown in Fig. 6. It is evident that the second alternating current, like the first, will pass only those alternations which are in the right direction, and that the others will be suppressed. But the former come just at the times

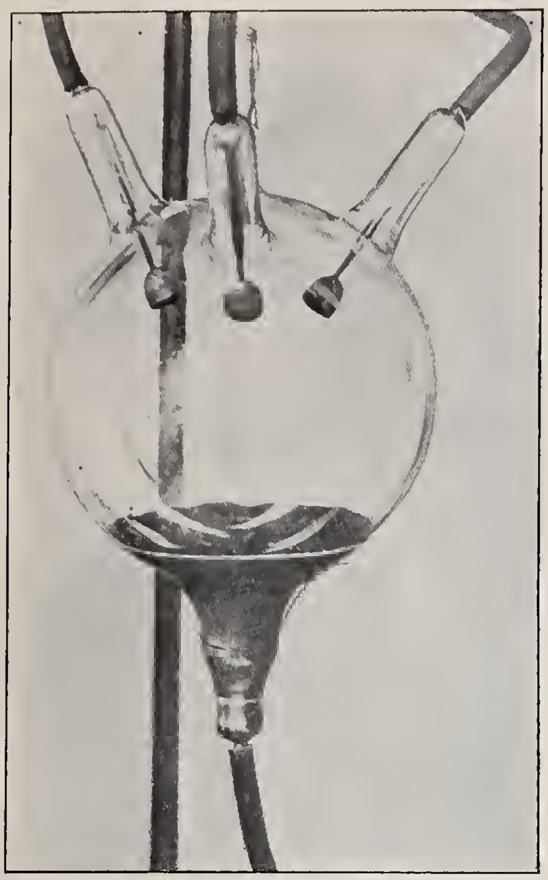


FIG. 4.—THREE-PHASE CONVERTER AS ORIGINALLY EXHIBITED BY DR. HEWITT

when the first alternating current is not acting, so that the gaps of direct current left by the first are filled in by the second, and the current flowing in the negative is much more nearly steady than in the first case. This current is shown at b in Fig. 8.

Should the direct current from 1 to 3 be suddenly stopped, alternating current would continue to flow from 2 or from the extra electrode, whichever happened to be then operating, until the first zero point was reached, when, since both alternating electromotive forces are zero at the same time, all current would cease and the apparatus refuse to operate.

Now, suppose that the vapor apparatus shown in Fig 4 be operated without direct current, and suppose that three different alternating currents be applied, each one between the negative and one of the three positive electrodes. These alternating electromotive forces are to be considered as three-phase electromotive forces—that is, each one lags one-third of a complete double alternation behind the one before it, as shown in b (Fig. 6). Suppose the electromotive force E in this figure to be passing a current from its proper positive electrode to the negative in the three-phase converter, shown in Fig. 4.

As this electromotive force becomes less and less until the point M is reached, the current through the converter would become less; but at this point the electromotive force F is seen to have risen to the same value in the same direction to which the electromotive force E has fallen; and thus, evidently, the electromotive force F, becoming greater than E, takes the current from E, and causes the current to increase in value again, following the curve F of the figure until the point N is reached, where the electromotive force G in turn takes the current away from F and carries it to the point P, at which the electromotive force E, having gone through a complete half-cycle, is ready again to take up the current from G and carry it to the point Q, and so on indefinitely. With this type of circuit there is evidently no time at which the current through the negative electrode becomes zero, and, consequently, the converter continues to operate indefinitely without the necessity of supplying direct current.

Such three-phase electromotive forces as are here described can be obtained from any three-phase circuit in which the neutral point is available. This is the type of converter first shown by Mr. Hewitt. It will readily be seen that in this case the direct current in the negative electrode—which is the current that is available for useful work—has a much steadier value than would be obtained by the apparatus of Fig. 7. Similarly, with an apparatus having still another positive electrode and four alternating-current electromotive forces, we should again have a converter in which the electromotive forces so overlapped as to require no direct current for bridging the zero points of the current. Such alternating electromotive forces can be obtained from any two-phase or one-quarter-phase circuit where the neutral point is available. In this apparatus the current in

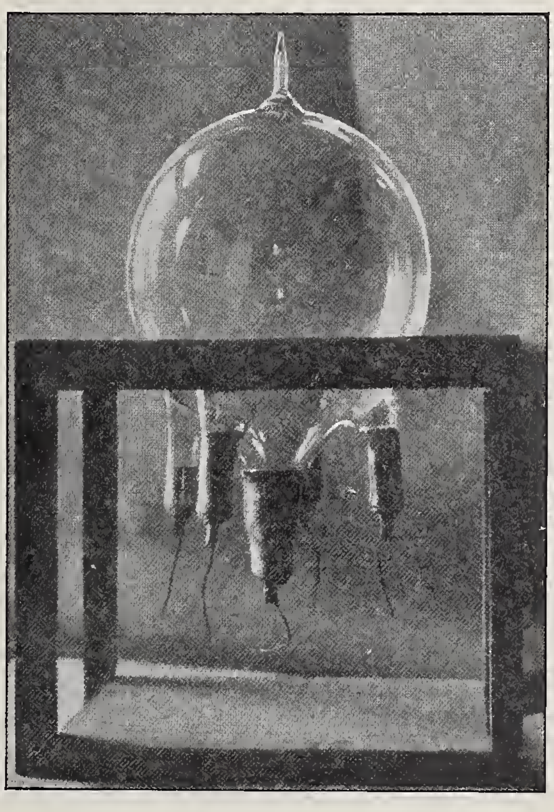


FIG. 5.—A VAPOR CONVERTER WITH ALL-MERCURY ELECTRODES

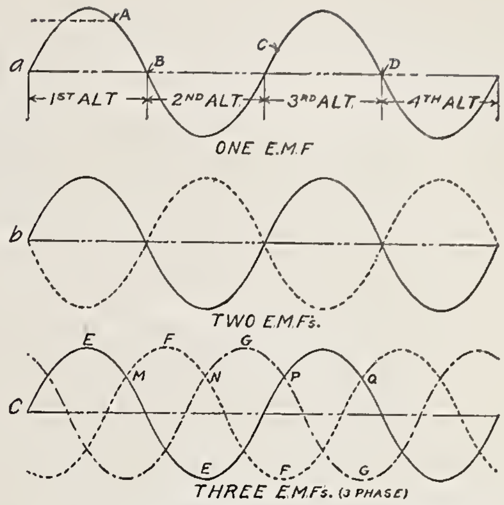


FIG. 6.—CURVES REPRESENTING SINGLE-PHASE AND POLYPHASE ELECTROMOTIVE FORCES

the negative is still more nearly steady than in the case of the three-phase converter.

The currents from the different types of alternating-current circuit are compared as to steadiness in Fig. 8. In this figure it is assumed that there is no choke coil to smooth out the variations of the current; whenever such choke coils are used, the current is materially steadied.

On many alternating-current circuits, however, only one voltage is available, and there is no direct current for bridging the zero points as was found necessary in Fig. 7. For these cases, it is very desirable to have some means of operating a vapor converter. This can be accomplished by the apparatus shown in Fig. 1, which is the same as that of Fig. 7, except for the connection to the supply circuit, and except for the choke coil placed in lead from the negative electrode.

Referring to the figure, suppose that the voltage between the electrode P and the middle point R of the supply transformer be supplying current through electrode 1; this current is delayed behind the electromotive force, since it has to flow through the choke coil. This means that when the electromotive force from 1 has dropped to zero, the current has not yet reached zero, since it lags behind. The converter does not go out at this instant. It would, however, go out a little later, when the current finally did reach the zero point; but the electromotive force between the terminals S and R, which is exactly opposite to that between P and R, is trying to force current from electrode 3 to electrode 1, and, on account of the lag of the current from 1, it will pick up this current before it becomes zero, and maintain it through the rest of the alternation, until this electromotive force in turn approaches zero.

Again, since the current is lagging behind, the electromotive force between P and R will pick it up from R and S before it actually becomes zero, preventing the converter from stopping, and so on. The simple introduction of the choke coil enables the apparatus of Fig. 7, when supplied by the proper electromotive force from a single-phase circuit, to operate indefinite-

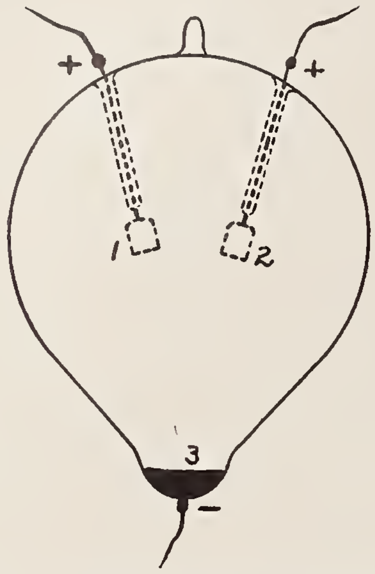


FIG. 7.—VAPOR CONVERTER WITH TWO POSITIVE ELECTRODES

ly without the use of auxiliary direct current. This is one of the most important applications of the converter. On account of the choking power of the coil, this arrangement gives quite a steady current; but, as in most of the cases above, it requires the neutral point of the alternating-current supply.

The vapor converter itself has a number of interesting characteristics. Its vacuum is similar to that of the mercury vapor lamp; on the other hand, since it is not intended to give light, its length is as short as possible;

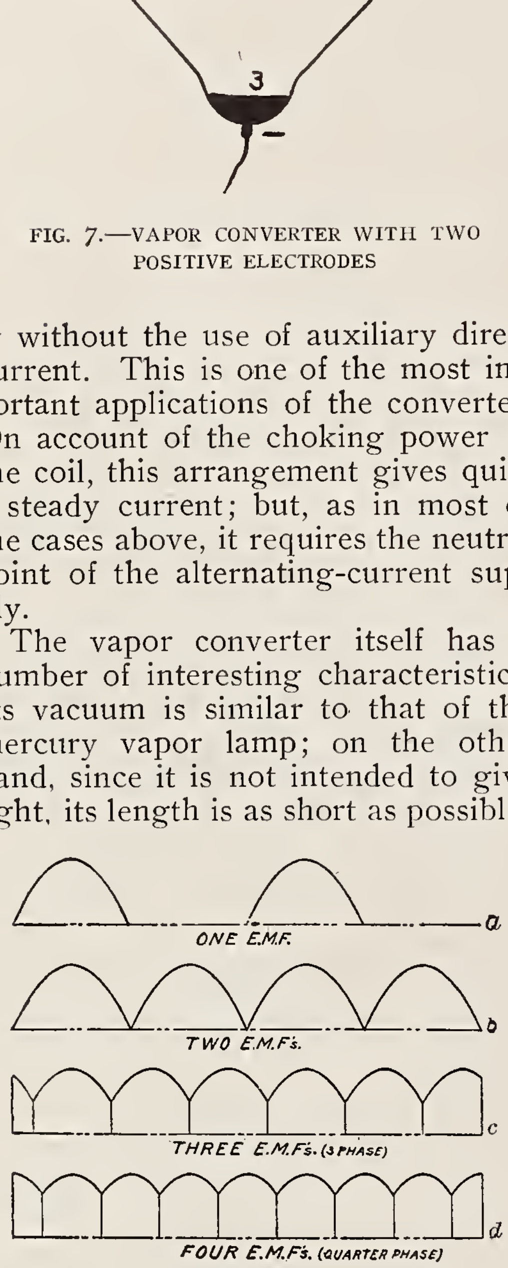


FIG. 8.—PULSATIONS OF DIRECT CURRENT FROM VARIOUS TYPES OF ALTERNATING-CURRENT SUPPLY CIRCUITS

this means that the voltage across the converter, which represents its total resistance, is reduced to 10 or 15 volts. As in the mercury vapor lamp, this voltage is practically constant, regardless of current, except for small currents. On the other hand, since with large currents in the container there is a considerable loss of energy, there is developed within the enclosing chamber a considerable amount of heat, which must be dissipated. It is therefore necessary to make the container itself of considerable size to get cooling surface; the mercury of the negative electrode is evaporated during the operation, and condenses on the surface, flowing back again to the electrode.

It is necessary to provide some means for the starting of the converter. This is accomplished in a number of ways, involving the same principles as the starting of the mercury vapor lamps. The converter can also be arranged to be started automatically.

Annual Meeting of the American Institute of Electrical Engineers

THE annual convention of the American Institute of Electrical Engineers will be held at Asheville, N. C., June 19-23, 1905. Arrangements have already been made for the presentation of the following list of papers:—

"Appalachian Water Powers," by F. A. C. Perrine; "Three-Phase Traction," by F. N. Waterman; "Limits of Injurious Sparking in Direct-Current Commutation," by Thorburn Reid; "A Study in the Design of Induction Motors," by C. A. Adams; Choice of Motors in Steam and Electric Practice," by Wm. McClellan; "High-Potential Oscillations of High Power in Large Power Distribution Systems," by Chas. P. Steinmetz; "Theoretical and Experimental Investigations on the Disruptive Strength of Air at Very High Voltages," by Chas. P. Steinmetz; "Heavy Electric Freight Traction," by C. de Muralt; "A New Instrument for Measuring Alternating Currents," by E. F. Northrup; "Motor-Generators and Rotary Converters," by W. L. Waters; "Frame Reactance." by Sebastian Sonstius; "Electrical Features of Block Signalling," by L. H. Thullen; "The Plant of the Ontario Power Company," by P. N. Nunn; "The Standardization of Fuses," by H. O. Lacount; "A New Induction Generator," by William Stanley.

Papers have also been promised by M. H. Gerry, Jr., John W. Howell, Percy H. Thomas and Dugald C. Jackson.

The committee on transportation and arrangements have arranged with the Southern Passenger Association, in whose territory Asheville is located, for a one and one-third round-trip fare on the certificate plan. The other passenger associations will probably follow the lead of the Southern Passenger Association in this respect. It is probable also that the Southern Railway Company will allow the members of the Institute a one-fare rate over their lines. As it will undoubtedly be convenient for most of the members in the New England and Middle States to meet in Washington, a special train will be run from Washington Sunday night, June 18, provided there are 85, or more, passengers.

The convention headquarters at Asheville will be at the Battery Park Hotel, where there is a suitable hall for the reading of papers. The hotel accommodations are excellent. The rates at this hotel will be from $3.00 to $3.50 per day, on the American plan.

The local committee is preparing a programme for the entertainment of members, and efforts are being made to make the convention attractive and pleasant. Delegates to the convention will have the privileges of the Asheville golf links, one of the most picturesque links in the country, and also of the Battery Park Hotel tennis courts. The natural attractions of Asheville and vicinity are exceptional. The city lies at an altitude of about 2200 feet above sea level, and is noted for its delightful climate during the summer months.

Local secretaries are requested to agitate in their several districts the matter of attending the convention in order to bring out large delegations from their respective territories.

The Bell Telephone Company is now closing a gap in its lines by which it will secure a complete telephone line from New York to San Francisco. The gap lies between Culbertson, Neb., and Ft. Morgan, Col., a distance of less than 200 miles. With the completion of the work, a direct through line will be established between Boston and Denver. Beyond Denver the service to the Pacific slope will be made over local lines of the Bell Companies, and the wires operated by the licensed companies which control extensive franchises in that region.

According to the report of the State auditor, 106 telephone companies are doing business in South Dakota, the number having increased from thirty-five in the last four years. Most of these companies have been organized as local conveniences and there is hardly a village or a farm in the old settled portion of the State that is not connected on one of these systems.

The Evolution of the Submarine Telegraph

By CHARLES BRIGHT, Assoc. M. Inst. C. E.

The recently-achieved jubilee of submarine telegraphy prompted the preparation by Mr. Bright of the following brief record of the engineering and electrical development of the submarine telegraph. It was originally presented before the Institution of Civil Engineers.—The Editor.

In no other branch of engineering have the principles originally laid down been so closely adhered to as in submarine telegraphy, whose pioneering days may be said to date from the year 1850, when the first telegraph between England and France was embarked upon. At the time of the early Atlantic cables, Professor William Thomson (now Lord Kevlin), evolved the speed-law for the working of submarine lines. He showed that the number of words capable of being transmitted through a cable in a given period of time depended inversely upon the electrical resistance of the conductor and upon its electro-static capacity, the product of these two quantities constituting the retardation effect.

THE CONDUCTOR

From the outset, copper was the metal selected for the conductor, that metal having a higher electrical conductivity than any other practicable material. Purity is the main object aimed at in the copper used for electrical purposes. In the earliest days of submarine telegraphy, the conducting power of copper was thought to be governed by its degree of softness, as an indication of the degree of purity. During the manufacture of the first Atlantic cable, however, Lord Kelvin discovered that other considerations entered into the problem of conductivity. He found that the effect of different foreign substances in the copper varied enormously, and that the increase of electrical resistance resulting from their presence was not by any means in regular proportion to the degree of hardening which they produced. Then, in 1860, Dr. A. Matthiessen made a complete investigation of the electrical conductivity of various specimens of copper under different conditions.

The general conclusions of these researches pointed primarily to the extreme importance of purity. Dr. Matthiessen found that the presence of even a small percentage of silver—notwithstanding its high individual conducting power—reduced the electrical value of copper considerably. The number of alloys introduced, as well as their proportions, also told against the result; and even the merest trace of arsenic was found not only to make the copper hard and brittle, but to reduce the conductivity by as much as 40 per cent.

Thus a chemical change was shown to occur by the mixture of various metals and metalloids, which produced an electrical result entirely independent of the specific value of each of the components taken separately. Matthiessen found that besides reducing the conductivity enormously, the alloys of copper seriously affect its mechanical qualities.

The beneficial effect of annealing a wire was also observed for the first time during these researches; and electrical conductors are now always so treated. Previously it had been the custom to specify only the gauge of the wire; but since the date of Matthiessen's experiments, the purest copper obtainable has always been insisted on for electrical conductors, and a certain proportion is tested to ensure this. The relative conductivity (C) of a wire, referred to that of pure copper (taken as 100) may be obtained by multiplying its calculated resistance (p) by 100, and dividing the product by its actual observed resistance (r). Thus $C = \frac{100\,p}{r}$.

The conductivity of the first Dover-Calais line of 1850 was as low as 30, and 50 was the corresponding figure for the first Atlantic cable. The great advances that have been made in the manufacture of copper wire—due largely to Matthiessen's exhaustive researches*—are best illustrated by the fact that at the present time commercial copper is frequently obtained which yields a higher conducting power than that of the standard of purity, which, therefore, obviously needs revision. Recent developments in smelting and refining account to a large extent for the advance made in the conductivity of commercial copper, and in 1883 Sir William Preece showed the importance of greater attention being paid to the drawing of the wire. The author has urged the desirability of applying a mechanical test, in addition to the usual electrical test, to the copper wire before stranding, in order to guard against brittleness.

The conductors of the earliest cables were composed of a single wire, Fig. 1, usually of No. 16 Birmingham wire-gauge. This simple form, besides being the most economical of construction, was the best adapted to electrical requirements, in view of the combination of a maximum amount of copper and a minimum outside surface, thereby introducing a minimum resistance and inductive capacity. It was, however, soon discovered that when conductors exceeding a certain size were required the single wire involved was too rigid to meet the necessary mechanical qualifications; and for ocean cables this form of conductor was very soon replaced by a conductor composed of several wires laid up together in the form of a strand.

The stranded conductor, Fig. 2, was first adopted in 1856, on the Gulf of St. Lawrence line, acting as a connecting link with the Atlantic cable, the conductor of which was similarly constructed a year later. Besides the objection on the score of rigidity, a single solid wire was found to be open to other objections, which were to a great extent met by stranding a number of smaller wires to produce a similar electrical result. The chance of a flaw in the metal or in a joint was a case in point, it being unlikely that a flaw would occur at the same spot in all the wires of a strand. The stranded conductor also had the advantage that the "lay" of the wires provided a certain margin for yielding, and so accommodated themselves to longitudinal strain.

It was, however, soon found that the stranded form had also its disadvantages. Thus, in the case of one of the small wires breaking, the fine points are more likely to damage the insulation, and possibly penetrate to the iron sheath, than with a single-wire conductor of comparatively large diam-

*Matthiessen also discovered that the electrical conductivity of metals varies with their temperature in accordance with the compound-interest law. The conductivity of copper at 6 degrees C. being represented by 100, and C being its conductivity at any temperature t, it was found that $\frac{C}{t} = 100 - 0.38701\,t + 0.0009209\,t^2$.

eter. Further, there is the greater chance of water creeping from a loose end along the inside of the core, although this is largely met by using "Chatterton's Compound," to be referred to later.

In 1863 an attempt was made by Messrs. Bright & Clark to combine the mechanical advantages of the strand with the electrical advantages of the solid wire, in the design for the first Persian Gulf cable of that year. The conductor, Fig. 3, was composed of four longitudinal quadrants fitted into one another and drawn down under pressure through a copper tube. Although a complete success, this conductor proved very costly on account of the labor, time and machinery involved in its construction.

In the Direct United States Atlantic Cable of 1874 the conductor consisted of a stout central wire 0.091 inch in diameter, surrounded by eleven smaller wires of 0.035 inch diameter. The section of this conductor, Fig. 4, shows that a given quantity of copper may be contained in a smaller circle by this method than in a strand formed of wires all of equal diameter. This device originated with the late Sir William Siemens, who claimed that the increased conductivity amounted to 10 per cent., with a sensible increase in working speed.

Messrs. Siemens Brothers have since adopted this form of conductor for all the Atlantic cables with which they have been concerned; and the last cable made by the Telegraph Construction Company for the Anglo-American Telegraph Company in 1894 was furnished with a similar conductor, the pattern of which has become more or less universal for all lengths exceeding, say, 1000 miles. In order, however, to meet the requirements of speed on so great a length as that involved by one of the sections (3458 nautical miles[1]) of the recently laid all-British Pacific cable, the conductor was constructed somewhat on the Bright and Clark system already described, as being a closer approximation to the electrical requirements so absolutely met by a single solid wire.[2]

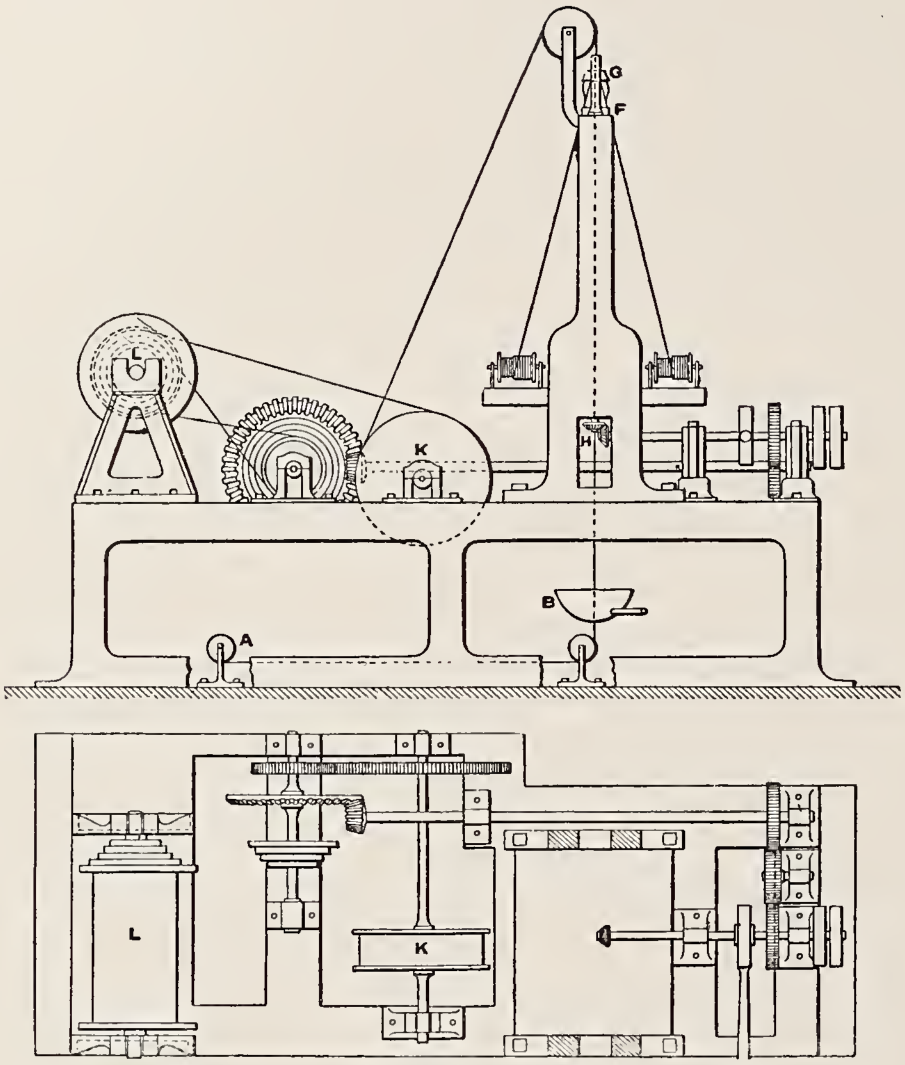
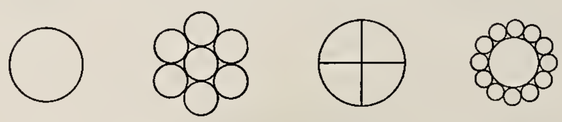


FIG. 5.—ELEVATION AND PLAN OF MACHINE FOR STRANDING CONDUCTORS

For moderate lengths the stranded conductor, pure and simple, is, however, usually adopted. The strand consists, in general, of seven wires of the same gauge—one central wire and the remaining six wires laid round it. Other combinations are possible, but this is found to give the most satisfactory results, electrical and mechanical. The gauge adopted for an ordinary stranded conductor varies according to the conditions between 0.028 inch diameter (No. 22 Standard wire-gauge), and something like 0.056 inch diameter (No. 17 Standard wire-gauge). For short cables, the conductor is sometimes composed of a strand of only three No. 22-gauge wires; and on the other hand, the central wire of the Siemens conductor used in some of the most recent Atlantic cables is 0.122 inch in diameter. This is surrounded by twelve wires, each 0.041 inch in diameter. There are limits to the gauge of wire which may be employed. If it exceeds a certain size it cannot be stranded; if it is too small, it is liable to break in stranding, and, if broken in the completed cable, to pierce the insulation.

It is now universally recognized that a high working speed should be attained by low conductor resistance rather than by low electro-static capacity. Conductors are therefore made of larger dimensions than they used to be, apart from the demands for high speed being so much greater. The Commercial Cable Company's 1894 Atlantic cable has a conductor weighing 500 pounds of copper per nautical mile; and the Anglo-American Company's cable of the same year is furnished with a conductor weighing as much as 650 pounds of copper to 400 pounds of gutta percha per nautical mile. Here again, however, a limit must be observed, or the number of sheathing wires involved will seriously increase the weight of the cable.

The stranding of the conducting wires is usually accomplished by means of a machine of the vertical rope-making pattern, shown in Fig. 5—occupying a ground space of about 10 feet by 5 feet. The central wire is drawn off the bobbin *A*, and is conveyed by a guide pulley through the



FIGS. 1-4.—TYPES OF CABLE CONDUCTOR

pot of "Chatterton's Compound" *B*, kept in a molten state by steam-jacketing. This composition, introduced by Mr. John Chatterton and the late Mr. Willoughby Smith in 1858, consists of three parts by weight of gutta percha to one of Stockholm tar and one of resin.

Thus compounded, the central wire is then drawn through the hollow

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[1] The longest length of cable at one stretch.

[2] Other attempts have been made from time to time to arrive at the same end, but difficulties have arisen in practice which have prevented their success. One of these plans is that of filling up the intermediate wires of the ordinary strand by worming them with intermediate fine wires in the process of stranding. Another plan is that of compression—i. e., by drawing the finished strand through a die and thus compressing the wires against one another, thereby obviating interstices, and also reducing the outside circumference of the strand. Although this compression naturally has the effect of hardening the copper and reducing the conductivity, this may be subsequently corrected by annealing the completed strand.

vertical shaft *C*, Fig. 6, and in passing through the die-plate *G* is enveloped by the outer wires. The latter are wound on bobbins *D*, supported on a horizontal turntable revolving with the shaft *C*. These wires are conveyed from their individual bobbins, through the two dies *F* and *G*, in turn, where they meet the center wire and are laid round it in more or less elongated spirals, the length of lay being governed by the rate of draw-off. The number of these bobbins obviously depends on the number of outer wires composing the strand. The machine, *i. e.*, the shaft and attached turntable, is rotated by means of bevel-wheels *H*. The stranded wire is conveyed by means of a pulley to the measuring drum *K*, Fig. 5, and thence on to the carrying reel *L*, which, when fully loaded, is taken off the machine and replaced by another. The stranded wire is usually made in 2-mile or 3-mile lengths, but in very heavy conductors 1 nautical mile is often the limit.

The length of lay is determined in practice by mechanical considerations, it being made sufficiently short, on the one hand, to ensure a firm lasting union between the wires, and long enough, on the other hand, to secure a sufficient degree of pliability. This is usually represented by about 1¾ inches for an ordinary seven-wire strand of No. 22 Standard wire gauge (107 pounds per nautical mile) to about 3 inches for a similar conductor composed of large wires, representing a total weight of, say, 500 pounds per nautical mile. The length of each outer wire of given lay for enveloping a wire of the same section may be ascertained thus:—

Let a denote length of lay.

Let b denote circumference of centers of enveloping wires.

Let l denote length of wire required for one complete turn round center wire.

Then, $$l = \sqrt{a^2 + b^2}$$

The rate at which the conductor is stranded depends mainly on the lay, and therefore also on the size of the wire; but something like a 5-mile length is a maximum output of stranded conductor from any one machine during a working day.

THE INSULATOR

The history of submarine telegraphy may, for practical purposes, be said to start with the introduction of an insulating medium suitable for the purpose. Previously a number of substances had been experimented with, some of which actually survived a practical test for underground wires as well as for subaqueous conductors across rivers and canals. In 1816 the late Sir Francis Ronalds employed glass tubes coated with pitch and resting in wooden troughs, in an experimental underground line. Another method of insulation that was tried for subterranean wires was by means of cotton steeped in tar.

From 1837 to 1840 Professor Wheatstone was engaged on a method of insulation for a proposed submarine cable across the Straits of Dover. Wheatstone's first idea was to envelop the conductor in tarred rope; but later he proposed to use worsted and marine glue, with an outer lead tube. It was in the attempt to overcome the problems of an aerial system through the humid atmosphere of tunnels that india rubber was first employed for insulating an electrical conductor; and it was not until then that any complete

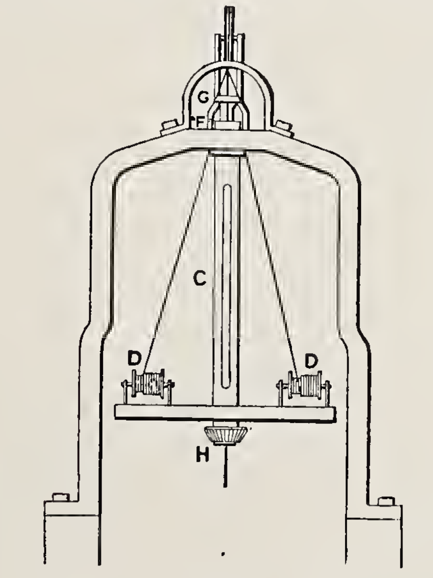

FIG. 6.—A DETAIL OF FIGURE 5

system of subaqueous insulation was accomplished. Even then but little was done before the introduction of gutta percha a year later. This, for insulating purposes, was brought about independently, in 1840, by Faraday and Werner Siemens.

On the discovery of the insulating properties of gutta percha and india rubber, their investigation was taken up by a number of chemists and engineers. The problem before them was how to apply the gum in a workmanlike and lasting fashion. Mainly owing to defective joints, the first attempts were by no means successful in either material. The material was rolled round the wires either in spiral or in longitudinal strips, thus involving a continuous joint, more or less subject to the percolation of water. In a method introduced by Messrs. Barlow and Foster in 1848 several wires were drawn between sheets of a compound of gutta percha, New Zealand gum and sulphur, the whole being pressed between rollers. Apart from other objections, however, the gutta percha was never sufficiently purified of wood and other substances to be met with in the gum when in the raw state.

The late Mr. Charles Hancock, in the same year, introduced a gutta percha mixture which produced no better results; the gutta percha being applied in strips or spirals, water percolated to the conductor at the seam. In fact, Messrs. Siemens and Halske appear to have been the first to use gutta percha for insulating conducting wires on a large scale successfully. In 1847 the late Dr. Werner Siemens devised a machine for covering wire with gutta percha by a method similar to that adopted in the manufacture of macaroni; and this, together with the Bewley tube-making apparatus of 1845, was undoubtedly the germ of the perfected gutta-percha-covering machines of to-day, the great merit of which is the avoidance of any seam by feeding the gutta percha in a plastic condition, from a steam-heated cylinder, through a die of the necessary diameter to give the desired thickness of covering.

The first gutta-percha-covered subterranean wire was laid by Messrs. Siemens between Berlin and Grossberen in 1847, not long after Dr. Montgomerie showed the first specimen of gutta percha at the Society of Arts. The same firm, a year later, laid a similarly-constructed line for a submarine mine system in the port of Kiel, and another across the Rhine from Dentz to Cologne. In 1849, a 2-mile length of gutta percha-covered wire was laid experimentally by Mr. C. V. Walker in the English Channel, on behalf of the Southeastern Railway Company. The copper conductor (No. 16 Birmingham wire gauge) was successfully signaled through after submergence; and this was accepted as a satisfactory test of the possibility of submarine telegraphy.

In the following year the first cross-channel telegraph line was embarked on. This was constructed by the Gutta Percha Company, and consisted of a copper conductor, thickly covered with gutta percha for the greater part of its length, but at each end the insulation consisted of cotton saturated with a solution of india rubber. Its failure the day after submergence could not be traced to any inherent defect of manufacture; but the method of insulation at the ends would scarcely lend itself to a lengthy electrical career at the bottom of the sea. The first actual complete submarine cable as at present constructed was laid a few months later, in 1851. This was manufactured by the same firm. There were six conductors, each of which was covered with gutta percha to a diameter of one-quarter inch.

For some years after the introduction of india rubber and gutta percha, various mixtures of these substances with other materials were tried, with a view to improvement and economy; but with gutta percha these all proved complete failures, the fact being that the purer it is the better is the result mechanically and electrically, and the greater its durability; indeed, even quite small admixtures deteriorate the material seriously, by degrees leading to complete breakdown, usually owing to physical change in the structure by chemical action. These investigations were, however, not without purpose, if only in saving their repetition to-day. With gutta percha costing double what it did at the time of the first Atlantic cable, and sometimes as much as 10s. per pound (owing to comparative scarcity and great demand) where it has been as low as 9d. per pound, it will be readily understood that, but for these early researches, manufacturers would be sorely tempted to adopt mixtures. As it is, attempts are sometimes made; but they do not meet with success.

The collection and preparation of the gutta percha gum, and the methods of mastication, etc., adopted for getting rid of impurities and foreign matter, scarcely form a part of the subject of this article; but the gutta percha covering and its manufacture may be briefly dealt with. Although gutta percha does not lend itself favorably to alliance with other substances, owing to chemical action being set up, various species and qualities of gutta from different parts may be mixed together with perfectly homogeneous and satisfactory results. Indeed, as soon as the price of the gum went up to an appreciable extent and competition in cable-making set in, this course was resorted to—in addition to the admixture of resinous matter, mainly for electrical reasons. Thus, although sometimes the addition of inferior insulating guttas has temporarily an improving effect mechancially, the gutta percha core of today is usually inferior in respect of lasting qualities to that of former times.

On the other hand, the total insulation on a line of given dimensions is nowadays much greater than it was in early times, partly owing to the efficiency achieved in joint making, as well as to the use of resin. Thus, a core when tested for dielectric resistance would show 10 megohms per nautical mile, say, thirty-five years ago; whilst nowadays some 1500 megohms per nautical mile can be obtained with a similar core. The electro-static capacity is, again, very much less than it used to be, owing to the greater proportion of resin and to increased mastication.

The introduction of anything like a large proportion of resin reduces the life of the gutta percha covering, as does also excessive mastication, by the removal of moisture; and the author has pointed out that the attainment of desired electrical results by artificial means of this character should be avoided. The deteriorating effects of resin are such that it would be well if, on a cable order being given, all the gutta percha obtainable were tested for capacity and insulation, and the specification based on the results obtained with the more durable materials. The latter usually have a moderate, rather than an extreme, insulation-resistance; and it should be observed that a cable having a comparatively low dielectric resistance—provided that such can be relied upon—is superior for electrical working to one having an abnormally high insulation.

Even with the imperfections in pioneer core making, it was observed that the insulation tended to improve after submersion. Salt water being so good a conductor and gutta percha having a considerable power of absorption, this was naturally a matter of some surprise. It was, however, then discovered that low temperature as well as high pressure (such as exist at the ocean bottom) increase the electrical resistance of gutta percha enormously. The effect of pressure on the insulating qualities of fibrous vegetable substances was first demonstrated before the British Association in 1863 by the late Sir William Siemens, based on experiments in which varying degrees of hydraulic pressure were applied to the gutta percha core of the 1861 Malta-Alexandria cable, and on certain india rubber cores. The formula arrived at was:—

$$R_p = R\ (1 + 0.00023p)$$

where R denotes the original resistance at atmospheric pressure, p denotes the pressure in pounds per square inch, and R_p denotes the increased resistance resulting from that pressure.

Thus, the increase of electrical resistance on unit resistance by unit pressure was 0.00023, which is equivalent to 2.3 per cent. for every 100 pounds per square inch pressure. In the course of similar experiments on the first Persian Gulf cable of the same year, Messrs, Bright and Clark found 2.6 per cent. increase of resistance due to pressure. The author believes that the subject has not since been dealt with on an extensive scale; and, with altered material and manufacture, such constants may not now apply to gutta percha cores in general. The law governing the variation with temperature of the resistance of gutta percha was determined by Messrs. Bright and Clark in the same year. During construction at the factory the core of the last-named cable was subjected to a series of tests in a tank of water, the temperature of which was altered as required. The following formula was obtained from the results arrived at by experiment:—

$$R \times 0.8944^t = r$$

where R denotes the resistance at any given temperature, t denotes the increase of temperature in degrees Centigrade, 0.8944 is a constant deduced from the experiments, and r denotes the resistance at the higher temperature.

The results went to show a variation closely, if not absolutely, coinciding with a logarithmic law, as in the case of metals, but at a greatly increased rate and in the opposite direction. If, however, strict accuracy is desired, the coefficient is sensibly inapplicable nowadays to gutta percha generally, and should really be separately determined for each gum and quality, and still more, perhaps, for core of different ages. Another important item in connection with the electrical resistance of prepared gutta percha is the mechanical "setting," as it is called, of the gum whilst maturing, more especially immediately after it is made up, the result being a great increase of resistance. The full bearing of this has only been appreciated within recent years; and in 1896 the author suggested a standard age for the purposes of specification and subsequent tests.

In connection with the construction of early Atlantic cables, Professor Thomson (now Lord Kelvin) enunciated the principle that the electrostatic capacity of a cable core depends upon the surface of the conductor and the thickness of the dielectric; that it, in fact, varies by inverse compound interest in respect of the relationship existing between D and d, which is expressed in the formula:—

$$KL \frac{1}{\log \frac{D}{d}} \quad 1$$

where K denotes the electro-static capacity of a hollow cylinder of length L, D and d being the exterior and interior diameters.

The core of the 1894 Anglo-Atlantic Cable—650 pounds copper to 400 pounds gutta percha per nautical mile—is shown in Fig. 7. This core—the largest so far made—yields a speed of nearly fifty words per minute by simplex working, the total length being 1955 nautical miles.

The quality of the dielectric also has a material influence on the capacity of a core, and the author has shown that more often than not a high insulation resistance implies a low electro-static capacity, the resistance to induction being great. Owing

FIG. 7.—THE CORE OF THE 1894 ANGLO-ATLANTIC CABLE

to the comparatively high cost of gutta percha the custom is for the dielectric to be made of just sufficient thickness to ensure mechanical safety, the requirements of speed being mainly met by the bulk of copper put into the conductor for low-resistance purposes. Some of the inferior gutta perchas having quite a high inductive resistance, the author takes this opportunity of suggesting that outside the ordinary insulation covering might be applied a further covering of low-class gutta, worked in with the jute serving, for reducing the capacity and thereby increasing the working speed of a cable. The majority of the cables at the bottom of the sea are insulated with gutta percha manufactured in accordance with a method instituted in 1869 by the late Mr. Willoughby Smith for reducing the capacity. The feature of this process is the freeing of the pores more thoroughly of moisture when drying the gutta after it has been through the washing masticator.

At the present time there are several different types of gutta percha-covering machines. Perhaps the oldest is that consisting of an ordinary cylinder and piston. The gutta is placed in the cylinder, and the piston forces it out into a die provided with holes through which the wire is drawn. This arrangement was soon found to be open to the serious objection that air enters the cylinder with the gutta, and finds its way into the pores of the latter. When a gutta percha covering contains air, the trouble only arises after the pressure of the ocean has forced it out again, causing a hole in the covering.

In 1879 an ingenious core-making machine was introduced by the late Mr. Matthew Gray, of Silvertown, by which air is excluded. The gutta percha is drawn between two horizontal rollers *D D*, Fig. 8, in the form of a thin sheet, to be afterwards forced along to the die by means of an Archimedean screw *A*. The uniform driving of the latter at an unvarying pressure provides a regular and uniform feed to the die-box *B*, through which the wire is led, and ensures uniformity of thickness.

By means of an additional set of rollers it might be found possible to squeeze out more moisture and to improve an inferior gutta mechanically and electrically. In any case such a plan would—by introducing mechanical "set"—obviate the delays caused by waiting for the effect to take place.

On its way to the gutta percha machine, the wire is led through a small tank of "Chatterton's Compound" *T*, in order to fill up all interstices and to ensure firm adhesion. Before the days of this compound, the subjection of the cable to strain sometimes caused the wire to start out of its gutta percha envelope. It was found, in the early days, that the core used to get damaged during manufacture owing to its hot—and consequently soft—condition. To meet this difficulty, on leaving the gutta percha machine the wire is slowly led through a long trough filled with water at an extremely low temperature, the result being that the core becomes perfectly hardened before it reaches the collecting drum.

In the early underground wires, and in the first submarine line of 1850 between Dover and Calais, all the insulation covering was applied at one operation. In the Channel cable of 1851 the gutta percha was laid on in two separate coatings, with the view of protecting and making good any small faults. This plan is now generally adopted, the number of coats for a medium core being usually three or four—or even five for heavier cores, such as those employed in Atlantic cable conductors. The thinner the coats, the greater is the chance of detecting flaws. In ordinary lengths of less than 1200 nautical miles, the total thickness of insulation is the minimum found to be safe for mechanically protecting and insulating the conductor; and three coats, each of 30 mils thickness (making a total weight of 140 pounds per nautical mile) is the recognized covering for the ordinary copper wire of 107 pounds per nautical mile, two coats being deemed somewhat risky, although with smaller conductors for very short lengths the latter number of coats are found to be sufficient.

An application of "Chatterton's Compound" is required between each two successive coats, and this material, besides being itself non-durable, has sometimes proved to be the cause of trouble in acting injuriously on the insulation and in tending temporarily to mask faults therein until the cable is laid at the bottom of the sea.

It may here be urged that the core should be tested after each separate coat has been added.

To meet these objections Mr. Ludwig Loeffler in 1880 introduced an ingenious compromise. By Mr. Loeffler's method, adopted by Messrs. Siemens Brothers, the gutta percha is applied to the wire in separate streams, but at one operation, by means of a multiple-die arrangement. The latter is provided with a series of holes, each one of successively larger diameter, and through these the wire is drawn. To the space between each set of holes lateral passages are fitted, in communication with the store of plastic gutta percha; so that, as the wire travels along, it receives its successive layers of gutta. The success of such a plan is dependent on the gutta being sufficiently "tacky" to ensure the coats properly adhering of themselves, involving therefore the maintenance of a somewhat higher temperature. By this method currents of air have a rather greater scope for intrusion than in the previously-described apparatus.

Perhaps partly on this account it has been the practice of Messrs. Siemens Brothers for the last twenty years to apply a pressure test to the core on completion. Besides representing the conditions about to be experienced at the sea bottom the pressure test at once brings to light any faults due to the presence of air or to other causes. Should there be any air imprisoned in the core the hydraulic pressure will cause the gutta covering

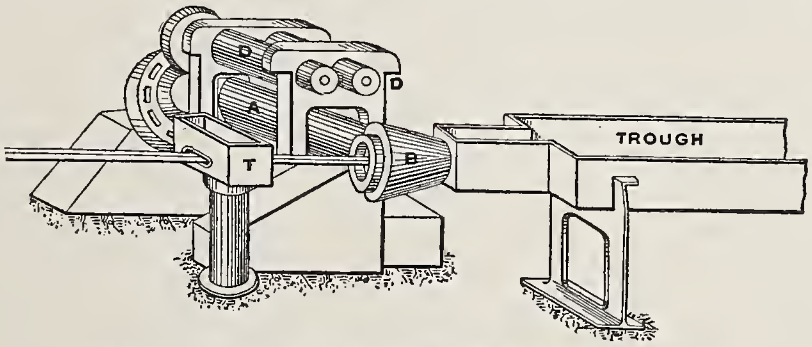

FIG. 8.—GRAY'S CABLE CORE-MAKING MACHINE

it to burst, thus revealing the defect, which can then be made good at the factory. The following is a brief description of the method of applying this test:—

The drum of core is first lowered

FIG. 9.—A SCARF JOINT

FIG. 10.—THE COPPER WIRE WRAPPING

FIG. 11.—THE COMPLETED JOINT

into a steel cylinder filled with water, having sides 18 inches in thickness. For the purposes of connection, stuffing-boxes are provided in the breech piece, for the end of the insulated conductor to pass through, the core being submitted to electrical tests whilst under hydraulic pressure applied by force pumps. The pressure is adjusted in accordance with the depth of water in which the cable is to be laid, and may be anything up to about 8 tons per square inch, which well provides for all conditions hitherto experienced. It may be considered that so severe a test is liable to permanently damage the core; on the other hand, the author has pointed out that the pressure might be employed for producing a permanently improving effect mechanically and electrically; and it seems as though a field of research might here be open for elucidating the problem of high speed and cheap but durable cables, and for meeting the requirements of long-distance telegraphy and telephony between important centers. A difficulty lies in the fact that such ideas can only be put to a useful test by a cable being not only made in accordance therewith but laid at the sea bottom—a somewhat costly experiment if culminating in failure.

The joints between the various lengths of core have now reached a high pitch of perfection. A scarf-joint, Fig. 9, with fine copper wire wound round it, followed by soldering, is the usual form for the conductor, Fig. 10. The gutta percha is then warmed at each side and is gradually drawn over the completed metallic union, after which two successive layers of new gutta serving are applied and worked over with a warm tooling-iron until the whole is fairly uniform. The completed joint, Fig. 11, is then placed in water at a very low temperature until it has become thoroughly cooled and hardened.

For the insulation of submarine cables the only other material which has been used in practice is india rubber. Although similar in regard to the method of collection and purification, manufactured india rubber is a very different substance from manufactured gutta percha; for, unlike the latter, a number of other substances are required to be mixed with it. Professor Jacobi, of St. Petersburg, in 1842, conducted a series of experiments on the electrical qualities of india rubber for covering underground conductors; but Mr. Charles West appears to have been the most prominent in first drawing attention, in the same year, to its practical utility as an insulation material for submarine purposes. Mr. West covered a few fathoms of copper wire with india rubber tape, and submerged it from a small boat somewhere in Portsmouth harbor. The experiment was a success, although the line did not work for long.

Notwithstanding that india rubber was introduced for the purpose on short underground lines some time previously to gutta percha, it never came into use on anything like a practical scale until after gutta percha had been similarly employed for many years. The first attempt, in 1848-1849, by Thomas Hancock, S. W. Silver & Company, Siemens and others, did not, in fact, meet with much success, owing to the chemical and physical changes which take place in rubber with variation of temperature. It was found also that when in contact with copper it was liable to undergo a species of decomposition, and to become permanently softened. This destructive action is now checked by "tinning" the copper conductor.

The hygroscopic qualities of rubber were also found to be a serious barrier to its use for submarine work. After being melted, india rubber never regains its former state, remaining soft and sticky when cold. On this account, as well as owing to its elasticity, it cannot be moulded or laid on to a wire in a tubular form when rendered plastic by heat as is done with gutta percha. Messrs. Siemens introduced an ingenious machine for applying pure rubber by what was then an improved method. Two strips of rubber were placed longitudinally on either side of the conducting wire, and the whole was then drawn through semi-circular grooves, which, in firmly pressing the strips round the conductor, caused them to unite at the edges. The main principle of the apparatus may be seen repeated in many modern india rubber-covering machines. More usually, however, the outer covering is applied spirally, for producing a firm binding and reducing the objections to a continuous seam more or less subject to the percolation of water.

When the late Mr. William Hopper applied the process of vulcanization to india rubber cores, a great improvement was effected; for, by the admixture of sulphur to the outer covering of rubber at a high temperature, the material is rendered impervious to climatic changes. In the Hopper core there is first a coating of pure rubber round the wire, then a mixture of rubber and zinc oxide to protect the wire from the sulphur in the outer "jacket."

There was, however, still the objection that the material could not be applied in tubular form, and that, therefore, a continuous seam is present in the core. Moreover, owing to a lack of homogeneity, the joints, as well as the core generally, are far less trustworthy than in the case of gutta percha. Again, on account of its variability, besides being less reliable than the latter material, it is liable to deteriorate, physically and electrically, rather than to improve, on submergence in the sea.

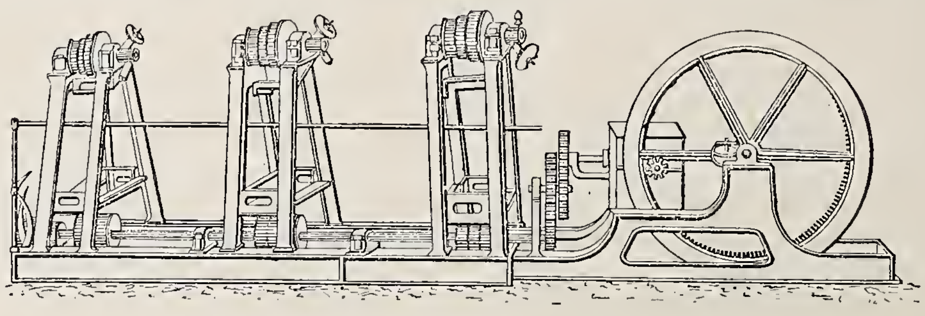

FIG. 12.—A MODERN TYPE OF TAPING MACHINE

Thus, although specifically superior in insulation and resistance to induction, india rubber cores are not usually employed for submarine lines except under special conditions where gutta percha is less satisfactory, such as at high temperatures, on dry beaches, in shoal depths, and in teredo-infested waters. Considerable lengths of india rubber core cable have been made and laid by Messrs. Hooper and the Silvertown Company in such localities; and in the event of the scarcity of gutta percha reaching a serious pitch, further attention will certainly require to be given to the development of india rubber as an insulator for submarine cables.

The cost of the ordinary insulation of a submarine cable forming so large a proportion of the whole, it is but natural that various attempts have, from time to time, been made to find a suitable cheap substitute for gutta percha and india rubber for this purpose. Okonite, kerite and nigrite are the names of some of the mixtures of each that have been tried in one way or another, but no lasting success has so far been met with in this direction. Quite recently what is known as "Gentzsch's gutta percha" has been brought to the notice of the public. In this, no natural gutta percha is said to be used. It is claimed to be much cheaper than the latter, the process of manufacture being extremely simple, and the result a low inductive capacity. "Gentzsch's gutta percha" is stated to have behaved well under severe practical tests, and if all that has been said of it proves to be correct, this material should have a future before it.

METAL TAPING

For waters in which the teredo or other marine organism abounds, the gutta percha core is usually enveloped in a metal taping. So far back as 1852 the brothers Edward and Charles Bright introduced a metal taping outside the jute serving, by way of protection to an insulated core. It was not, however, until 1878 that the present method was introduced by Mr. Henry Clifford, in which the tape is applied immediately outside the core itself, thereby ensuring a more even bed, and avoiding rucking. The substance usually employed for this purpose is Muntz metal, or some other form of brass, mainly on account of its toughness and strength. A fine, wet cotton tape, about one-half inch in width, is first applied spirally to the core; then the brass tape, of the same breadth and 4 mils in thickness; and finally a cotton tape, previously soaked in stearine, or ozkerite, mainly for purposes of preservation. The taping is all applied with half-overlap and with opposite lays, for complete protection. Cotton threads, without overlap, are sometimes preferred to calico tape, as giving a softer and more even bedding.

A modern type of machine for applying all the tapes at one and the same time is shown in Fig. 12. A three-speed cone pulley is attached to each tape-loaded head, these being revolved by belting from the main shaft at the base of the machine. Each "head" holds about a mile of tape, and the successive lengths of brass are brazed together. A dab of compound serves for uniting the lengths of tape and "whipping" for the threads. The speed at which the taping operation can be performed depends, of course, on the width of tape and length of lay adopted—which again depend on the size of the core—but 3 or 4 miles length of cable may be taken as an average day's output. In view of the corrosion to which all forms of brass are more or less subject under the combined action of sea water and iron sheathing, Mr. Arthur Dearlove (of Messrs. Clarke, Forde & Taylor), has proposed to coat the metallic strip with anti-sulphuric enamel, but this plan has not yet been adopted in practice.

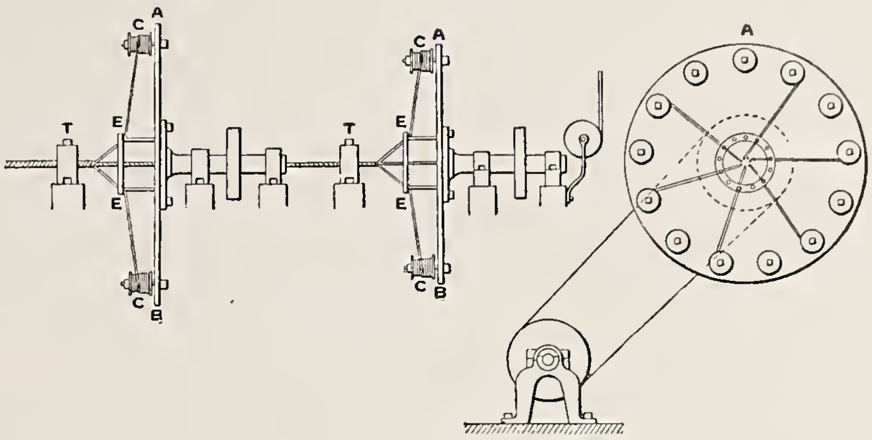

FIG. 13.—MACHINE FOR SERVING THE CORE

INNER SERVING

It was at once recognized that the insulated conductor could not be laid in water of any depth—and, if laid, could not be maintained or subsequently recovered for repairs—without outside armor. It was also recognized that the core must be enveloped in a bedding of some sort to take the sheathing of iron wires adopted at the outset by way of armor. Hemp yarn was selected for this purpose in the first cable of 1851, which has formed, indeed, the pattern of all subsequent cables, so far as cardinal principles are concerned. The thickness of the yarn serving depends upon the number and size of the iron wires forming the cylindrical sheath. Being softer and more pliable, jute was soon adopted in place of hemp. It being discovered that jute had a tendency to decay in water, it soon became the practice to adopt tarred jute for this purpose, on account of the insulating and waterproofing qualities of tar. The damaging effect—electrically and otherwise—of drawing the served core through a vessel of molten pitch, was, however, bound to manifest itself in time, and especially after the "masking" of faults of insulation by the tar had been overcome by the pressure experienced subsequent to submergence.

Thus it came about that in 1860 the late Mr. Willoughby Smith introduced jute that had been previously steeped in brine or spirit. This was adopted for the inner serving of a cable by Messrs. Bright & Clark, in the Persian Gulf line of 1863, it being expected to have the effect of "showing up" rather than "masking" any small defects in the dielectric. This proved to be the case; but the brine and the sea water combined tended to shrink the yarns, the core being sometimes strangled in consequence. Subsequently, therefore, jute soaked in a solution of tannic acid—a strong preservative for fibrous substances—was adopted for the inner serving. Tanned jute is now generally adopted in this country, the jute being thoroughly shrunk previous to application; and, being applied under a stream of water, there is every chance of discovering flaws in the insulating envelope. Jute yarns have a very low breaking strength, the result being that the yarns frequently part in the process of "laying up" round the core. They also rapidly decay in water, especially when in combination with iron; thus the inner serving is the weakest and least durable part of a submarine cable.

The machine for serving the core, shown in Fig. 13, consists of a hollow shaft carrying an iron disc *AB*, about 6 feet in diameter, upon which the bobbins *C*, containing the jute yarns, are disposed circumferentially, near the edge. A hollow ring *E*, pierced with as many holes as there are bobbins, is fixed to the disc by four iron studs, and therefore rotates with it. The jute yarns—usually "single ply"—as they are unwound from their bobbins, are conveyed through the holes in the guide ring *E*, and meet the core, round which they are wound.

The core itself is drawn forward through the hollow shaft by means of pulleys. At the point of junction with the core, the yarns pass through a die or lay-plate *T*, which consists of an iron collar divided horizontally into two parts and adjustable according to the diameter of the served core. The rapid rotation of the hollow shaft and disc, combined with the slow longitudinal "draw off" of the core, results in the jute yarns being wound in more or less spiral form.

The stoppage of the machine—for loading with a fresh bobbin, or for making a joint—is effected by a brake, acting upon the revolving parts. The joints are constituted by a whipping of single-spun yarn bound round the ends. The number of bobbins is mainly governed by the thickness of serving required.

With an average core about twenty-five separate yarns is a usual number for a first serving, and for intermediate or shore-end types the yarn is thicker than for the main type. The inner serving is invariably applied in two separate and reverse layers, the core, after it has been served with the first layer, being drawn through another similar machine running in the opposite direction. The inner serving is applied with quite a short lay (between 2 inches and 3½ inches), as longitudinal strength is not important, in order to provide a fairly close packing for the core, the limit being that the outside circumference must not be so great as to prevent the sheathing wires butting against one another.

The weight of the inner serving in a cable may be calculated and arranged for in the following manner: In Fig. 14, let D_1 be the diameter of the center line of the iron wire in inches; D the diameter of the dielectric in inches; d the diameter of a single wire, also in inches; and n the number of iron wires. Then the transverse sectional area of the jute is $0.7854 \left(D^2_1 - D^2 - \frac{n}{2} d^2\right)$ in square inches, and the weight per nautical mile of the serving required to fill up the space between the core and the cylinder of iron wires is approximately $20 \left(D^2_1 - D^2 - \frac{n}{2} d^2\right)$ cwt.

Recent practice has tended towards reducing as much as possible the thickness of the inner serving with a view to reducing the bulk, and therefore the weight, of the cable. This can only be effected by tight packing, which must not be pushed too far or it may result in a springy, uncoilable cable. With cables in which the core is "brass-taped," or the outer wires are not strictly "close-sheathed" but are first individually protected by tape, the inner serving may be reduced without affecting the mechanical properties of the cable. In the case of multiple-conductor cables for heavy traffic to neighboring islands and continents, the insulated conductors are laid up and "wormed" with intervening jute yarn—the process being somewhat

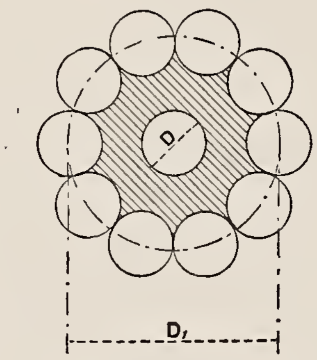

FIG. 14

similar to that in serving and sheathing—followed by the usual inner serving.

SHEATHING

The armor of a submarine cable is usually composed of a close sheathing of iron wires having a diameter of 0.07-inch to 0.400-inch, according to circumstances, and varying in number between ten and twenty. For the purposes of after recovery from great depths, tensile strength and lightness are the main objects. A wire of comparatively small gauge, of mild (Bessemer) steel or homogeneous hard-drawn iron, is therefore adopted, such a wire having a breaking strength of at least 80 tons per square inch. For shallow water cables, however, the considerations are entirely different. Thus, in the type used for shore approaches, large metallic surfaces to withstand abrasion by rocks, etc., and great weight to avoid shifting and consequent strains in anchor-ridden waters or heavy seas and strong currents, are of the first importance.

The increased quantity of metal thus entailed being more than sufficient to withstand all longitudinal strains likely to be experienced under such conditions, an ordinary class of iron wire ("Best-best" quality) of comparatively low-tensile strength, say 30 tons per square inch, may be employed. Moreover, the reduced rigidity thus obtained is necessary on account of the increased bulk. This wire gives an elongation of 18 per cent., and, being annealed, it is very ductile.

In any cable, as now made, there are at least three types of construction, namely, the "shore end," the "intermediate" and the "deep sea" (or "main") cable, the last mentioned usually constituting by far the greater portion of the entire length. The "shore end" is employed, say, for the first 2 miles from the beach, in depths up to about 35 fathoms; the "intermediate" to a depth of 250 fathoms; and the "main" type for the remaining portion. Sometimes, however, as many as six different types are necessary for coping with the varying conditions along the route, and then it is often found convenient to apply a distinguishing number or letter to each. The "shore end" type is usually furnished with two sheathings, the outer of which is composed of wires of large diameter, with an intervening layer of jute.

In general, more or less the same quality of iron is employed for the ordinary "intermediate" type in a single sheathing of wires of medium, though rather large, diameter. With a view to preserving the iron from oxidation, the sheathing-wires of all types are, and have practically always been, galvanized. When a stock of sheathing-wire reaches the cable factory, a certain percentage of the hanks or coils, besides being weighed and gauged, are tested for tensile strength, elongation and torsion, the two former tests being applied in the case of deep-sea types and the latter to the shore end and intermediate wires. Results of such tests, showing the capabilities of the various classes of wire at present employed for sheathing submarine cables, are given in the table on page 351.

The galvanizing is also tested for quality and thickness. It was early discovered that galvanizing does not completely preserve the sheathing wires against corrosion by salt water, especially when the cable rests on ground containing soluble sulphides. Under such conditions, rust ensues and the cable becomes so weakened as to be incapable of recovery for repairs. It was partly to meet these drawbacks that in the 1865 and 1866 Atlantic lines each iron wire was encased in tarred hemp. This type of construction was subsequently adopted in a number of undertakings, but it did not prove durable and was eventually abandoned.

The oxidizing influence of salt water on the galvanized iron wires is nowadays mainly arrested by the use of "Bright & Clark's Compound," a mixture of mineral pitch, tar and silica. This composition was first adopted on the Persian Gulf cable of 1863.

The actual proportions, as well as the temperature of the mixture, are varied according to circumstances, the silica (from calcined flints) being added for the purpose of withstanding the attacks of the teredo. At the present time it is customary to dip each hank of sheathing wire into a tank of this compound whilst hot.

Another method of preservation, introduced in 1870 by Matthew Gray and Frederick Hawkins, and largely adopted in modern practice, is the envelopment of each iron wire in cotton tape previously saturated with the compound, thereby rendering it more or less waterproof. Besides reducing the specific gravity, the taping of each wire has the additional advantage of rendering an ordinary close-sheathed cable more pliable and therefore better adapted to cable operations, such as coiling, uncoiling, laying and recovery, where rigidity and springiness are liable to lead to accidents and even to kinks.

RESULTS OF TESTS OF SPECIMENS OF IRON WIRE USED FOR SHEATHING CABLES

Number of Tests Averaged	Diameter of Wire in Inches			Breaking Strength in Lbs.			Elongation per Cent. 10-inch Length			Torsion Twists in 6-inch Length			Breaking Stress in Tons per Square Inch		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
No. 6 L. S. W. G. Wire															
15	0.200	0.204	0.196	2,434	2,610	2,220	24.8	27.0	22.0	14.0	15.0	13.0	34.6	35.6	32.8
14	0.198	0.201	0.194	2,039	2,160	1,910	16.7	20.0	14.0	16.5	18.0	15.0	29.6	31.9	29.0
30	0.200	0.204	0.198	2,435	2,580	2,220	20.2	24.0	15.0	...	...	...	36.0	39.0	32.8
30	0.199	0.203	0.197	2,225	2,460	2,040	17.0	21.0	12.0	17.0	25.0	10.0	33.2	35.3	32.1
30	0.202	0.205	0.197	2,324	2,550	2,100	23.0	29.0	17.0	11.0	20.0	10.0	33.7	36.9	31.7
No. 9 L. S. W. G. Wire															
25	0.144	0.151	0.141	1,143	1,296	1,065	17.9	21.0	16.0	23.3	26.0	20.0	31.2	34.3	29.4
40	0.145	0.147	0.142	1,122	1,298	1,003	15.6	22.0	11.0	23.0	26.0	20.0	30.3	34.1	27.1
40	0.144	0.147	0.142	1,102	1,232	1,007	14.7	20.0	10.0	23.3	26.0	21.0	30.1	32.8	27.4
15	0.144	0.147	0.142	1,147	1,272	1,045	14.4	20.0	11.5	23.7	28.0	21.0	21.3	33.5	28.2
15	0.143	0.145	0.142	1,122	1,301	1,004	14.6	17.0	11.0	24.1	25.0	22.0	31.0	35.7	27.1
No. 13 L. S. W. G. Wire															
25	0.098	0.100	0.096	1,454	1,600	1,360	6.8	8.0	6.0	...	....	...	93.5	105.1	89.4
30	0.098	0.101	0.095	1,430	1,600	1,300	7.9	8.0	5.0	...	...	...	92.0	96.7	78.5
30	0.098	0.101	0.096	1,404	1,600	1,320	6.7	8.0	5.0	...	...	...	90.3	100.8	90.6
25	0.099	0.102	0.096	1,506	1,640	1,360	6.5	8.0	4.0	...	...	...	94.8	107.8	91.3
30	0.099	0.101	0.094	1,478	1,610	1,390	6.3	7.0	4.0	...	...	...	93.1	99.3	85.7
No. 14 L. S. W. G. Wire															
30	0.083	0.085	0.081	1,152	1,280	1,050	5.4	6.0	4.0	...	...	...	104.9	110.9	95.6
30	0.083	0.085	0.081	1,119	1,240	1,020	6.1	7.0	5.0	...	...	...	101.9	107.4	90.6
30	0.083	0.085	0.082	1,100	1,300	1,020	5.7	7.0	5.0	...	...	...	100.2	112.6	95.3
30	0.083	0.086	0.081	1,078	1,180	1,000	4.9	6.0	3.0	...	...	...	98.2	99.7	95.9
30	0.083	0.087	0.081	1,003	1,060	950	4.8	6.0	3.0	...	...	...	91.3	99.0	86.5

The individual taping of each iron wire adds somewhat to the initial cost of a cable, but, in the author's opinion, this is more than repaid where the exigencies of recovery become a serious consideration. The taping operation is usually performed by vertically spinning round the wire a disk loaded with the prepared tape, the speed of draw-off providing for the desired lay with a slight overlap, where the width of the tape is about one-half inch.

The process of laying up the iron wires is performed in much the same way as the serving, by means of a wire-rope-making machine. Apart from providing for longitudinal strain without damage to the core, the semi-spiral lay ensures a firmer cohesive binding than could be obtained by a number of straight wires laid side by side. In ocean cables, however, the lay is determined with a view to providing the greatest possible longitudinal strength, by distributing the stress proportionately to the various component parts of the cable, as well as for ensuring a firm "binding."

Broadly, the following is the routine of the operation of laying up the wires:—The served core is drawn from the tank in which it is coiled, by means of pulleys, through a hollow shaft of the "closing" machine, to which is connected a skeleton cage frame which carries the bobbins of wire. The wires then unite round the served core at a certain distance from the carriage, the cable being drawn steadily forward throughout, as fast as it is made up. The wires are led from the bobbins through their respective holes in a plate, arranged in a circle at equal distances from one another. They are thus wound round a serving in a perfectly symmetrical form, after the manner of a long helix, the actual length of lay being governed by the relation existing between the velocities of the longitudinal and rotary motions.

The proper tension is kept on the cable throughout by adjustment of the hauling-off gear. It is apparent that, unless special provision be made, each wire will be twisted through 360 degrees at every revolution of the carriage, and will, therefore, very soon break. In the application of the jute serving, torsion does actually take place, but in this case it gives rise to no serious inconvenience, owing to the pliability of the jute or hemp; the only precaution necessary in this instance is to see that the jute is as free as possible from twist to start with.

In the sheathing machine, on the other hand, special arrangements must be made to eliminate all torsion from the wire. This necessity was recognized in the manufacture of ordinary wire ropes many years before the introduction of telegraph cables, both by W. Küper and R. S. Newall. In the devices introduced by Mr. Newall, the bobbins all turn on their own axis as they revolve round the axis through which the core passes, and remain always horizontal, thereby ensuring the absence of twist in any individual wire. This constitutes what is known as a "sun and planet" motion, and all sheathing machines are constructed on this principle.

The early sheathing machines used were of the vertical type, as were also the rope-making machines of that period. These were, however, replaced, after a time, by horizontal machines, the first of this class being used in the manufacture of the Persian Gulf Cable of 1863, at the works of W. T. Henley. This form has been adhered to ever since. Although the vertical machine naturally occupied less floor space on the same level, it involved either a materially greater diameter to carry all the bobbins, or a number of platforms to enable it to be attended to at various points, thus also requiring a larger number of attendants to look after it. With the horizontal pattern, moreover, a higher working speed is possible. In the early machines the revolving carriage to hold the bobbins took the form of large disks of great weight, and the speed at which it was safe to run such a machine was limited.

These have, therefore, been gradually replaced at all the cable factories by machines having carriages consisting of a long and comparatively light framework. For laying up very heavy wires, the old disk carriage is still sometimes adhered to, speed having, in such cases, to give way to strength; moreover, in the class of wire involved, the breaks are of somewhat frequent occurrence, and, therefore, high speed would be out of place. Again, the lengths of the heavy types being comparatively small, there is practically no call for a high speed. In the case of a double-sheathed cable, the second sheathing is performed by the cable being run through a larger machine suited for loading with the heavy class of wires constituting the outer sheath.

A general view of a modern sheathing machine for light cables is shown in Fig. 15, the principles of its construction being illustrated by Figs. 16 and 17. The three frame wheels *A*,

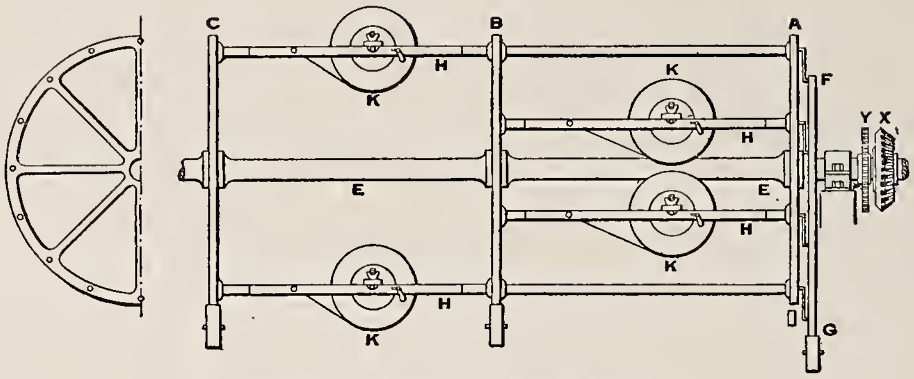

FIG. 16.—A DETAIL OF FIGURE 15

B and *C*, Fig. 16, are keyed to the hollow shaft *E*, and turn with it. Round the circumference of the front wheel *A*, are fitted several cranks *m*, Fig. 17, of equal length, which are coupled to a large ring *FG*, the diameter of which is equal to that of the wheel *A*. The center of the ring is in the same vertical line as the center of the wheel *A*, and the ring is kept in position by the two adjustable rollers *DD*.

For carrying the reels of wire *K*—of which there may be as many as twenty-four, according to the number of wires—rectangular horizontal iron frames *H*, Fig. 16, are fixed between the wheels *A* and *B* and between *B* and *C*. On a bobbin of wire being entirely wound off, the empty bobbin is replaced by a full one, and the ends of the wire are jointed together. With the large soft iron wires, this joint is effected by a weld only. The small "homo" and steel wires are, however, jointed together by "brazing," i. e., a hard metal, like brass, is used as a solder.

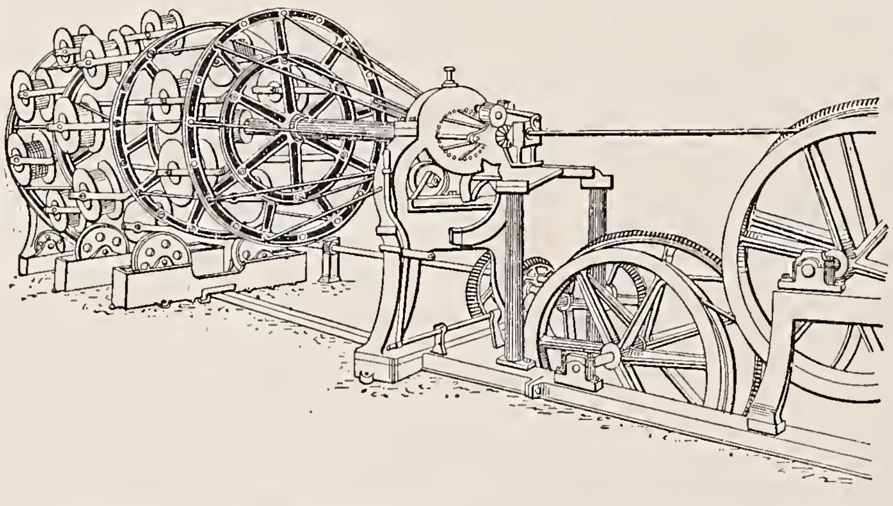

FIG. 15.—A MODERN SHEATHING MACHINE FOR LIGHT CABLES

Within recent years, however, the joints in both classes of wire have been very successfully made by the process of electric welding, which provides a weld free from sulphur and other impurities, and therefore superior to any ordinary forge weld, besides being more quickly effected. These joints in the wires necessitate stopping the machine whenever a bobbin has to be changed. The length of wire which each drum or bobbin holds varies considerably with the class of machine and the type of wire. In any case, however, the stoppages are fairly frequent, as arrangements are, as a matter of course, made so that no two wires terminate at the same point. A small strap-brake presses against the frame or spindle of each bobbin, thus restraining its motion and causing the wire to unwind with the requisite amount of tension.

On leaving the bobbin, the wire passes over a small guide-pulley, and on through the hollow pivoting-rods to "laying-up" dies. The actual "laying-up" of the wires round the core naturally takes place at the further end of the machine. In front of the bearing supporting the end of the hollow shaft is keyed a toothed wheel *N*, pierced with holes through which the several wires are led, Fig. 18. On coming through the holes in the wheel *N*, the wires pass along longitudinal grooves cut in the body of the hollow shaft where it passes through the main bearing, and thence to the lay-plate *P*. The wires, in passing through these grooves, are united round the core at the point *R*, where a jet of water keeps them cool. The die block *S*, through which the cable passes immediately behind the point *R*, serves to force the wires into their places and render them close-fitting. On leaving the die, the cable is given three turns round a large drum, shown in Fig. 15, which regulates the travel of the cable through the whole train of the machinery.

For reasons already stated, the original disc machines of Küper and Newall are still largely used in the construction of heavy cables. The reels containing the wire are carried on a single cast-iron spur-wheel *A*, Fig. 19, formed in sections bolted together, and having a hollow shaft *BC*, through which passes the served core. The framework of this wheel consists of radial and concrete bars which are pierced with holes in certain places, and on to which plates of sheet iron are secured. On the back of the wheel are a large number of small toothed wheels $D_1D_2E_1E_2$, all of the same diameter, gearing into one another. The spindles of these wheels pass through the holes in the framework of the wheel *A*, those of D_1 and D_2 being simply secured by a shoulder and nut, whilst those of the wheels E_1 and E_2 are prolonged and terminate in a fork to carry the reels of wire.

The wheels D_1 also gear into the wheel *F*, which has the same diameter and the same number of teeth as the others; this wheel is fixed to the plummer-block *P*, and has no rotary motion. The hauling-off gear and its working are similar to those of the cage machine. In general, it is desirable to drive all machines for laying up the outside sheathing of shore-end cables direct from an independent engine, and if of the heavy disc pattern this becomes absolutely necessary.

Several improvements in connection with sheathing machinery have recently been introduced. Johnson & Phillips now manufacture machines of the cylindrical cage-type for making the heavier cables. They have constructed machines of this type capable of carrying eighteen bobbins, each 3 feet in diameter, and capable of holding upwards of a ton of wire each. The total weight of one of these machines, with the bobbins loaded, is as much as 70 tons. The central hollow shaft is of Whitworth fluid-pressed steel, bored and turned all over. It is in two parts, connected by a strong

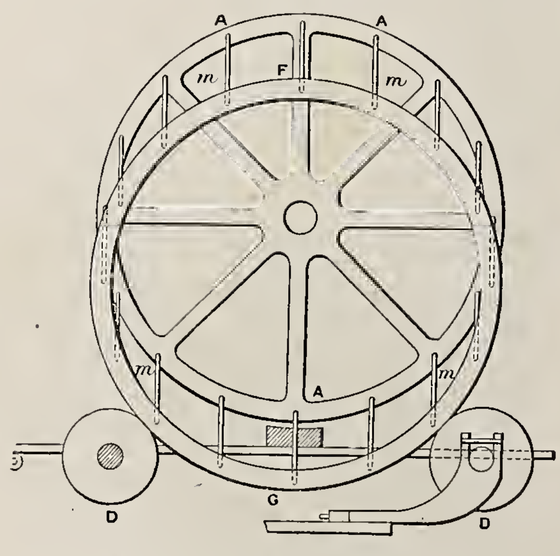

FIG. 17.—A DETAIL OF FIG. 15

coupling, and is 28 feet in length by 9 inches in external diameter. If provided with roller bearings, the power required for driving this machine is only about 35 H. P.

Sheathing machines are now in-

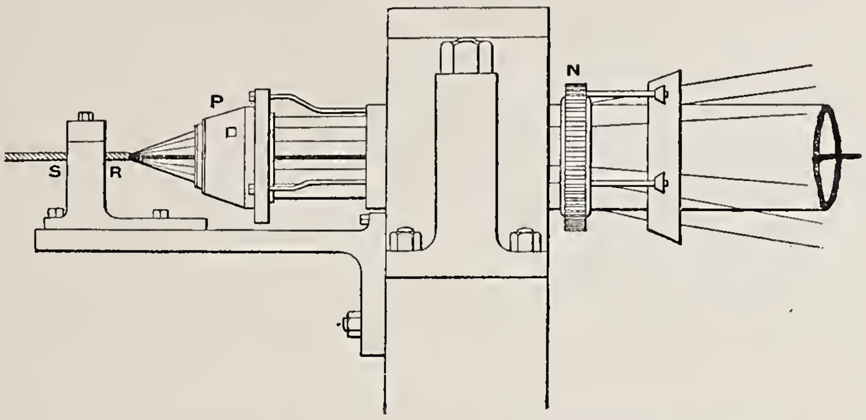

FIG. 18.—"LAYING UP" THE WIRES AROUND THE CORE

variably designed to avoid torsion of the wire by means of eccentric gearing and cranks, in place of the old spur-wheel gear. The bobbins are provided with tension bands, and usually each holds at least 3 cwts. of wire. There is a limit to the number of bobbins which a cylinder frame, or disc machine, can safely carry whilst revolving. If, however, a large number of bobbins be divided amongst two or more frames placed one behind the other in tandem fashion, the requirements are met by the wires from the bobbins on the different frames being made to alternate with one another, with uniform tension and lay. Johnson & Phillips have recently designed a triple tandem machine on this principle, having three skeleton carriages

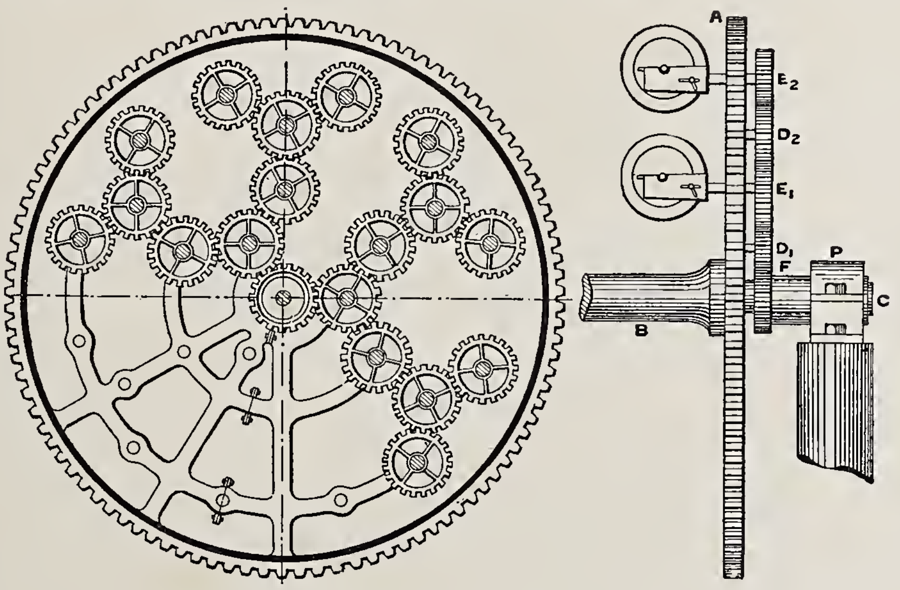

FIG. 19.—A DISC MACHINE FOR SHEATHING HEAVY CABLES

to meet special conditions. A novel feature of this machine is that the three sections are driven separately by chain gearing instead of by the usual counter-shaft belt or spur-wheel gearing.

Although at first different lays were adopted for different cables, nowadays the sheathing wires are almost invariably laid up with a left-hand lay. The length of lay for deep-sea cables varies between about 9 inches and 11 inches, whereas for a shore-end cable —composed of, say, eighteen wires of No. 1 Standard wire gauge—it may be as much as 18 inches. As in the case of the jute serving, this is adjusted solely by the speed of "draw-off," the revolving parts of the machine being always run at the highest safe speed. The angle of the wire at the lay-plate must also be constant in order to avoid all possibility of "crippling" the wires by straining due to too sharp an angle.

From the foregoing it will be obvious that the capacity of sheathing machines, of whatever form they may be, is clearly defined. Further, the bobbins must be at a sufficient distance from one another and from the lay head, to ensure that the wires shall not overlap. Both these distances require to be greater with large wires than with small wires, since large wires naturally tend to dip more, cannot be bent to so sharp an angle, and require more straightening out. Allowing 3 per cent. for lay and waste, the weight of iron in a sheathed cable is given by the formula—

$$\frac{d^2 n}{6806} \text{ cwts. per nautical mile,}$$

where d denotes the diameter of the wire in mils, and n the number of such wires, 6806 being an empirical constant.

The diameter of any iron wire weighing w pounds per nautical mile is $7.91 \sqrt{w}$ pounds.

The diameter of the completed sheathing laid straight would be

$$D = d\left(1 + \frac{\text{cosec } 180}{n}\right)$$

where n is the number of wires adopted, and d the diameter of the wire.

When, however, the wires are laid

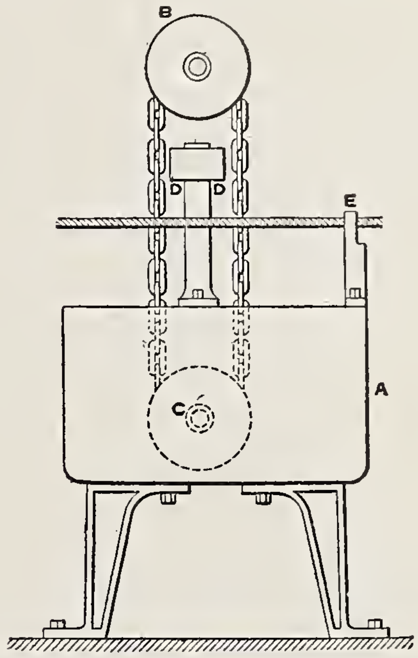

FIG. 20.—PUTTING ON THE OUTER COVERING

up spirally, as in a cable, the cylinder of iron wires would be increased in bulk, since the section of each wire then becomes elliptical, and therefore the major axis takes the place of the diameter of the wire. This increase may be actually calculated from the angle of the lay; but in practice it is not unusual to allow about 5 per cent. for twelve wires, or 7½ per cent. for twenty-four wires.

OUTER COVERING

If the iron sheathing wires have not been individually immersed in "Bright & Clark's Compound" previous to laying up, a coating is applied to the cable during the process of sheathing, a thin stream of the compound being poured over the surface of the sheathed cable just beyond the point at which the wires are laid up. This is effected by means of the apparatus shown in Fig. 20, which is driven from the sheathing machine, so that when the running of the latter is at any time stopped, the supply of compound is simultaneously shut off. This system has been in universal use ever since its introduction.

To obviate the possibility of overheating the insulation, it is now customary to apply the compound in a semi-cold state, in which condition it is superior as an adherent, although less readily workable than a hot compound. The bituminous composition is contained in the iron tank *A*, to which is fixed an elevator, in the form of a large link endless chain, which works round two fixed pulleys *B* and *C*, Fig. 20. A certain proportion of the compound, in being drawn up by the chain, falls from the upper pulley into the inclined "shoot" *D*, which conveys it on to the cable. The die *E*, besides limiting the thickness of the coating, forces some of it in between the wires.

In a modification of this apparatus,

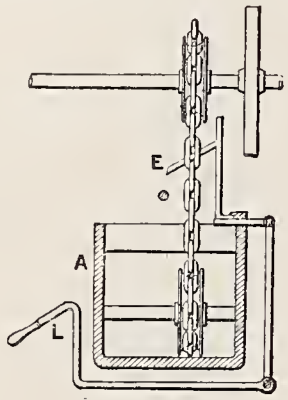

FIG. 22

the elevator working the compound through the tank consists of a revolving disc, and is especially adapted for cold compounds.

A plan for applying tarred canvas (Hessian) tape, about 1½ inches to 2 inches in width, as an outside preservative covering and binding (in place of the hemp yarns forming part of the Bright & Clark system) was introduced by Johnson & Phillips in 1872. The tape is applied spirally, and usually in two successive but opposite layers, with no overlap, the edge of each turn butting against the next so as to provide an even surface and to reduce the space occupied by the cable in stowage.

The end of the compounded strip is drawn from its reel *G*, Fig. 21, into the hollow shaft or tube *AB*, supported by two standards *P*, and having a longitudinal opening at the opposite end about a foot in length and 2 inches or 3 inches in width. The shaft is rotated by a belt driving the pulley *S*. To the hollow shaft is fixed a collar *C*, having two arms, one of which, *D*, carries a counterpoise *E*, and the other, *F*, carries the "head" *G* on which the tape is wound. The tape head is secured by a bolt and thumb-screw *H* to a quadrant *I*, pivoted at *F*, and adjusted to the required angle by a bolt and nut at *I*.

The strip of canvas *L* enters the hollow tube through the opening at *m*, and, carried round by the rotation of the shaft and reel, winds on to the cable, which at the same time is being steadily drawn forward through the shaft. Thus, under the combined effect of the two movements, the strip is laid round the cable in spiral turns. The requisite tension of the strip *L* is given by means of a small brake at-

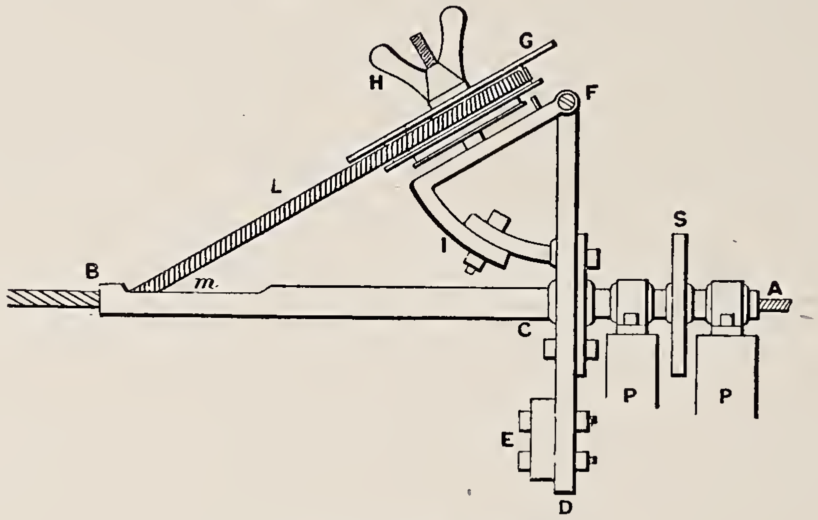

FIG. 21.—PUTTING ON THE TAPE

tached to the reel *G*. To regulate the length of lay, the angle of the head at *F* is set as required. This naturally varies with the width of tape adopted, where there is no overlap, and may be anything between 1 inch and 2 inches.

A second coat of compound is now given to the canvas tape, the mixture in this case being applied hot. The compound is contained in the tank *A*, Fig. 22, to which heat is applied. Here, also, the elevator for conveniently applying the compound to the cable takes the form of a chain, but in this case its direction is usually diagonal instead of vertical. When it is necessary to stop the cabling machine, the inclined "shoot" *E* is temporarily drawn aside by means of the lever *L*, thereby allowing the compound to fall clear of the cable, and diverting it back into the tank. The independent running of the elevator,

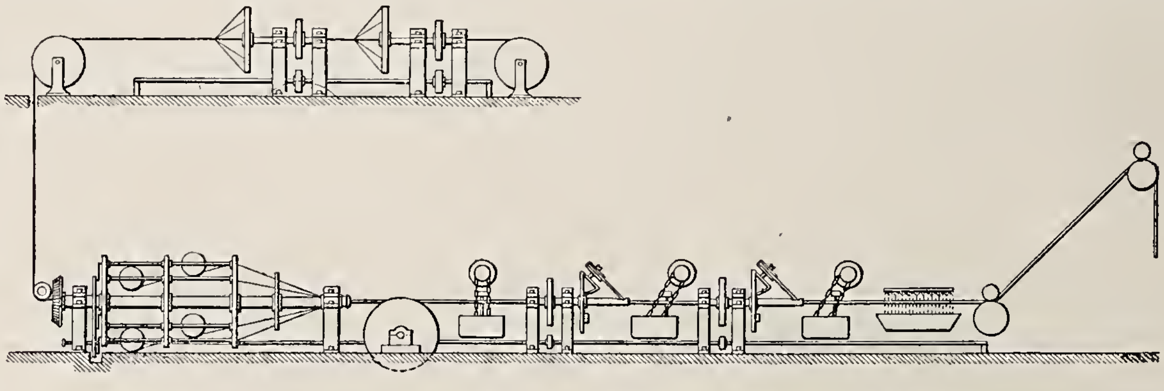

FIG. 23.—SERVING AND SHEATHING A DEEP-SEA CABLE IN ONE OPERATION

however, prevents the mixture from solidifying and so choking the apparatus.

A heated die is now commonly fitted to this part of the machinery; coming into operation just after the cable has received its outer serving and compound, its object is to smooth off any surface irregularities. Formerly a pair of heated hand tongs were used for this purpose. When the two layers of outer covering have been each in turn followed by an application of compound, the cable is completed; and on its way to the storage tank passes under a pipe from which water drops on to it to cool and "set" the compound. This is shown in Fig. 23, which illustrates generally the entire process of serving and sheathing a deep-sea cable at one operation, where the outside covering consists of two layers of canvas tape. The complete floor space covered by the machinery is about 75 feet by 10 feet.

The outer covering of previously compounded tape was for some time extensively adopted in place of hemp or jute yarns, over which it had certain advantages. Being capable of application under greater tension it was found to provide a more reliable binding, besides resisting the attacks of submarine organisms better. Recently, however, a reversion to hemp (previously compounded) has, to a great extent, taken place. This is partly due to its superiority as a vehicle for the compound, and to the fact that it renders the cable more pliable.

An outer yarn serving is usually composed of "three-ply" hemp of anything up to sixty yarns. The method of application is the same as for the inner serving, with two layers in opposite directions, each layer being, in turn, separately compounded. Being composed of stronger material, however, the lay is somewhat longer, although on the same principle much shorter than that of the sheathing. As in the case of the tape outer serving, the entire operation is performed at one and the same time as the sheathing, the taping apparatus being replaced by revolving yarn-loaded carriages placed behind the sheathing frame. Owing to improvements in the quality of jute, and to decrease in price, jute yarns are now much used for the outer serving of shallow-water types.

For deep-sea cables, however, where extra strength is aimed at, hemp cords, composed of several strong Russian hemp yarns laid up together, are largely adopted for the outer covering. Each cord is capable of withstanding a pull of about 1 cwt., and the lay is so arranged that the cords add to the strength of the sheathing, notwithstanding the different elongations of the two materials; moreover, they serve as a more secure outer binding, and really tend to restrain the unlaying of the wires under stress. It is usual to apply only one layer of hemp cords (generally about twenty in number), a serving of hemp yarn or canvas tape having been first applied, the advantages of both being thereby combined.

The author has endeavored to deal briefly with the various forms of outer covering and methods of application, but there may be other modifications and different routines with which he has not had an opportunity of becoming acquainted, and the same remark applies equally to the various other stages of manufacture dealt with.

Running along the length of the cabling machine, a counter-shaft is fitted, and this is coupled to the shaft leading to the factory power house. From this counter-shaft the yarn discs or taping heads are driven by belts, and by means of bevel or spur gearing the drawing-off machinery (supplied with a measuring drum) is correspondingly actuated. The entire machine is capable of being speedily stopped by the action of a brake surrounding a portion of one of the cylinder frames or discs, and actuated near the lay-plate by a lever.

Within the last few years most of the large cable works have been supplied with electric power, each machine being run from its own motor, the current for which is transmitted from the factory electric generating station. Stoppages for fresh bobbins and brazing wire form a considerable element in the time occupied in making a cable, especially in the case of the heavy types, for reasons already stated. Thus often only about 1 mile of "shore end" cable is turned out by a given machine in the course of a working day, whereas some 7 miles (or more) of deep-sea cable may be constructed by one machine (running at more than 100 revolutions per minute) in that time. Under ordinary conditions, 35 miles of cable is a fair output for a modern factory during a working day of 12 hours.

THE COMPLETED CABLE

The weight of a cable in salt water is arrived at by weighing a given sample length, suspended in water from one end of a balance. The specific gravity is found from the formula—

$$\text{Specific gravity} = \frac{W}{W - w}$$

where W denotes the weight, dry, in air, and w denotes the weight in water. A deep-sea cable weighs, in air, roughly about 1 ton per nautical mile when wet; the corresponding weight of a heavily armored shore-end type is often as much as 30 tons. Another important consideration is the stress which a cable is capable of bearing. This can be ascertained from the accredited breaking stress per square inch, and the cross-sectional area of each wire. Where, however, the serving adds to the strength of the cable, the total stress which can be borne can be accurately ascertained by actual tests of samples. Cables intended for laying at considerable depths are made to bear about 6 tons or 7 tons,[1] with an elongation of at least 3 per cent.

The actual available strength of the last, 1894, Atlantic Cable of the Anglo-American Telegraph Company is almost 30 per cent. greater than of the 1865-66 line (open-sheathed type), although its specific gravity is higher. The landing place at the Irish end requires special provision for coping with the prevalence of rocks, and the large iron wires are, in this type, given an exceedingly short lay, in order to combine great weight and surface. This type has now replaced the sheathing of several large wires individually stranded (or plaited) before laying them up together. Various other types of cable—some without any iron wires—have been suggested from time to time; but as these have not been adopted in practice it has not been considered necessary to describe them.

At the present time there are more than 225,000 miles of telegraph cable, chiefly of British manufacture, in working order at the bottom of the sea throughout the world, representing some 60 millions sterling, mainly British capital. These have a carrying capacity up to about 100 words per minute by the duplex system. With the present-day machine method of transmission, this is, in practice, solely limited by the size of the conductor and its corresponding insulating sheath, which again is only governed in its design by traffic considerations.

[1] A good rule is 2 tons per pound of iron per fathom; another is to allow four times the tensile strength that would be necessary for the cable's suspension in its greatest depth. Thus, for 2000 fathoms, the cable would have to bear the weight, in water, of about 8 miles of its length.

Steam Turbines and Electric Driving for Bleaching and Dyeing Mills

SPEAKING of the reorganizing of the power plant in bleaching and dyeing mills recently, before the New England Cotton Manufacturers' Association, George I. Rockwood said that in nine cases out of ten nothing can be done to effect much economy by concentration unless the owners will consider the expense of an electric drive. Fortunately, the power requirements of the kind of mills in question are relatively small.

Many times the number of boilers needed to supply a single large engine for driving shafting are used to make steam for kiers, dry-cans, dye-tubs, ageing machines, etc. The machines to be driven are widely scattered. The cost of an electric generator and motors is relatively small, and to establish the policy of concentration made possible by the use of the electric transmission of power is of great importance to the subsequent growth or alteration of the plant as a whole.

The steam turbine can only be used to drive a generator. It cannot drive direct, by ropes or belts. The steam turbine cannot be used, therefore, unless the electric drive is also used. But the turbine has an advantage, as a source of dye-house or print-works power, over the reciprocating engine in one important particular, namely, its exhaust steam is pure and uncontaminated with cylinder oil and can be used in creating a hot-water supply in the place of live steam.

The steam turbine and generator combination are very considerably cheaper in cost of installation, and somewhat so in cost of operation, as compared with the steam engine and generator unit. From Mr. Rockwood's experience thus far with steam turbines, he would favor their purchase every time and for every place when the electric transmission of power is in itself desirable. It may be said, in passing, that electric motors should not be put up inside the bleacheries themselves, nor in any place where fumes or vapor can harm them.

Some Details of High-Pressure Line Construction for Alternating-Current Railways

PRESENTED BY THEODORE VARNEY BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

IN the report in last month's issue of the papers read before the American Institute of Electrical Engineers, only brief reference was made to the paper by Theodore Varney, entitled "High-Pressure Line Construction for Alternating-Current Railways;" hence the appended extracts from it, together with illustrations.

Of the various methods of current supply heretofore employed, the overhead conductor is considered by Mr. Varney to be the only one capable of development into safe or permanent operation with trolley pressures running up into thousands of volts, and his paper described several forms of overhead construction carried out on a practical scale.

BRACKET-ARM CONSTRUCTION

This system consists of a single line of wooden poles spaced well apart and fitted with bracket arms and steel catenary suspension cable for supporting the trolley wire. The bracket arm is a T-iron supported by a tension rod at its outer end and fitted at the inner end with lugs which partly embrace the pole to which they are bolted with lag screws. Fig. 1 indicates the construction.

The insulator is of corrugated porcelain, cemented to a malleable-iron sleeve, which in turn is slipped over the bracket arm and held by clamps and set screws. The porcelain insulator has a groove at its center surrounded by a malleable-iron collar similar to a pipe clamp. This collar has an eye on the lower side into which the hooks of a clamp which carries the steel supporting cable or messenger are inserted. Wheel trolleys will probably be used to a considerable extent with the lower pressures. Guard loops are provided to prevent breakage of the porcelain, in case the trolley should leave the wire under a bracket. The insulator with its fittings is shown in detail in Fig. 3.

The guard loops are also of service in temporarily supporting the cable while it is being run out and pulled up. The trolley and messenger are run out together, and the former is supported from the messenger at occasional points by temporary tie-wires. The tension in the messenger cable is adjusted to give the proper sag, and the trolley wire is pulled up tight enough to take out all kinks and bends. Both trolley and messenger are then anchored. The messenger is next clamped to the insulators and the trolley is permanently supported from the messenger by means of hangers or clips which are adjusted in length in such a manner as to hold the trolley horizontally. By this means, the tension in the trolley is slightly relieved and allowance is made for expansion and contraction. The hangers are stiff and, being placed only 10 feet apart, correct any tendency of the grooved trolley wire to twist. This insures that the smooth lower surface will always be downward, a feature especially necessary when bow or sliding trolleys are used. The short distance between hangers also prevents the end of a broken trolley wire from coming dangerously near the ground.

The method of supporting the messenger below the bracket arm enables a tension rod to be attached to the outer end of the bracket without the necessity of fishing the messenger cable over the arm and under the brace. The cable and trolley may be run out along the track and pulled up in place under the brackets with a minimum amount of labor. Another

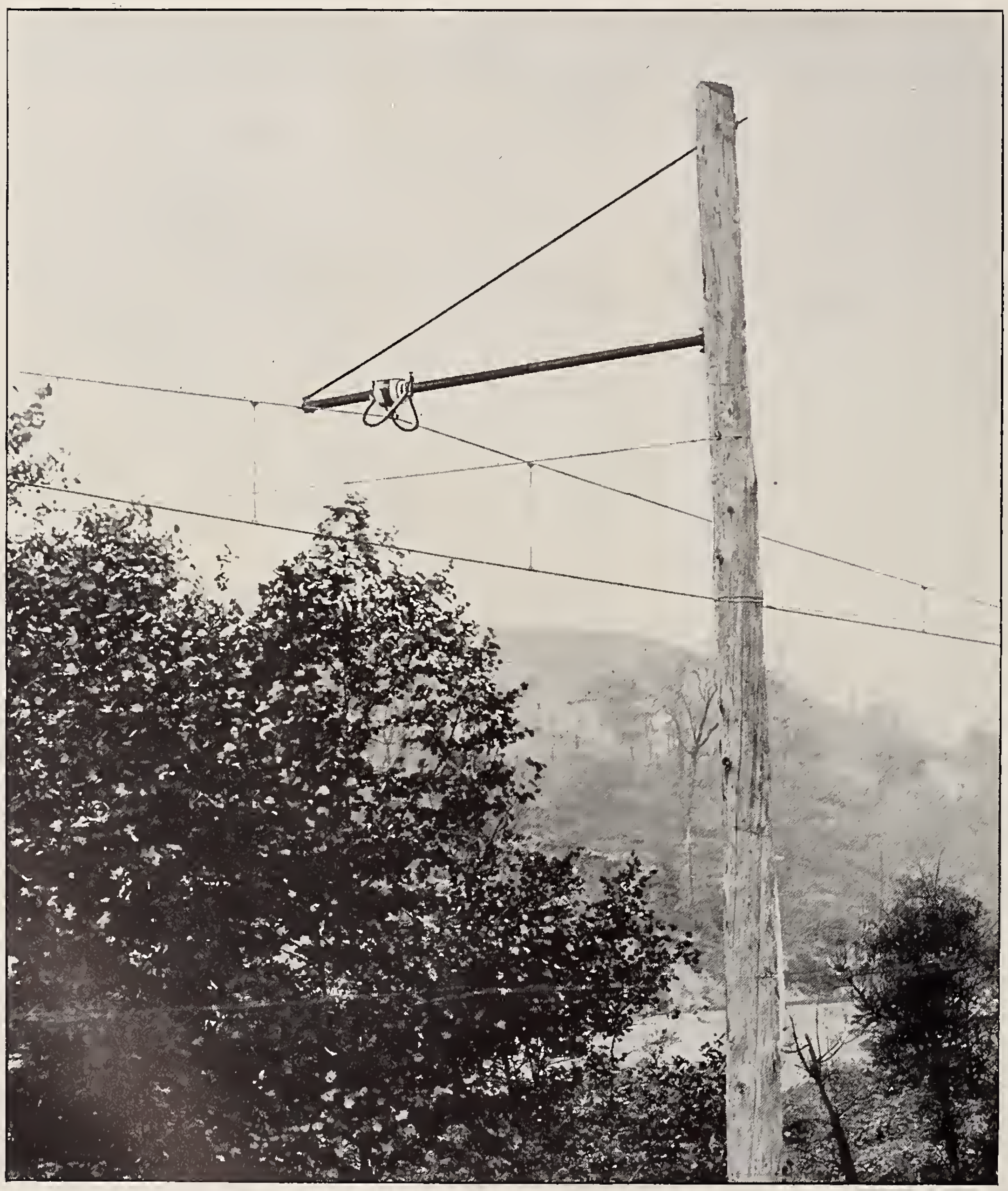

FIG. 1.—BRACKET ARM CONSTRUCTION

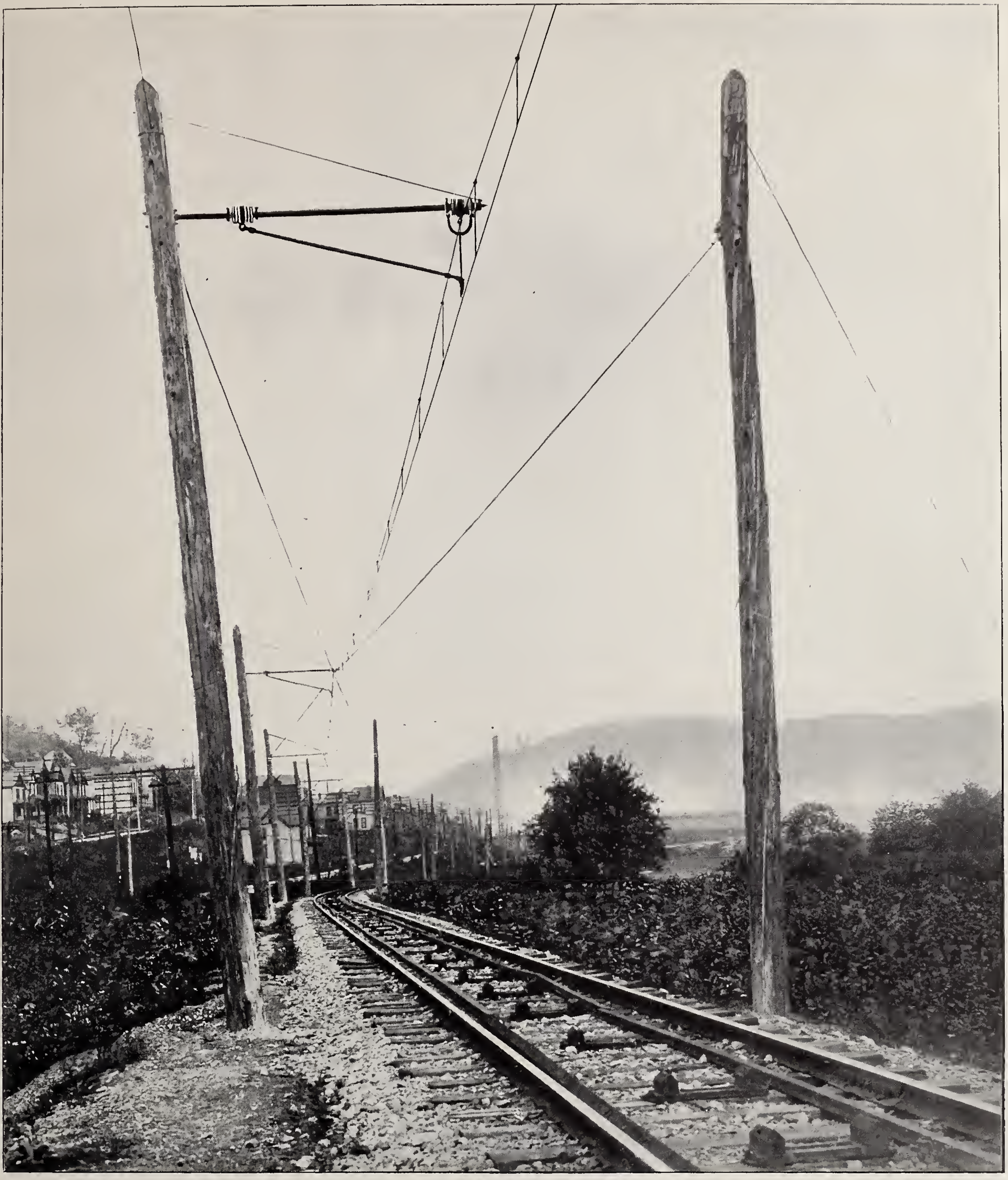

FIG. 2.—STEADY-STRAIN BRACKETS ON A CURVE OF LARGE RADIUS

advantage in this arangement is the slightly flexible character of the point of support of the messenger; this is not sufficient to permit any considerable vibration of the span as a whole but will allow any small vibration set up by the trolley to pass on. It has been noticed in rigidly supported spans of considerable length that a tendency exists for waves to be reflected from these fixed points which, when they reach the trolley, lift the wire from it, thereby causing flashing.

The hanger is illustrated in Fig. 4 and consists of a galvanized malleable-iron casting made in ten lengths. It is fitted with a bolted clamp to take the messenger cable and is secured to the trolley with screws. At intervals of about 1000 feet and upon curves of large radius, a steadying device shown in Fig. 1 is used. The pull-off used on sharp curves is shown in Figs. 5 and 6.

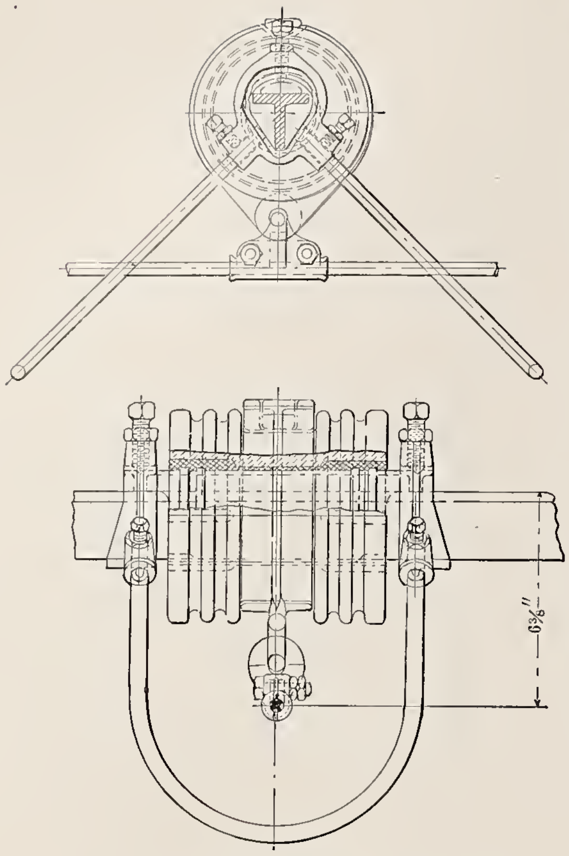

FIG. 3.—INSULATOR AND FITTINGS

CROSS-SPAN CONSTRUCTION

For conditions where bracket arms cannot be used, cross-span work may sometimes be employed. For this purpose the arrangement indicated in Figs. 7 and 8 has been designed. The difference between this arrangement and the bracket-arm construction is the substitution of a 0.4375-inch steel span cable for the bracket. Other details are practically the same.

BRIDGE CONSTRUCTION

For the heavy service requirements of steam roads having from two to four tracks, the construction described above is not adequate; a more substantial equipment and one which will not encroach upon the present standard clearances is necessary. Obviously, the best form of support to accomplish this result is a bridge long enough to span all tracks with ample clearance on the sides and overhead,

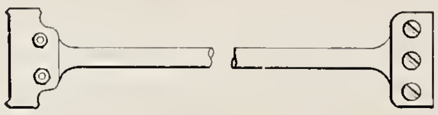

FIG. 4.—ONE OF THE HANGERS

and stiff enough to carry all of the overhead conductors without undue vibration. Bridges of this character are at present in use on many roads to support semaphores and other signal apparatus.

Fig. 9 illustrates a section 2500 feet long of a three-track road, one track of which has been equipped with the bridge construction. The double catenary system is used, each messenger being a 0.4375-inch steel stranded cable. The trolley wire is 000 grooved, and the supporting hangers are placed 10 feet apart. The average total weight per foot supported by each cable, including its own weight, is 0.91 pounds. The vertical sag in the first span, which is 230 feet long, is 2.6 feet, and in the second span, which is 270 long, 3.6 feet, both at 26.6 degrees F. The corresponding tension in the messenger cables is 2300 pounds.

Fig. 11 shows an extension of the double catenary construction supported upon latticed poles.

PROPOSED GENERAL PLAN

It was first thought advisable to run the messenger cable over the bridges. Fig. 9 shows this construction. It is necessary, however, to provide an unobstructed view of the signal apparatus, and it is accordingly considered

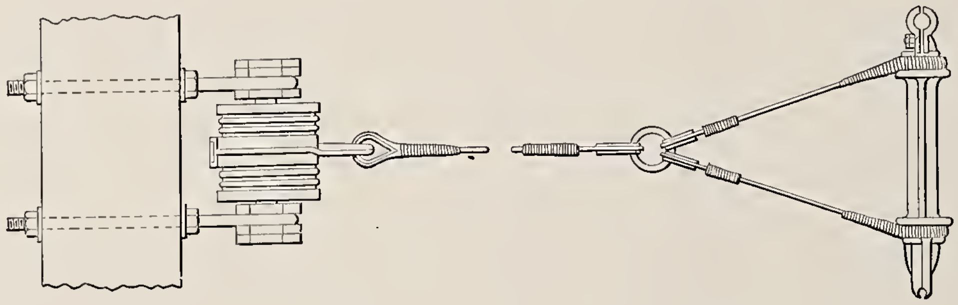

FIG. 6.—CURVE PULL-OFF

preferable to make the bridge high enough to permit the semaphores to be suspended below the truss.

Fig. 10 indicates a signal bridge which has been devised for a four-track road carrying beside the semaphores, the four sets of cables and trolley wires suspended below the truss. This construction is a decided advantage in erecting, as the cable and trolley wire can be run out along the track and lifted into place. Massive porcelain insulators will be used mounted on heavy pipe and fitted with collars having soft lead strips under them. From these the cables will be hung by means of bolted clamps. By anchoring all cables to the bridges after being drawn up to a uniform tension, the effect will be to steady the bridges. For roads having wide rights of way comparatively light bridges steadied with guy cables may be used, but for most cases a substantial structure similar to those now used for signal towers will probably be preferable. It will be noted, however, that owing to the comparatively long intervals between signals only a few of the bridges carry semaphores; the others may be made lighter than the one indicated in Fig. 10.

Spans of 300 feet for straight tracks appear to be satisfactory, not being so long as to permit undue vibration in the cables, and not so short as to require a large number of bridges per mile.

For the messenger cables 0.625-

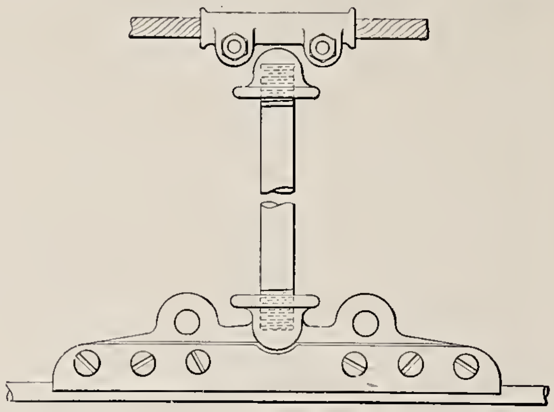

FIG. 5.—CURVE PULL-OFF HANGER

inch extra-high strength steel strands are suitable. With a No. 0000 grooved trolley wire and hangers spaced 10 feet, the average load per foot on each cable is 1.43 pounds, and with a vertical sag of 2.7 feet the tension is 6000 pounds. In a rough climate, wind and sleet will at times increase this tension; assuming that the tension may be doubled, a factor of safety of about 3.5 will still remain, as the breaking strength of the cable is about 40,000 pounds.

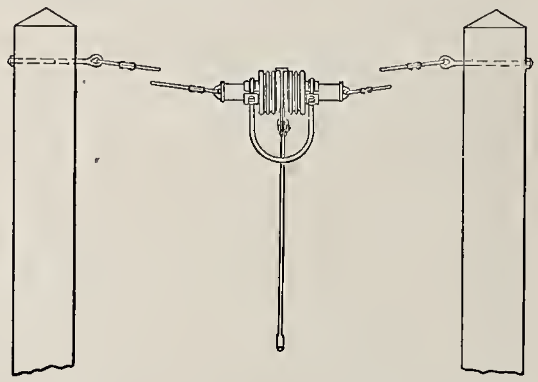

FIG. 7.—CROSS-SPAN MAIN LINE SUSPENSION

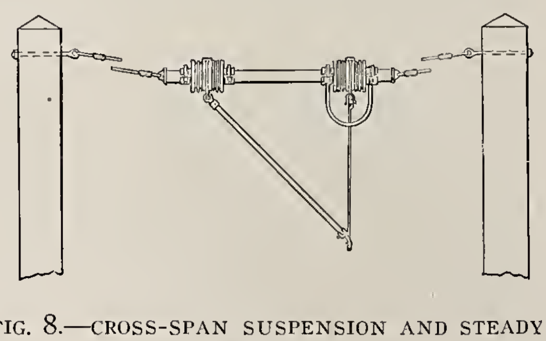

FIG. 8.—CROSS-SPAN SUSPENSION AND STEADY STRAIN

For use in localities where milder weather conditions may be assumed, lower grades of steel may be used having breaking strengths for the same weight per foot of 25,000 pounds and 19,000 pounds. These latter cables are somewhat easier to handle and would be sufficiently strong for most conditions.

The sag given above is taken to be the cold-weather condition and for 100 degrees F. rise the sag would be about 4.4 feet, or a variation of 1.7 feet. In Fig. 10 this allowance is made in the height of the bridge so that the lowest point of the trolley wire will be 22 feet above the track. It is not believed that the variation will be this much on account of the giving of the supports and other causes.

For curves, the length of span will be decreased; and when necessary to hold the wire in the center of the track, radial pull-offs will be used, secured to strain insulators. These will be mounted on latticed poles which in turn will be braced by guy anchors.

For sharp curves, the radial pull of all the messenger cables would be severe, and it is intended to provide at the tangent points anchor bridges which will have trusses stiff enough in the horizontal plane to stand the strain of slacking off the cables about one-half. These anchor bridges will then

FIG. 9.—DOUBLE-CATENARY LINE CONSTRUCTION, WITH BRIDGE SUPPORTS

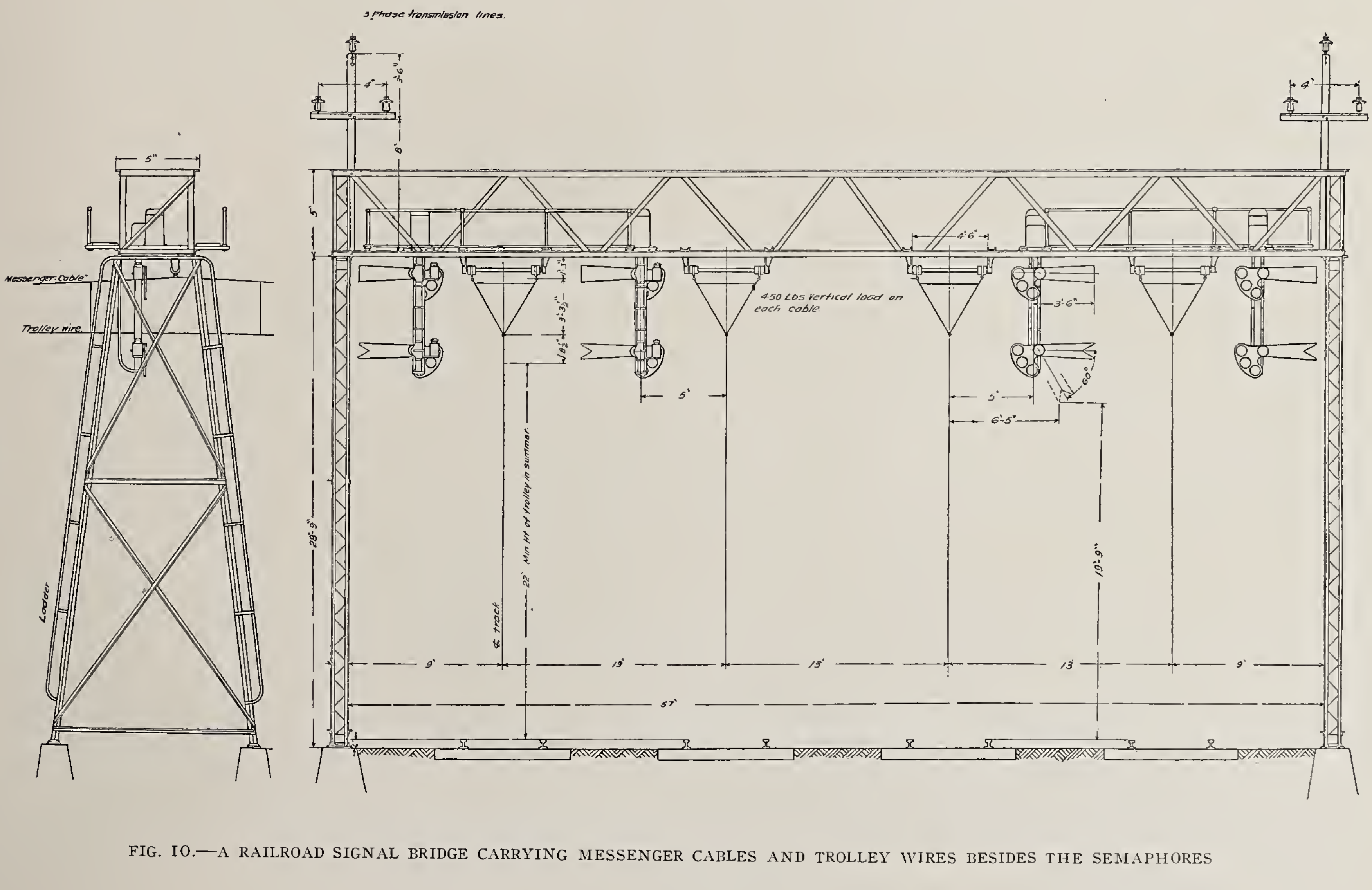

FIG. 10.—A RAILROAD SIGNAL BRIDGE CARRYING MESSENGER CABLES AND TROLLEY WIRES BESIDES THE SEMAPHORES

FIG. 11.—DOUBLE-CATENARY LATTICED POLE CONSTRUCTION

be held by long guys running out a considerable distance from the bases of the bridges and anchored to cross-ties or channel-irons buried in the ground and concreted.

Several details for the double-catenary construction are shown in Figs. 12 and 13. All of the metal parts other than the bridges and trolley wire are galvanized, but as a further protection against depreciation from locomotive fumes periodical painting is advisable.

Regarding the efficiency of the insulation employed, it may be stated that under the snow-clad conditions indicated in Fig. 11, the 2500 feet of iron bridge work and 5 miles of single-catenary construction showed under test a leakage of one ampere at 6000 volts.

CONCLUSION

The foregoing describes some of the work which has been carried out with the view of developing a system of overhead conductors for moderate and heavy traction service, and which will approach in a far greater degree than heretofore the reliability and permanency of present steam-railroad equipments.

Aside from this work, 40 miles of road using the single-catenary wood-pole construction have been put in operation in Indiana. This has been in successful running order since the first of this year. The remaining 60 miles of this road will probably be completed in the near future. The pressure is 3300.

The 353-foot chimney of a smelting plant in Denver, Col., has been used to support the antennæ of a De Forest wireless telegraph station.

The highest bridge in the world is being constructed on the Cape-to-Cairo railroad in Africa. The huge one-span arch steel bridge—the main span 500 feet—crosses the Zambesi River a short distance below the Victoria Falls. An electric cableway is employed to carry the materials across the river.

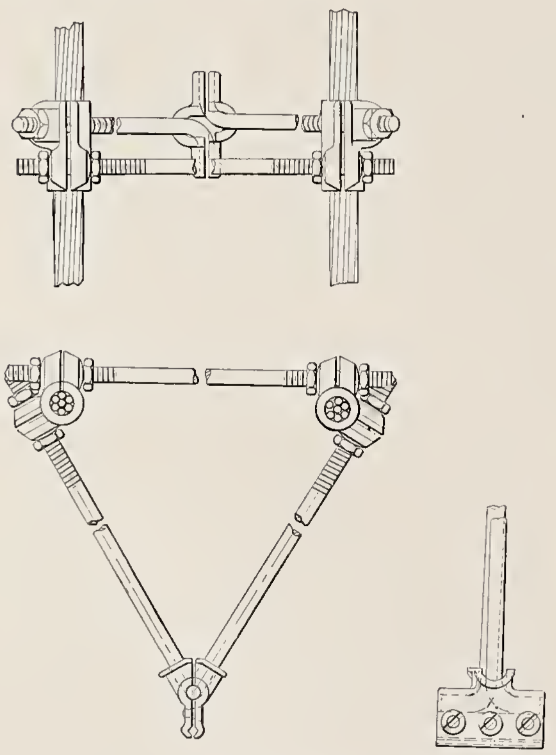

FIG. 12.—DOUBLE-CATENARY ADJUSTABLE TROLLEY HANGER

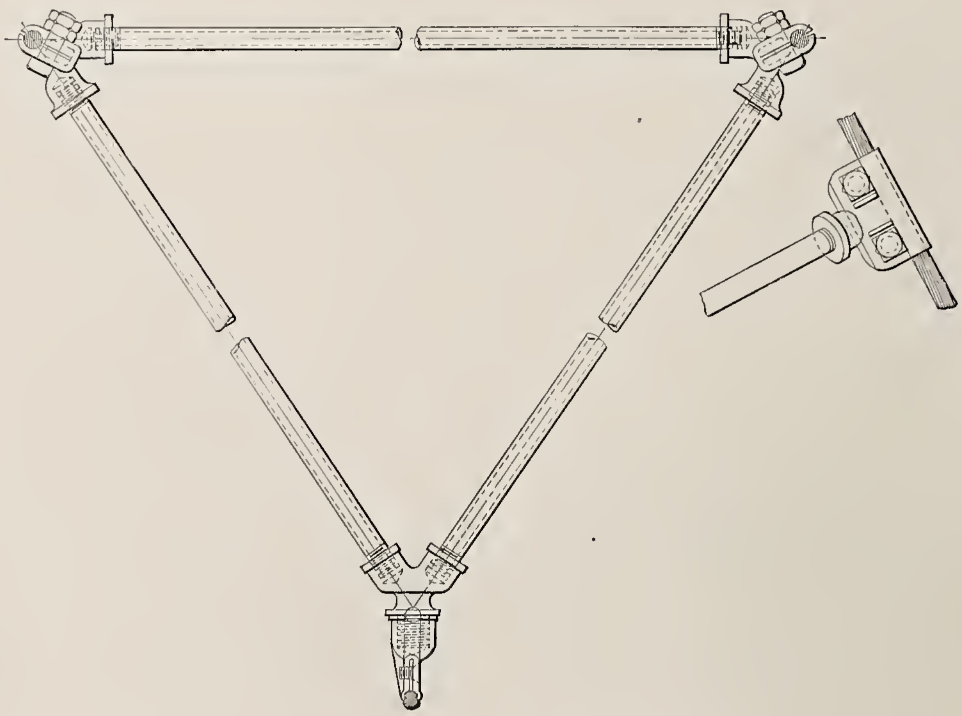

FIG. 13.—DOUBLE-CATENARY CURVE PULL-OFF

The Latest Papers Before the American Institute of Electrical Engineers

THE 196th meeting of the American Institute of Electrical Engineers was held in Carnegie Hall, New York, on April 28, 1905. President J. W. Lieb, Jr., presided.

The following papers were presented and discussed:—"Some Notes on Polyphase Metering," by J. D. Nies; "Notes on the Use of Instruments on Switchboards," by F. P. Cox; "The Oscillograph and Its Uses," by Lewis T. Robinson, and "Maintenance of Meters," by W. J. Mowbray.

In the absence of Mr. Nies, his paper was abstracted by F. J. Roller.

POLYPHASE METERING

This paper embodies the results of a series of tests recently made in the interest of a large operating company for the purpose of determining the most satisfactory method of metering the power delivered to certain consumers whose demands ranged from 200 to 1000 K. W. The aim was to determine the nature and probable extent of the errors that occur in the established available methods of polyphase metering, and to find which of these methods would be on the whole the best to use for the given work—regarding as best that system in which errors are not only least liable to occur, but also in which, if they do occur, their presence can be most quickly and readily detected.

The practice had been to install polyphase meters on such circuits, and in cases where especial accuracy was desired to put two of them in series. It was found that the two meters would never give identical readings; they were seemingly affected differently by changes in frequency, pressure, and power-factor. The difference between their readings was not constant; one meter would sometimes register alternately faster and slower than its mate; but always, in the long run, the divergence between the two readings would become so great as to make it a matter of some risk to accept either of them, or the average of both, as the true value of power registered. The behavior of the instruments indicated that errors existed other than those of calibration, errors which would make it unwise to place implicit confidence in the readings of such meters, unless some means were provided whereby their readings could be continuously checked.

The field of application of the polyphase meter is necessarily rather limited. It will probably always remain true that the bulk of the alternating-current output will be delivered through single-phase meters. When power is consumed in large blocks—from 25 to 100 K. W. or more—the delivery is nearly always made in the polyphase form; for example, the power measured at the input end of a transmission line or at the input side of a synchronous converter has to be measured nearly always by a polyphase meter. Therefore, though there are fewer examples of polyphase meter installations, the individual cases are of greater importance. The requirements for high accuracy are far more strict, inasmuch as the load carried by such a polyphase meter may be several thousand times as great as that on the average single-phase meter, and an error of a small fraction of one per cent. in its registration means a considerable error when figured in dollars. It is not correct to say that a percentage error bears the same significance whether it applies to a large or to a small amount. Besides, many of the errors occurring in individual meters will be averaged out when a large number of them is considered; it would be possible to have an error of one per cent. in each one of 100 meters, and yet have a combined error of almost vanishing dimensions. But a polyphase meter of large capacity must operate as an individual, and will impress its own peculiarities upon the power bill that is based on its readings. In what follows, the reference is principally to the high-tension, three-wire, three-phase system with balanced load, employing instrument transformers as intermediary between the line and the meter, the latter being of the induction type.

Inasmuch as the errors introduced by instrument transformers have the same effect upon the accuracy of all meter systems, whether single phase or any form of polyphase, the consideration of them will naturally precede consideration of the different systems. It is necessary in all high-pressure meter work, to use instrument transformers instead of connecting the meters directly into the line. In this way the meter, instead of receiving upon its shunt coil the full line pressure, receives a known fraction of that pressure, through the agency of the pressure transformer; and, instead of carrying through its current coils the full line current, it carries a known fraction of that current, through the agency of the current transformer. The result is, that the meter receives at its terminals only a small fraction of the actual power undergoing measurement, and its reading must, therefore, be multiplied by the product of pressure transformation-ratio into current transformation-ratio, in order to get the registration. The instrument transformers then really constitute parts of the meter system, and should be considered in connection with it. The question may then be asked, do the instrument transformers correctly perform their function of delivering to the meter those fractions of line pressure and of line current called for by their ratios?

A pressure transformer differs in no radical way from an ordinary transformer, its operation is similar and is governed by the same rules, and therefore the pressure delivered from the secondary coils (supposing constant primary pressure) will vary with the amount of load that is put upon the transformer, by reason of the impedance drop in its coils.

The impedance of a 200-watt transformer built for 10,000 volts in the primary, and 100 volts in the secondary would be about 10,000 ohms, and with the full-load current the impedance drop would be 200 volts, reduced to the primary! this would represent a drop of 2 per cent., but as it is a vector subtraction, the error is less than this; it is about 1.6 per cent. This will vary with the frequency, and with the power-factor of the load. All instruments supplied by such a transformer at full load would read 1.6 per cent. low. The error could be reduced by putting more turns on the secondary coil; but in that case the secondary pressure would be too high at all lower loads. Perhaps the best that could be done would be to make the ratio correct at half load. The point is, that the ratio cannot be correct throughout the whole range of the transformer; and that the results of even the most careful calibration can be vitiated by using a meter in connection with a recklessly loaded pressure transformer.

For a transformer supplying voltmeters only this will be the only error to expect; but when wattmeters are supplied there is another effect to be considered, namely, phase displacement between primary and secondary electromotive forces. In a perfect transformer without reactance this phase displacement should be exactly 180 degrees, so that when the secondary electromotive force is reversed it will be returned into perfect phase with its original, the line electromotive force. If the displacement is not exactly 180 degrees, the result will be that the meter receives an electromotive force the phase of which, with respect to the line current, is not the same as it actually is in the line; the meter, therefore, works on and registers a false power-factor. The phase error introduced by a loaded shunt-transformer represents an apparent decrease in the angle of lag of the system of perhaps one-half degree—this depending upon the frequency and upon the power-factor of the secondary load.

The error in the case of the current transformer arises not directly on account of the impedance of the coils, but on account of the fact that not all the primary current is transformed, as part is diverted for the purpose of magnetizing the core. After the exciting-current component is subtracted vectorially, the residue is transformed at the true ratio. Consequently two errors are introduced: the quantity of secondary current is too small, unless the ratio of the transformer is corrected by removing the proper number of turns from the secondary coil; and the phase of the secondary current is different from the phase of its primary.

Certain curves calculated from measurements of exciting current and coil inference over a wide range indicate an increase of phase displacement on low loads sufficient to introduce errors. A lagging current registers in the meter with a reduced angle of lag, hence higher power-factor and increased registration; therefore, the percentage error and the phase error are to some extent compensative. A leading current registers in the meter with an increased angle of lead; hence, lower power-factor and decreased registration, and the phase error and the percentage error are additive. Wherever the highest possible accuracy is desired, it is best to install special transformers for the meter and use them for that purpose only, or else run the risk of introducing errors which may completely oveshadow the ordinary errors of calibration.

Current transformers are subject to another error which may occur if they are installed too closely together. Ordinarily the primary winding consists of but few turns, and on that account the magnetizing effect of strong currents in neighboring conductors cannot be neglected in comparison with the magnetizing effect of the current in the transformer's own primary circuit. This result is the same sort of inaccuracy in the registration of the meter that would occur if the meter itself were installed in the presence of an external field. The error simply arises in the transformer instead of in the meter. Ordinarily in high-pressure circuits the necessary mechanical separation between conductors is sufficient to prevent this effect.

It is the usual practice to provide the two sets of transformers, for pressure and for current, with the same common return. This introduces an error due to wiring loss between transformers and meter. The result is that although the drop of pressure on this common return does not affect the operation of the current transformers materially, it subtracted from the pressure delivered from the pressure transformers. If the common return is 100 feet of No. 12 B. & S. wire, the error will be about 5 watts when the current in the common return is 5 amperes, which is too great an error to neglect, and may mean a difference of hundreds of dollars annually in the bills based on the reading of a high-capacity meter. The effect could be prevented by running a separate return wire for the pressure transformers, connected at but one point to the return wire for the current transformers. All meter wires should be run close together, preferably in conduits, to prevent inductive effects from outside fields. Meters of all types have a tendency to run "slow" on full load, and also on low load. This difficulty can be met by calibrating a meter for its probable average load. The error caused by variations of temperature makes a very complete problem in the induction meter.

Mr. Nies then considered the different methods of applying induction meters to the measurements of polyphase power. One method employs a single-phase meter with star box, the meter pressure-coil acting as one arm of the star-box. The meter reading is then to be multiplied by three. This method is open to the objection that it is difficult to get the impedances to balance perfectly, and to restore them if the balance becomes disturbed. The method is not accurate unless the load is in perfect balance; the entire responsibility rests on a single meter, and any error that occurs in it is multiplied by three in making the final estimate; and there is no check on its reading.

A preferable method of applying a single meter to a balanced circuit would be to insert the current coil into one of the conductors, and connect the pressure coil between that conductor and the middle point of the transformer secondary connected across the two other conductors; the true power is found by multiplying the reading by 2. This method eliminates the troublesome star-box.

Another method in common use employs two separate single-phase meters so connected that the two meters receive in their current coils the currents in two of the wires, and receive in their pressure coils, respectively, the pressures between these wires and the third wire. This method gives results which are theoretically correct on any three-wire circuit whatever, with balanced or unbalanced load; but it has practical disadvantages, particularly on circuits where the average power-factor is low, when by reason of the unequal division of the load, one meter—the one on the lagging side—is made to run habitually on the low-load end of its calibration curve, and the other meter carries nearly the whole load. This introduces the low-load error of the lagging meter into the final result, even though the actual load of the circuit may be fairly heavy.

To give correct readings on circuits in which the power-factor goes below 50 per cent., the meters used must be able to register as accurately when running backwards as when running forwards. Any meter which is provided with a friction compensating device is debarred from consideration for this particular service. This statement should be qualified to suit those cases where the power-factor of the circuit may only occasionally go below 50 per cent. The commutator type is entirely unfit. Another objection is that the meters are compelled to work under false phase-angles, which is especially the case with the meter on the lagging side. This increases the probability of error due to improper adjustment of the phase of the shunt, which error has been shown to be a maximum at 90 degrees of lag or lead.

Besides, the meters do not furnish a check on each other, and in many cases practically the whole responsibility rests upon one meter only. Another and much better method is to use two single-phase meters as just described, but with the difference that the meters are combined and both moving elements are attached to the same shaft, thus making the so-called polyphase meter. This removes most of the objections that may be urged against the preceding methods, except that the error due to the displacement of the phase of the shunt is just as great in the polyphase meter as it is in the two separate single-phase meters. The speed of the combined meter is the average for the separate meters, and in this way the operation of each of the latter is brought to a better point on the calibration curve.

It is suggested that a better plan than any one of the preceding would be to employ three separate single-phase meters, one for each phase of the circuit, having three pressure coils connected in star, the junction point of which is connected to the neutral formed by a star connection of the secondary of the pressure transformers. The summation of the three readings gives the true power on either balanced or unbalanced circuits. This is true, even though the neutral is displaced from the true central position —which might happen if the junction point of the three meter shunts is not connected to the transformer neutral, in which case the three branches must establish their own neutral—provided the deviation from the correct position is not great enough to bring an abnormal pressure to bear upon any one of the meters. It is better, however, to make use of the fixed neutral than the derived one. Such an arrangement of three meters would possess many marked advantages over the polyphase meter. In the first place, there would be no difficulty in calibration, more than exists in the case of the ordinary single-phase meter, and very much less than exists in the case of the polyphase meter. By arranging the meters in series, all three could be calibrated in but little more time than would be required for one alone.

The checking of the meters in place, which is practically impossible with polyphase meters, becomes comparatively easy and simple when three single-phase meters are used, as each meter can be checked individually, either by using a standard indicating wattmeter, or by temporarily connecting two of the meters in series on the same phase and thus checking them against each other which should conduce to high accuracy. After a meter becomes inaccurate it can be taken down for recalibration, and the registration will be maintained by the two remaining meters. Another advantage is that the responsibility is distributed over three meters instead of one, and it may be expected that the average of the three will be more nearly correct than any one of them singly. Again, an installation of three single-phase meters is less liable to be affected by errors due to displacement of the shunt phase. If all meters in any installation are subjected to the same error, then the total error is the same for any system of metering whatever method is used; but it is altogether unlikely that all the meters should be affected in the same way, and if they are not, then the total error, if three meters are used, will be less than if the two-meter method or polyphase meter is used, because in the three-meter installation the meters are not compelled to operate on false phase-differences, thus reducing the error which has been shown to be a maximum when the phase-difference is 90 degrees.

But the prime advantage that this method presents is that, on balanced circuits, the three meters give a continuous and automatic check on one another. On such circuits all three readings should always agree, or at least should differ by a fairly constant ratio. Any departure from these usual conditions, any failure on the part of one of the meters to agree with is companions, would result in throwing suspicion on that particular meter.

The only disadvantage of the method is that it requires the presence of a neutral conductor, and therefore is not available for ordinary three-wire three-phase service. This disadvantage does not exist in systems using pressure transformers, since the secondaries of the latter can as easily be connected in star as in ring, thus furnishing the required neutral. The cost of the three meters is higher; but this item sinks into insignificance in comparison with the value of the output that would be passed through the meters when used on a circuit of large capacity.

In conclusion, the statement can be made that in metering three-phase systems the method of using two separate meters is not entirely satisfactory; the modification of this method, the polyphase meter, is much better, but is still very far short of perfection; that three separate single-phase meters make the best arrangement, and should be employed when the highest degree of accuracy is demanded. For low-pressure three-wire circuits of small capacity the polyphase meter would undoubtedly be preferred. The conclusions reached in this paper are intended to apply mainly to high-capacity circuits using instrument transformers and involving a large multiplier.

THE USE OF INSTRUMENTS ON SWITCHBOARDS

Mr. Cox then read his paper on "The Use of Instruments on Switchboards." The object of this paper is to invite discussion on the more important features of instrument engineering. It is evident that the conditions on a central-station switchboard will not permit of the same accuracy as could readily be obtained in a laboratory, and the information to be derived from the instrument readings does not require so exact a determinatioin of values. For example, a shunt ammeter best adapted for laboratory conditions would have a shunt loss too great for switchboard service, and one designed for switchboards would have temperature errors so great that its use in the laboratory could not be contemplated. The author confined his notes to the conditions which are found on switchboards in central stations.

One of the most important considerations is in connection with the capacity of instruments to be used, and present needs cannot be altogether overshadowed by possibility of future growth. An ammeter whose needle constantly hovers around zero position is of comparatively little use, and an integrating wattmeter, which normally operates at ten per cent., and frequently at less than one per cent. of its rated capacity, may give a false impression of the operating efficiency of the station.

The friction of a jewel-bearing is generally considered so small that it may be neglected; but it must not be forgotten that a torque of 25 millimeter grammes is a little less than one five-thousandth of a foot-pound, and friction must be very small indeed if it is negligible as compared with this torque. Under normal working conditions, integrating instruments frequently operate at much lower torque, and even at full scale indicating instruments never approach this value.

It must also be remembered that the vibration of the board tends to impair the perfect polish of both jewel and pivot, and thus affect the accuracy of the readings. Other things being equal, it is apparent that these errors will be minimized by high torque, but they must not be altogether overlooked even under the most favorable conditions.

In deciding upon the capacity of an instrument it is necessary to take into consideration the relations between the smallest load, which it is desired to read, and the peak. It is generally considered advisable on railway circuits to have considerable overload capacity, and but little attention is paid to the light-load period. On lighting circuits, however, the overload is not considered to be as important as on railway circuits, and the light load is given more attention. It is usually good practice to select instruments of such capacity that under normal working conditions the needle of an indicating instrument will rest between half and two-thirds scale. This allows a reasonable capacity for growth and for overloads, and at the same time permits of sufficient accuracy during the light-load period.

Integrating instruments should be fully loaded under normal conditions, for they have an inherent overload capacity not possessed by indicating instruments; such practice insures not only low-load accuracy, but also a reasonable dial registration over comparatively short periods of time. Where hourly or even daily readings of the dial are recorded, it is not necessary that the registering train should have a capacity sufficient to care for several months' output. A rapidly-moving dial-train permits full advantage to be taken of the meter's accuracy, and a change of one or two figures should be recorded for each observation period.

Stray fields are always present in central stations and are frequently so strong that they cause marked instrument errors. In locating instruments on the board it is not sufficient to allow for position of bus-bars in relation to the instruments themselves, but the location of the iron framework of the board must also be taken into consideration. Magnetic fields have been carried by such iron frames and have introduced errors in instruments located many feet from the bus-bar itself. Such errors may be almost entirely eliminated by properly shielding the instrument, and no error need be introduced on account of residual magnetism or hysteresis of the iron shield.

The use of series transformers, even on circuits of comparatively low pressure, seems to be increasing; the added convenience in removing or in cutting out instruments for recalibration, and the added security for the operators, more than compensate for the slight errors introduced by their use. This practice is particularly to be recommended in those cases where both sides of the line are brought into the same instrument; such for example as the polyphase, integrating, or indicating instruments. It is also a good practice to interconnect the stationary and moving circuits and case of indicating instruments, and very often this would hardly be practicable unless series and pressure transformers are used.

Commutator meters are the only ones available for measurement of direct current; properly equipped with cupped diamond jewels, and occasionally corrected for commutator friction, they give excellent results. But induction meters with light moving element and no commutator are to be preferred wherever their use is possible.

In the measurement of polyphase circuits, the greatest care should be taken to see that the instruments are installed exactly in accordance with instruments received from the manufacturer. Sometimes a slight deviation from the connection shown on the diagram to connections which seem to be equivalent introduces considerable error, due to the instrument coils being in wrong phases; instruments are not infrequently charged with errors which should properly be attributed to incorrect connections.

THE OSCILLOGRAPH

The paper on "The Oscillograph and Its Uses" was read by title by the author, who later in the evening gave a practical demonstration of his oscillograph. The paper was an excellent résumé of the oscillographic art, profusely illustrated with photographic reproductions of apparatus and curves. Mr. Robinson, in part, said that the usefulness of a satisfactory method of observing or recording the wave forms of rapidly varying electric currents and pressures has been appreciated almost from the time that investigators and designers commenced working with electrical apparatus. The various methods which have been used for obtaining these records or indications have had, and are having, an important influence on the design of apparatus and a clearer understanding of the phenomena accompanying their use.

Instruments for obtaining wave forms divide themselves naturally into two classes,—those using point-by-point methods, most generally useful in connection with the investigation of recurring waves; and continuous methods which show recurring waves or record the individual waves. The first class can be traced to a common origin in the point-by-point method of Joubert, and the second to the vibrating-coil device of Elihu Thomson, 1881, and to his later apparatus, and that of Frölich for observing the excursions of a telephone diaphragm acted upon by the current, the wave form of which is to be investigated.

Various modern modifications of Joubet's method are Hospitalier's Ondograph, Rosa's curve tracer, and the General Electric wave meter. These instruments, however, are not suited to commercial work on instantaneous phenomena, as they require many repetitions of the wave to be viewed or recorded before its complete form is shown. But they can be made to operate with very little energy from the circuit to which they are attached and can be constructed to give records of any desired size, and of considerable accuracy.

These records are, therefore, well suited for analysis and furnish a positive means by which records or observations by the oscillograph may be checked, and the absence of errors, due to lack of critical damping and sufficiently high frequency of vibration, determined.

In the Rosa curve tracer the record is obtained on a drum by printing automatically from a potentiometer contact which is set by hand to a point indicated by a zero reading on a galvanometer. In the General Electric wave meter the record is obtained on a photographic plate from a galvanometer receiving the discharge from a condenser which is charged and discharged continuously by means of a commutator and contact brush attached to a synchronous motor which is, in turn, electrically connected to the circuit under test. The contact brush is carried around with reference to the poles of a synchronous motor at any desired speed, and in this way the record of the wave is made.

In this instrument the inconvenience of obtaining photographic records was thought to be outweighed by the fact that a photographic recording instrument can be operated with a minimum of energy, and its record can be produced almost absolutely correct with reference to rectilinear coördinates.

In the ondograph the record is obtained by an inking pen on a revolving drum. The actuating part of the recording instrument is traversed by the discharges from a condenser. The condenser is charged from a revolving contact which, by an ingenious method of gearing, is automatically changed with reference to the poles of the synchronous motor, thus producing on the recording surface the desired record of the wave. We have here an instrument entirely automatic in operation, but in which the time of taking the record is fixed by the frequency of the circuit to which the synchronous motor is attached.

The ondograph is, also, not particularly well suited to producing waves for analysis by reason of the fact that the record is not made with the abscissas referred to a straight line, therefore the record is bent over, which is a little confusing to one who is not used to the records made with the instrument. This distortion is due to the fact that the pen arm, although of long radius, still travels across the recording surface in a curved line, and all abscissas must be referred to this curved line instead of to a straight line as in the other two instruments referred to.

The true oscillograph, that is, the instrument with high period, critical damping, and comparatively good sensibility is to-day existent in two forms, both due primarily to Blondel, who has developed, to a high degree of perfection, the moving iron or vibrating strip type. This consists of a thin ribbon of iron tightly stretched between the pole tips of a powerful magnet, thus forming a polarized needle, held in position by the directive force of the magnetic field, and, also, by the resistance to torsion of the strip itself. Two small coils, to which the circuit under investigation is connected, are arranged on either side of this strip in such a way that the strip is acted on by the current flowing in them and at any instant the strip, having the necessary high period of vibration and critical damping, takes up a position which is a measure of the current flowing in the coils at that instant. A minute mirror is attached to the middle portion of this vibrating strip and a beam of light reflected from its surface can be made, by suitable means, to render the wave of current in the coils visible, or to record it on a suitable photographic surface.

The alternate type, or the vibrating-loop construction, is in reality a D'Arsonval galvanometer in which two metallic bands constitute the moving coil, as well as the suspensions. These are located in a strong magnetic field and the varying current to be investigated is led through the strips in opposite directions. The current flowing through the strips will then, at any instant, bend them in opposite directions, with reference to the field in which they are situated, and a small mirror, attached by its edges to the middle portion of the strips, will be deflected. The deflection of this mirror can be used, as in the first-mentioned type, to indicate or record the wave form of the current passing through the strips.

An oscillograph to give satisfactory results should have:

1. A short, free periodic time compared to the period of the wave forms being recorded.

2. Critical damping, that is, the motion first ceases to be oscillatory.

3. Negligible self-induction.

4. Sufficient sensibility.

To these might be added a fifth consideration; namely, the instrument should be so constructed that the working parts are readily accessible, and of sufficient size that they may be renewed or repaired by persons ordinarily skilled in the handling of testing instruments.

Referring to these various conditions in the order given, it is undoubtedly true that the iron-strip type can be made to have shorter free periodic time than the moving strip type, unless the dimensions of the parts in the latter are reduced to an impossible degree. Both types can be given critical damping. The vibrating-loop type is superior as far as negligible self-induction is concerned, and it is believed that it can also be operated with less expenditure of energy than the iron-band type.

Mr. Robinson believes the fifth condition is more fully realized in his instrument than in any instrument heretofore made, and which will, at the same time, satisfy, to a reasonable extent, the other conditions given. For practical work it is, in most cases, not necessary to use a periodic time shorter than that which can be conveniently obtained with the moving-strip type, and it is also believed that the negligible self-induction and small resistance of this type is of the greatest advantage when large currents, especially undirectional ones, are to be dealt with. Cases have frequently arisen in practice where such currents of several thousand amperes have been measured by passing them through shunts, similar to those used in connection with direct current moving coil ammeters, which is believed could not have been successfully handled with the iron-strip type. The accessory parts of this oscillograph for photographing and viewing the waves, have been developed to meet the special requirements of various investigators.

The instrument consists of a light-tight box in which is placed a three-element galvanometer to which are attached devices, by means of which the waves may be viewed or photographic records of them taken. The vibrating strips are contained in three containing cells, each of which is inserted and held between the pole-pieces of magnets, which are magnetized by suitable coils, the cells being vertical and parallel to one another.

The principle on which the instrument operates has already been referred to in speaking of the vibrating-loop type in general. The three elements of the galvanometer are entirely complete within themselves, with the exception of the magnetizing coils, and can, therefore, be insulated from one another to stand almost any required pressure. It is then not necessary to insulate the vibrating loop from the frame which holds it, or to rely for insulation on the somewhat uncertain condition that the vibrating loop can always be kept a safe distance away from the pole pieces, between which it moves. In fact, it has been found desirable in most cases actually to connect the strips electrically to the magnet, between the poles of which they are located. In the instrument shown, a pressure of 5000 volts has been applied between the separate galvanometer elements and between all of these and of the frame to which they are attached.

When the vibrator is removed from the containing cell, the vibrating strips are exposed on all sides; this is of the greatest advantage in restringing the vibrator and making any required adjustments to the moving parts. The vibrating strips, and consequently the mirror to which they are attached, can be moved around a vertical axis passing through the center of the mirror by means of a knurled head on a worm-gear. Each containing cell as a whole is movable around a horizontal axis passing through the same point by means of a screw.

These two adjustments make it possible to bring the image of the mirror into the desired place on the photographic film or vibrating mirror, even though it has been attached to the vibrating strips in a somewhat imperfect manner. The containing cell is filled with a damping liquid above a certain level. The vibrating loop, or strips, is usually made of pure silver hard drawn, and the mirror of silvered glass.

Suitable terminals convey the current to the strip.

In a standard pattern of this instrument the period is one five-thousandths of a second, the sensibility about 0.007 amperes per millimeter deflection, and the resistance about one ohm. The dimensions of mirror employed are 80 x 20 x 10 mils. It is possible by employing smaller mirrors to obtain higher periods, up to, perhaps, 10,000; but unless such a high period is absolutely necessary, the advantages are more than outweighed by the difficulty of handling the very small mirror required, and of reflecting sufficient light from its surface.

The advantage of silver over phosphor bronze which has usually been employed for the vibrating strips, is considerable. The resistance, and consequently the energy required to operate the vibrator, is, by this means, much reduced, which permits current waves to be taken with shunts having comparatively small fall of pressure, and the danger of creeping of the reflected image, due to expansion of the strips on account of the current passing through them, is entirely overcome. With high resistance alloys this is one of the limiting features.

The optical system employs a source of light, usually an arc lamp; a condensing lense by means of which a very nearly parallel beam strikes three small prisms, and is by this means split up into three portions, which are directed on to three vibrating mirror systems, and from this are reflected to a photographic drum, or to a synchronous mirror, from which they are reflected on to a surface where they may be viewed or traced.

In front of the photographic film is a cylindrical lens, and in front of the synchronous mirror another cylindrical lens. The latter are removed from the path of light when photographic record is to be made. The light from the arc lamp is intercepted by a shutter which is operated by electrical contacts. The shaft which operates the shutter contacts is also arranged to drive the photographic drum, and usually receives its motion from a small electric motor, the motion of which is transmitted from a cone pulley through a counter shaft. Speeds of from 6 to 600 revolutions per minute of the drum may be thus obtained.

The shutter-operating mechanism is so arranged that the shutter is open during one revolution of the drum, and for this purpose two devices are employed. In the first the shutter is opened just after passing the joint in the film and is closed when the joint is again reached. The cylinder which carries the contacts by means of which the shutter is opened and closed may be advanced by means of spring pin and holes in the ends of the cylinder, so that time required by the shutter to open may be allowed for. The adjustment required varies with the speed at which the photographic drum is rotated. For obtaining records where it is not possible to wait for the joint in the film before the exposure is made, the second device has been provided; this opens the shutter at any required instant and allows it to remain open for one revolution.

For viewing recurring waves, the lens and vibrating mirror, by means of a lever, are lowered into the path of light and the shutters, which close the opening to the tracing surface, are opened. The synchronous motor and mirror driven by it then being in operation and the shutter open, to allow the light to pass along the path indicated, the wave is visible on the surface.

The vibrations of the mirrors having been adjusted to have a suitable amplitude, and the synchronous mirror being moved through a suitable angle during one complete cycle, the point of light on the surface will move through a path equivalent to the figure obtained when the wave is plotted to rectilinear co-ordinates. As the mirror returns to its original position another shutter cuts off the light and again allows it to pass when the mirror again moves in the direction first indicated. This prevents the admission of light to the surface when the mirror is not moving in the proper direction.

Given an apparatus similar to that just described we can see and record waves of current and electromotive force in any circuit which can furnish sufficient energy to operate the device, and the frequency of which is not too high to be correctly recorded by it. In general it may be said that a period in the neighborhood of 5000 is sufficient for handling most phenomena which occur on circuits up to and including those having a fundamental frequency of 125 cycles.

The tests in which such a device has been found useful are of great variety. Photographic records taken simultaneously of the impressed electromotive force, the current in reactance, and current in condenser; of the current rush in primary of an 1875-K. W. transformer; of the spoken word "oscillograph," in which the vibrator was connected in the secondary of a small transformer, the primary of which was connected to a battery and a telephone transmitter, and other records were shown in the paper.

MAINTENANCE OF METERS

Mr. Mowbray then read his paper on "Maintenance of Meters," saying in part that to the company supplying electric energy which is measured by meters and charged for accordingly, the maintenance of meter accuracy is of supreme importance. Losses in other apparatus become insignificant when compared with the loss of revenue from meters that are allowed their natural tendency to run slow.

Periodic overhauling is the obvious and generally adopted means of maintaining meter accuracy. Overhauling is efficient in proportion to the cheapness and accuracy with which it is done and to the permanence of the result. Attention is first called to a portable test-meter used by the author for the accurate and almost instantaneous determination of the percentage by which a meter is running fast or slow.

This meter is similar to a customer's ordinary watt-hour motor-meter in that it has a rotating armature, each revolution of which represents the passage through the meter of a certain number of watt-hours. A rotating armature in a test-meter is advantageous in that its revolutions and those of the meter under test are directly comparable, making it immediately apparent whether the latter runs faster or slower than it should. Another advantage is that the comparison of revolutions is quite unaffected by fluctuations in pressure or current which would tend to render an indicating instrument unreadable because of the swinging of the needle.

The ampere capacity of this test-meter can be varied at will by means of a plurality of windings. To understand the utility of an adjustable carrying capacity it should be noted that a meter generally operates most accurately at full load and that as the load is decreased the meter is likely to become inaccurate. This is because it is impossible entirely to eliminate friction from the bearings and contacts of a meter armature, or to keep this unavoidable friction at a constant value.

Meters of widely varying capacity have to be tested in practice, and a test meter should accordingly be equipped with at least three different current windings and two different pressure windings.

Accurate and cheap calibration is, however, of comparatively little value if a meter soon returns to its former condition of inaccuracy, therefore in old meters appliances should be provided for increasing the permanence of calibration. Owing to the advance of the art, modern meters are fairly reliable, but their improvements are not generally applicable to the older forms. Suitable appliances have, however, been developed, chiefly by the large operating companies, with the result that meters manufactured some ten years ago can now be made at least equal in efficiency of operation to the most modern ones. Among the most prominent of these appliances are the adjustable friction compensating coil, the cupped, or concaved, diamond bearing, and a means for correcting the disposition of the drag-magnets relative to the field coils. The friction compensating-coil in operation carries a current of constant value, and can be moved into such proximity to the rotating armature that its accelerating effect exactly neutralizes the retardation due to friction. Commutator friction increases very rapidly when a meter is first put in service, owing to oxidation and roughing of the surface, but after a time it assumes practically a permanent maximum value. If at this time the compensating device be adjusted, a great part of the inaccuracy due to commutator friction will be permanently removed.

Diamond being the hardest known substance, was long recognized as the most desirable bearing material for meters, but it seemed impossible to get anyone to grind out a nicely curved and highly polished cavity in a diamond to receive the lower end of the vertical steel shaft. In the search for a new optical effect, however, the lapidary art has so developed that no serious difficulty is now experienced in satisfactorily cupping the surfaces of a diamond. As a meter-bearing it seems to embody the ultimate degree of perfection, the initial friction being a minimum and the wearing qualities a maximum. It is especially necessary in the old types of commutator meters, with their very heavy rotating elements, because in these meters the material next in hardness to the diamond, and which is generally used, sapphire, quickly breaks down in service.

In old meters the stray flux found a convenient path along the drag or braking-magnets, which tended to demagnetize them, thus causing the meter to record more than the true energy. Van Vleck found that by changing the disposition of the magnets so that the stray flux traveled across, instead of along them, this effect was minimized, and manufacturers changed their designs accordingly. Old meters can now be modernized in this respect by removing the magnets and attaching additional small bases thereto, the drilling of these new bases permitting the magnets to be remounted in the meter at right angles to their former positions.

DISCUSSION

Inasmuch as the foregoing papers are more or less correlated they were discussed jointly. In calling for discussion, President Lieb said it was unfortunate for the art that there is not the proper public confidence in the systems of metering ordinarily used to which those systems are entitled as measured by their results. Unfortunately, also, there is not adequate municipal or legislative enactment as to what constitutes an accurate meter. Obviously, a meter tested under ideal laboratory conditions where vibration, stray fields, variation in current, and similar factors can all be obviated, is not comparable with a test made under many of the conditions of actual practice, and it is usually a test under the latter conditions that the customer desires.

It is often very difficult to reconcile the firm belief of a customer as to the amount of current he is using with the indications of his meter. One is face to face with a question of fact as developed by the best instrument obtainable on the one hand, and on the other hand with a well-grounded belief, or perhaps only a general impression on the part of the customer as to what the conditions of use have been. Mr. Lieb thought that those who have to do with a decision of this kind should make it their duty to consider the conditions under which results are obtained, and, where there is any question, should make a careful investigation of all the conditions under which the test is made before casting any doubt on the instruments with which the results are obtained.

Caryl D. Haskins said it had always been a source of wonderment to him that the attitude of the layman is so different in regard to metering devices that it is in regard to all other forms of mechanical appliances. He called attention to some of the results of the Massachusetts State tests of electric meters. For example, the average error of all the electric meters tested in 1904 in that State was 1.08 per cent. from unity at full load, and less than 1 per cent. at one-fifth load,—50 per cent. better than the accuracy shown by gas meters on the complaint test. The total amount of money refunded as a result of complaint tests of electric meters in the year 1904 was $4.50. The State collected from the same group of complainants, as a mere guarantee of good faith, $138. Mr. Haskins thought Mr. Nies had assumed in his argument conditions far more adverse to accuracy than those which usually prevail. He wished to emphasize two facts which Mr. Cox mentioned in his paper, the importance of stray fields about the switchboards in relation to the instrument accuracy. There are innumerable switchboards to-day where the effect of stray fields almost destroys instrument accuracy; also that the accuracy of indicating instruments is substantially worthless at the very low readings of the scale. Mr. Haskins thought the indicating instrument should not be installed to such a capacity as to call for the acceptance of readings below the one-fifth scale.

Referring to the oscillograph he said its possible uses are almost endless. There is scarcely any electrical phenomena the study of which will not be quickly simplified by the use of this instrument or kindred devices. He differed with Mr. Mowbray in attributing to the operating companies the latest improvements in recording instruments. He thought the manufacturing companies were entitled to most of the credit in this respect.

Professor Edward B. Rosa agreed with Mr. Cox in regard to the use of switchboard instruments as precision instruments for testing. They should not be so used, but they are frequently used for this purpose. He had recently tested at the Bureau of Standards at Washington a series of four shunts, the values of which were from 1000 to 3000 amperes direct-current, which has been used in a railway station, and the correct value of which was desired to be known. The heating effect was found to be considerable, the thermo-electric effect was large, and the design was such that on certain contacts the variations in the contacts of the terminals of the bus-bars or leads would change the distribution of the current at the terminals of the shunts and change the potential at the ends. In one case the values were found by connecting up and disconnecting, and varied 8 per cent. from the minimum and the maximum values; yet this shunt had been used on a curve test of some value.

As to the transformers, his experience was that they were more reliable and accurate than is generally supposed, provided the load on the secondary is constant, that the transformer has been calibrated, and it is known what its ratio is compared with a given load.

Dr. Clayton H. Sharp said that the important thing concerning indicating instruments on switchboards is to check their accuracy in position and under working conditions. The difficulty with the ordinary methods of checking by comparison with standard instruments is that the standard instruments themselves may be so affected as to yield erroneous results. This difficulty may be overcome by using in checking an instrument such as the potentiometer, which is not affected by stray fields, or by using an A. C. instrument as standard, as suggested by T. Varley. The moving coil of this instrument is first connected into circuit, and the orientation of the instrument determined in which the moving coil is unaffected. Then readings are taken when the instrument is so shifted that the moving coil lies in the direction so determined.

As to the oscillograph, Dr. Sharp thought Mr. Robinson deserved great credit for having produced a really usable instrument, one so constructed that the user of it may be able to repair it when it meets with an accident. By experience he had found that a new strip can be put in and a new mirror attached in a very few minutes; therefore the rupture of a strip due to overheating by the current or to undue tension being put upon it, is no longer a serious matter. The manipulation also of this oscillograph is simple. He had used a Mowbry test meter with very good results.

A. R. Everest said that in the case of one type of current transformer of which he had knowledge an accuracy of within an error of less than 1 per cent. is obtainable over the entire useful scale of the instrument. He thought Mr. Nies's statement that a pressure transformer differs in no radical way from an ordinary transformer is somewhat misleading. The pressure transformer designed to supply the potential circuit or instruments is as much a special type of constant transformer as the meter is a special type of alternating motor, and the special characteristics which distinguish it can be readily brought out.

F. C. Pratt, commenting on Mr. Nies's paper, said strong fields from one transformer to another are an almost impossible condition. There might be possibly current which would make the flux on one side of the core excite that of the other, and give thereby an incorrect ratio. He disagreed with Mr. Nies in saying that on a polyphase meter there is excessive difficulty in calibration. He finds that a polyphase meter can be calibrated as easily as two single-phase meters, because in many cases, in the matter of checking, there is but one dial and one running mechanism to look over, and one set of readings to be taken.

A. H. Ackerman had found considerable trouble with balanced three-phase Thomson meters on account of the use of sapphire jewel bearings. After the meters were equipped with cupped diamonds the errors were diminished, on an average, not to exceed 1.5. He emphasized a point in Mr. Cox's paper to the effect that every switchboard should be provided with suitable arrangements for the testing of meters. He noted that the report of the Electric Light Commissioners of Massachusetts had shown that 48 per cent. of the gas meters were found fast; only 14 per cent. of the electric meters were found fast. Many of them were within the 2 per cent. limit.

At the conclusion of the meeting the members inspected the oscillograph in operation.

Electric Shop Power

THE problem of equipment for machine tool driving and for hoisting and crane work generally in a machine shop, has undergone much change within the past few years. Electricity and compressed air have radically changed both.

To a certain extent these agencies are rivals, but only within a comparatively limited area. The latter agency scarcely touches the driving of machine tools outside of the portable types, nor is it used much for hoisting tackle, excepting in the lighter class of traveling crabs and hoists. It is not a serious rival to electricity in the heavier cranes, whether they are of fixed or of traveling types. Neither is it adaptable, like electricity, to transmission over long distances. The air compressing plant must not be located far away from the tools and machines to be operated, but the power house generating electricity can serve the largest works equally efficiently with the smallest. The elasticity of the electric system, therefore, as well as its economies, explains and justifies its phenomenal growth.

The General Electric Company's Annual Report

THE thirteenth annual report of the General Electric Company, issued on April 25, 1905, shows that the profits of the company for the past year, after deducting all expenses and allowances for depreciation and losses, and writing off liberal amounts from the Patent Account and from Factory Plants and Machinery, were $6,719,545.78. After revaluation of the assets of the Stanley Electric Manufacturing Company and other acquired interests, and paying $3,684,384 in dividends, there was left a surplus for the year of $2,275,-507.73, making the total surplus on January 31, 1905, equal to $9,569,,-196.48.

The sales billed by the company to its customers for the past year were about $2,500,000 less than for the previous year, showing a shrinkage in business done of about 6 per cent. The amount itself was $39,231,328.

Among the important contracts made during the year are mentioned those with the New York Central Railroad for thirty 90-ton electric locomotives, for 40,000-K. W. capacity steam turbines, for entire switchboard plants for the Mount Morris and Yonkers Power Stations; contracts for generators to develop water powers in ten of the United States and in Mexico and other foreign countries; and contracts for 154 steam turbines with eighty-six corporations and individuals.

It is interesting to note that on February 1, 1905, the company had sold a total of 289 Curtis steam turbines capable of generating in daily operation from 450,000 to 500,000 K. W. Ninety per cent. of all turbines installed and in actual operation November 1, 1904 (three months prior to the close of the fiscal year), have been accepted by the customers and payments made. The company have sold a large number of these turbines to various customers in Canada, Europe, South America, Japan, New Zealand, Mexico and other parts of the world.

The magnitude of the company's business is strikingly illustrated by the statement that during the year 187,350 separate orders were issued (not including contracts), an average of 624 per working day. The average orders per day indicate the growth of the business as follows:—

AVERAGE NUMBER OF ORDERS RECEIVED PER WORKING DAY

Year ending Jan. 31—	
1900	473
1901	500
1902	533
1903	541
1904	570
1905	624

While the total business was less in 1904 than in 1903 in money value, the number of contracts and orders was greater, resulting in more work for the organization. Where a customer placed one large order in 1903, he placed several small orders in 1904; where a customer promptly decided on his requirements in 1903, he asked for and considered many alternate propositions in 1904. More work for the same volume of business was required of the company's salesmen, engineers, manufacturers and managers in 1904 than in 1903.

The report of the third vice-president, E. W. Rice, Jr., shows that, while in 1901 the total number of employees in the company's three plants at Schenectady, N. Y., Lynn, Mass., and Harrison, N. J., was 12,000, it had grown to 18,000 in 1905.

In connection with long-distance transmission work, the report further tells that the company have now on order apparatus for nine installations employing currents of 60,000 volts or over, and transmitting electricity from 47 to 100 miles. One of the recent and interesting installations is that of the Mexican Light & Power Company, Mexico, which will eventually develop 60,000 K. W. and transmit much of the energy 100 miles to the City of Mexico for light and power. This company has been supplied with 31 transformers of 60,000 K. W. total capacity.

It is not practicable to even mention the constantly increasing number of applications of electric motors. One interesting instance is that of the high-speed electric motor centrifugal pump, which promises to replace the steam pump for supplying water to cities. This electric pump occupies about one-quarter the space, costs much less and is more efficient than the present steam pump.

The company's line of steam turbine generators has been extended and improved, and a large number of important installations were made during the year. The New York Central Railroad ordered eight 5000-K. W. turbo-generators for supplying the electric energy for that portion of its road between Croton and the Grand Central Station which it is proposed to electrify. The vertical type which the General Electric Company developed for large units, largely because of its economy of space, has been uniformly successful and reliable. The few difficulties naturally encountered on account of the newness of the art have been gradually overcome.

The first of the locomotives built for the New York Central Railroad was subjected to its initial tests on the Central tracks west of Schenectady on October 27, 1904. The locomotive was tested in daily operation under all conditions for several months. It attained a speed of 52 miles per hour with a 550-ton train, and 69½ miles per hour with a 265-ton train. These are official figures with a four-mile track. After the track was extended to six miles, unofficial tests showed a speed of 75 miles per hour. The tests were satisfactory in all respects.

The company's new alternating current railway motor has been successfully employed on two tramways, and a number of additional orders have been received. This novel form of motor is, under certain conditions, cheaper and more economical than the company's standard direct-current motor, and the field of electric traction will be extended by its use.

The company has succeeded in still further improving the design and reducing the cost of its standard switchboard devices, and as heretofore has obtained the bulk of orders in this important line.

As the result of persistent effort on the part of the company to discover better methods of electric illumination than the present carbon arc and incandescent lamps, they introduced last year the "Magnetite" arc lamp, which is claimed to give a light equal to the present carbon arc with about one-half the consumption of energy. Improvements also have been made by the engineering staff all along the line of meters, switches, controllers and other of the company's small articles of manufacture.

Under the head of "Liabilities" in the financial report, the very gratifying statement is made that the company has no note payable. During the past year the company has not borrowed money or incurred obligations, nor has its credit been used either by issuing notes, endorsing customers' paper for discount or lending its name in any way. Its established policy of maintaining sales on a basis of cash, or short credit to desirable customers, has been adhered to.

When the electrification of the railroads which run under ground in London is completed the traveler will be able to traverse 60 miles under ground by electric traction without running twice over the same piece of track.

A movement is said to be on foot in Albany, N. Y., to raise a fund for the erection of a statue of Joseph Henry, one of the pioneers in electrical research, who was born in that city in 1797.

5-7

A Welland Canal Electric Power Project

It is stated that the Niagara-Welland Power Company, capitalized at $5,000,000 and having unlimited bonding privileges, will soon start to develop electric power under an old Canadian charter. The site of the projected development is near St. Catharines, Ont., to which point a surface canal 7 miles long may be built from the Welland River. This canal would carry water to the top of the escarpment, where a fall of 200 feet would be available. Harry Symons is president of the company and Roderick J. Parke consulting engineer. The proposed canal would provide for a development of 100,000 H. P., which ultimately could be increased to 200,000 H. P.

The project is very similar to what is known as Love's Model City Canal, a development that was projected on the New York side of the Niagara, but which never was financed. Love's canal was to have been of similar length to this proposed Canadian canal, but it was to carry water from the upper Niagara on the New York side to the escarpment at Lewiston, an industrial village being contemplated. This charter is still alive, it is believed, but the project appears lifeless. As capital hesitated about investing on the American side, it may do no better on the Canadian side, where prospects are less attractive, considering the great power development at Canadian Niagara, all of which has taken place since the original charter of the Niagara-Welland Power Company was granted in 1894.

Electric Heating and Cooking

In order to promote the sale of electric cooking and heating apparatus in and around the city of Philadelphia, the Philadelphia Electric Company last month arranged for a special meeting on the subject for their district managers and solicitors. A lecture on electric cooking and heating was delivered on that occasion by Max Loewenthal, secretary and electrical engineer of the Prometheus Electric Company, New York. Mr. Loewenthal showed by experiments the historical development of the electric heating industry, and presented considerable valuable data of a practical nature relating to this subject.

During the course of the evening a complete meal was prepared by means of Prometheus electric cooking apparatus by Miss Helen Tovell, a graduate of the Lemcke School of Cooking, and handsome menus were presented to those in attendance. A flashlight photograph was taken of the novel scene, showing a lecture table filled with experimental devices, and a dinner table completely set and a meal served.

Electric Power for Heavy Freight and Trunk Line Service

The application of electricity to heavy freight and trunk line railways was the subject of a recent lecture by J. H. Hallberg, before the Electrical Engineering Society of Columbia, at Columbia University. Mr. Hallberg described in detail all electric systems which have been proposed and tried for trunk line service, and a number of lantern slides, illustrating the 15,000-volt single-phase railway developments carried on by the Oerlikon Electric Company, of Zurich, Switzerland, under the direction of Mr. Emil Huber, were the subject of interesting discussion.

The electrical equipment for the New York Central Railroad, now being turned out by the General Electric Company, was also illustrated by lantern slides.

Mr. Hallberg also had prepared for the occasion a number of special slides, illustrating the Siemens & Halske locomotive used for the high-speed electric railway tests between Marienfeld and Zossen, and others, showing in diagrammatical form the power and distribution equipments required for the various systems.

One of the subjects discussed during the evening was the single-phase polyphase electric railway system proposed by Mr. Hallberg, and which has already been described in the electrical press. The important advantage claimed for this system over others is that it is possible to build very powerful locomotives, which can be operated with only one contact wire, delivering high-voltage single-phase current to the locomotive on which the current is converted, by means of a motor-generator set, into polyphase currents suitable for the polyphase induction motors, which are mounted on the driving axles.

Attention was further given to the various forms of construction for overhead contact wires for high-speed trunk line railway service, and the inverted catenary construction developed by Mr. Huber, of the Oerlikon Company, was favorably commented upon. Mr. Huber proposes making contact on the top of the contact wire instead of using the ordinary catenary suspension which makes it necessary to collect current from the under side of the wire.

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Leading Articles

Rapid Development in the Electrical Art

THE contractor for the building of the New York rapid transit subway some time ago, during the progress of the work, made the somewhat startling statement that owing to the great developments of the electrical art then going on, a generation of electricity was not now over three years, whereas when he had originally figured on the work it was considered to be at least seven years. The great advance in the design and construction of an electrical equipment for the production and utilization of electric power for tractive purposes had enhanced the cost of equipment to such an extent that although the contractor in question had engaged the best electrical engineering talent in the preparation of his original estimates, he found that the actual cost for the equipment was going to exceed the estimate by many millions of dollars. This experience, however, is not altogether peculiar to electric traction equipments, for there is probably no large electric light or power company in existence, with operations extending back over fifteen or eighteen years, that has not found it essential to change its entire system two or three times in that period.

The telephone exchanges especially have undergone repeated radical changes in the period mentioned, so much so that an immense quantity of perfectly operative apparatus has been thrown into the junk heap to make way for improved and generally more economical methods of operation.

In one case alone, in the city of New York, telephone apparatus to the value of $400,000 was for this reason deliberately dumped into the junk pile. It is also fresh in the minds of the American investing public how the traction companies of New York at enormous expense changed, in a few years, from horse-power to the cable system and then to the underground electric traction system. In addition to the losses which these various changes in the methods of operation have involved, enormous expense has also been incurred in the larger cities by the substitution of the underground in place of the aerial system of conductors. This change in the case of the telephone company operating in New York City entailed a loss equal to three-fifths of the entire net earnings of the company since its organization.

The only electrical industry, it may be remarked, that has not suffered in the past twenty or twenty-five years from radical changes in the methods of operation is the telegraph, the losses of this general nature here having been confined to the change from aerial to underground wires in cities. This fact has given the impression in some quarters that the telegraph companies are not progressive, and loud demands have been made upon those companies to adopt some of the many systems of rapid machine telegraphy whose inventors are clamoring for recognition, the fact being lost sight of, or ignored, that the methods now in vogue in telegraphy are, it may be said, specimens of the survival of the fittest. Machine telegraphy from the earliest days has been tried and, in numerous respects, found wanting.

The Wireless Telegraph Decision

WHAT is probably the first legal decision in this country relative to wireless telegraphy has recently been rendered in a long opinion by Judge Townsend, United States Circuit Court, Southern District of New York, in the case of Marconi Wireless Telegraph Company, of America, vs. De Forest Wireless Telegraph Company, on reissue letters patent, No. 11,913, of June 4, 1901, the original of which was issued on July 13, 1897.

The claims sued upon were 1, 3, 5, 8, 10 and 24 of the reissued patent. These claims are as follows:—

Claim 1.—In an apparatus for communicating electric signals by means of a producer of Hertz oscillations and a signaling instrument, the combination in the receiver of an imperfect contact, a circuit through the contact and a receiving instrument operated by the influence of such oscillations in said contact, substantially as and for the purpose specified.

Claim 3.—The combination in an apparatus for communicating electric signals, of a spark producer at the transmitting station, an earth connection to one end of the spark producer, an insulated conductor connected to the other end, an imperfect electric contact at the receiving station, an earth connection to one end of the contact, an insulated conductor to the other end, and a circuit through the contact, substantially as and for the purpose specified.

Claim 5 is identical with Claim 3, except that after the words "at the receiving station," the words "choking coils connected to each end of the contact" are added.

Claim 8.—The combination in an apparatus for communicating electric signals, of a spark producer at the transmitting station, an earth connection to one end of the spark-producer, an insulated conductor connected at the other end, a tube containing metallic powder at the receiving station, an earth connection to the powder and an insulated conductor connected therewith, and a circuit through the powder, substantially as and for the purpose specified.

Claim 10 is the same as Claim 8, except that after the words "at the receiving station," the words "choking coils connected to the powder" are added.

Claim 24.—The combination of a transmitter capable of producing electric oscillations or rays of definite character at the will of the operator, and a receiver located at a distance and having a conductor tuned to respond to such oscillations, a variable resistance medium in circuit with the conductor, whose resistance is altered by the received oscillations, means controlled by the received oscillations for restoring the resistance medium to its normal condition after the reception of such oscillations, and means for rendering the received oscillations manifest.

The Court held that Claim 1 is invalid by reason of broadening; that Claims 3 and 5 are valid and infringed by the devices shown; that Claims 8, 10 and 24 are valid, but not infringed by the defendants.

It appears that the prima facie evidence of infringement submitted in the case was one of the earlier of the De Forest wireless systems, consisting of a single vertical wire, insulated at the top, without plates, and in the circuit of which was the spark gap, shunted by a condenser at the transmitting station, and at the receiving station a vertical wire in the circuit of which was the so-called "goo," or chemical responder, of De Forest and Smythe, with a telephone as the receiver or indicator of the signals.

The claims of the original Marconi patent were limited mostly to a combination in the receiver for electrical oscillations of a coherer consisting of a tube and powder and means for shaking the powder. As Claim 1 of the reissued patent would obviously cover the previous work of Branly, Lodge and Popoff, as well as any other form of imperfect contact detector whenever combined with any electrical signalling device employing Hertz oscillations, the Court held that it constituted an under broadening of the original claim. It will be noted that no mention is made of the vertical wire in re-issued Claim 1.

The original patent also claimed a plate or plates suspended on a pole and insulated from the earth, presumably by the spark gap or by the imperfect contact.

Regarding Claim 3, it would appear that a main contention was as to what constituted an 'insulated conductor" and an "imperfect contact" within the meaning of the patentee. Defendants argued that this claim was inoperative inasmuch as it lacks a receiving instrument in the circuit through the imperfect contact; and that if the Morse receiving instrument be read into the claim it implies a different instrumentally than that of the defendant's detector, which employs a telephone receiver and is inoperative with the Morse telegraphic instrument.

It was also contended by the defense that the suspended conductor of the original patent applied directly to the metal plates suspended on poles, the connecting wire of which was insulated at its lower end by the spark gap or imperfect contact. The complainant held that the insulated conductor of Claim 3 is a conductor insulated at the top, which view was generally upheld by the court.

Claim 5 may be regarded as virtually similar to Claim 3, and is not of great consequence, since choking coils may be, and are, frequently dispensed with.

Claims 8 and 10 differ from claims 3 and 5, respectively, only in that in the former the words "a tube containing metallic powder" are substituted for "an imperfect contact." The Court thus apparently holds that a detector consisting of a tube containing a liquid with small particles of metal such as the De Forest-Smythe chemical responder may be classed as an "imperfect conductor," but not as the equivalent of the filings coherer or a tube containing powder. As the evidence did not show that the De Forest system under consideration employed any tuning devices in its operation, it was held there was no infringement of Claim 24.

In the view of the Court, Marconi discovered the possibility of making the prior work of Maxwell, Hurtz, Lodge and Popoff available by transforming electric oscillations into definite signals, thereby inventing a new instrumentality, and his monopoly should be sustained. The Court ordered a decree for an injunction and accounting as to Claims 3 and 5 and dismissed the bill as to Claims 1, 8, 10 and 24, the complainant to recover one-half of its costs. It is understood that the Court has subsequently revoked the order granting one-half of its costs to the complainant.

Both sides to the controversy claim to be well pleased with Judge Townsend's decision; the Marconi interests asserting that the upholding of Claims 3 and 5 protect them in the use, in wireless telegraphy, of an insulated conductor and grounded connections in combination with the imperfect electrical contact at the receiving station, thereby, they claim, giving them control of the wireless situation.

On the other hand the De Forest Company contend that in the decision declaring Claim 1, of the reissued patent, invalid by reason of broadening, it is now open to any one in this country to use a sending station employing a producer of Hertzian oscillations and any signalling instrument such as a telegraph key, and a receiving station including an imperfect contact or any other oscillation detector with a circuit through the contact, and a receiving instrument, such as a Morse recorder, or sounder, or a telephone, provided he does not use the specific devices included in the claims held to be valid.

Thus a system not including a vertical wire insulated at the top, and one which does not employ an imperfect coherer, such as the coherer in which the terminals of the imperfect contact and the spark producer are not connected to the earth and vertical wire, respectively, do not infringe Claims 3 and 5. Further, it is claimed that detectors such as the magnetic detector, the polariphone or fine wire electrolytic receiver, the hot wire barreter and other forms of detectors which are not imperfect contacts do not infringe said claims. As the De Forest Company claims not to employ imperfect contact detectors nor vertical wires insulated at the top in their later systems of wireless telegraphy, it is alleged that the system now employed does not infringe the claims held to be valid.

It may, therefore, be assumed that the end of litigation on these and other features is not yet in sight. Indeed, it may prove that this art will be as prolific of patent litigation as was the Morse telegraph system in its early days. In the art of wireless telegraphy there still remain to be determined, amongst other important questions, that of priority in the use of storage or oscillating circuits at the transmitting and receiving stations, tuning arrangements, the electrolytic detector, and presumably the question as to whether auto-detectors come within the scope of Claim 24.

Upon the announcement of the decision in the foregoing case no time was lost by the brokers who handle stock of the American Marconi Company in calling the attention of the people of this country and Canada to the increased value of the stock due to the said decision. Canada, by the way, is not affected by it. Advantage was also promptly taken by the brokers of the recent arrival of Marconi on these shores en route to Nova Scotia, to boom the stock with implied promises of trans-Atlantic wireless telegraphy in a short time. Marconi, himself, is said to have predicted that his trans-Atlantic wireless system will be in practical working order within six months.

The station at Glace Bay has been removed seven miles inland for the purpose, according to Marconi, of obtaining a location which should be safe from bombardment and destruction by the enemy's fleet in case of war. This is, no doubt, a wise precaution, and has already been advocated in these columns.* It would seem, however, that preliminary experiments might readily have been made with the existing coast station at Glace Bay to demonstrate the practicability of the proposed long-distance wireless signalling.

The advertisements referred to virtually claim that the Marconi system has a commercial monopoly of the business, and ends as usual with urgent advice to prospective investors to purchase stock while it is cheap, and before it, like the stock of the British Company, doubles in value.

No doubt the Marconi companies are making rapid commercial progress, as indicated by the installation of the Marconi system on the ships of the British and Italian navies, on many of the trans-Atlantic greyhounds, on the British coast lightships and lighthouses, and on the Gulf of St. Lawrence, together with its recent arrangement with the British postoffice department for the interchange of telegrams between ships and shore as noted at different times in these columns. But in the face of what other companies and governments are also doing in wireless telegraphy it is rather difficult to comprehend the extent to which a claim for a monopoly of the business can be justified.

For example, it is known that the German and United States navies and coastwise stations are equipped largely with the Slaby-Arco system; the French, Austrian and other navies and lighthouses are equipped with other than the Marconi systems; the De Forest system is installed on many of the coast liners of this country, and on vessels running to South American ports; and the Fessenden and other systems are also getting a share of the business.

There is perhaps another feature of the case which should not be overlooked when the reported enhanced value of the stock of the British Company is mentioned as an incentive to investments in the stock of the American Company, namely, that presumably the profits accruing from the outfitting of the British warships, trans-Atlantic liners and foreign coastwise stations, go into the coffers of the British company. This would appear to leave but little in the way of pecuniary return to the American company, apart from its prospective share of the trans-Atlantic wireless business, which is yet an uncertain quantity. In fact, even the earnings of the British company can hardly be considered to afford great cause for enthusiasm. This company, it appears, is capitalized at $1,150,000, and its gross earnings for the year 1904 were $63,401.05. Deducting operating expenses, this would not leave an inordinate rate of interest on the stock at par. It is proper to note, however, that better earnings are expected for the current year according to the statements of the officers of the company.

* Proposed Government Control of Wireless Telegraphy, The Electrical Age, June, 1904.

Niagara Power Underground

SNOQUALMIE FALLS, Washington, has a subterranean electric plant. Similar developments are practicable at Niagara Falls. In fact, there are a number of points on both sides of Niagara River near the great cataract, and on Goat Island, where underground power plants might be constructed at less probable cost per unit of capacity than some of those now at the surface.

Of the six great electric power plants now either partially or entirely completed at Niagara Falls, four are of what may be termed the pit and tunnel type. At each of these plants the development of power has been made possible by excavating a wheel pit for the water to fall into and digging a tunnel to deliver this water below the Falls. The wheel pit at each plant has a depth that corresponds approximately to the head of water available on its wheels, and is somewhat less than the difference of water level between the upper and the lower river.

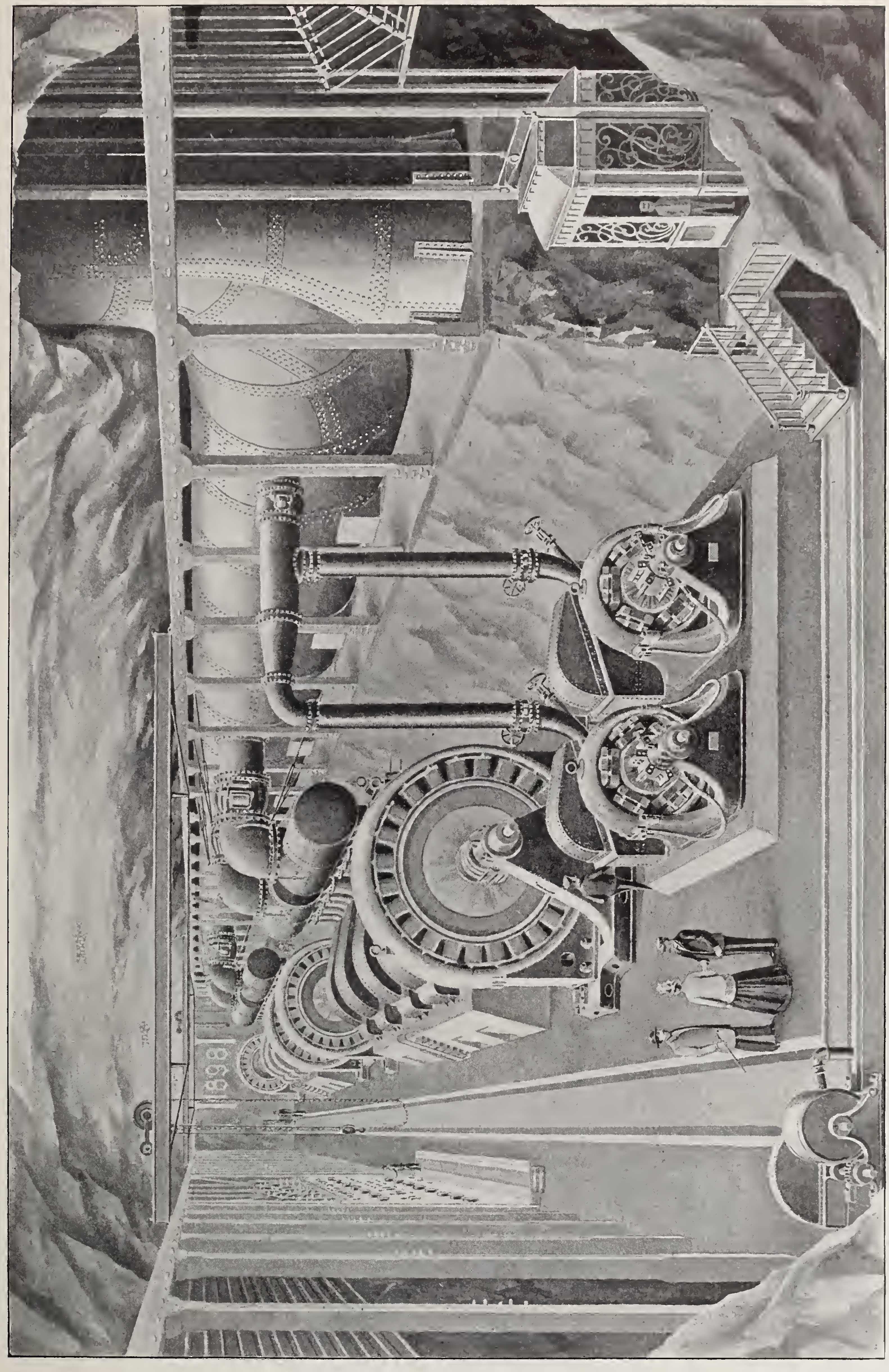
In order to obtain suitable locations for the power houses at the surface along the banks of the upper river, it has been necessary to excavate tunnels varying from 2100 feet length for the shortest to 7436 feet for the longest. Each wheel pit has a width greater than the diameter of each vertical electric generator above it, and a length nearly the same as that of the single row of these generators. The wheel pit with this length and width is carried down with vertical sides from the level of the upper river, and thus represents a large volume of excavation.

All of this excavation for both wheel pits and tunnels, save a thin layer of earth at the surface, is in shale and limestone rock. To connect each pair of turbines near the bottom of the pit with its electric generator at the top, it is necessary to employ a towering vertical steel shaft whose length is nearly equal to the depth of the pit.

A comparison of these features of the surface plants with those of a subterranean rock chamber for the same purpose, shows several points in favor of the latter. Such a subterranean chamber to contain the direct-connected water wheels and electric generators might be located beneath any one of many points on the banks of Niagara River, where a surface power house would be impracticable, or even under the river bed. More important still, the location of the subterranean chamber might easily be anywhere within several hundred feet of the brink of the Falls on either side of the river, or of Goat Island, and the necessary length of tunnel might be anywhere from less than one hundred to several hundred feet in length.

Next to the saving in the volume of tunnel excavation would be that of the subterranean chamber compared with that of the wheel pit. In length, the underground chamber would be approximately the same as the pit for equal capacities. For width, the chamber would require a dimension greater by perhaps 50 per cent. than that of the open pit, but a height of 30 to 40 feet would suffice for the chamber instead of 150 to about 180 feet for the depth of the pit.

The intake for a subterranean power house would require no more room on the river front than the intake for such a house at the surface, and the large area of real estate necessary for the latter would be saved with the former. Instead of a vertical shaft about 150 feet in length, and of a diameter of 11 to 15 inches in its solid portions and 38 to 40 inches in its hollow ones, as is now used to connect each pair of turbines in one of the wheel pits with a generator at the surface, only a short horizontal shaft would be necessary in a subterranean power plant.



UNDERGROUND POWER STATION AT SNOQUALMIE FALLS, WASHINGTON, DEVELOPING 11,000 H. P.

Such an equipment would have horizontal generators and turbine wheels on solid rock foundations, instead of vertical machines mounted on cross beams in the pit. Steel penstocks would carry the water down to the wheels in a subterranean power house just as they do now to wheels in the pits. The entire cost of a building for the power house would be saved by using a chamber in the rock for this purpose, since the construction of such a chamber, together with that of vertical tunnels for the penstocks, could hardly involve a greater sum than the excavation and lining of an open pit for a power house at the top.

To sum up, the subterranean power plant would save much cost of real estate and equipment, most of the cost of a tunnel, and all of the cost of a station building.

Against the subterranean plant, constructed in the way just outlined, there would be the necessity for the constant use there of artificial light and of special provision for ventilation, and the possible danger to the life of attendants and to the electric machinery by a break in the penstocks that would flood the underground chamber. Much of such force as these objections have would be destroyed by locating the entire generating plant at the bottom of an open pit similar to those now in use and covering its top with a glass roof. This plan would bring wheels and generators together with short horizontal shafts at the bottom of the pit, and would save more than the cost of a station building.

Electrically Operated Machines for Office Use

OFFICE work, in recent years, has shown a marked development from hand methods to those carried on by machines. In the working of a lever, however, the item of manual labor still exists in the latter to a large degree, but further developments are toward the elimination of hand levers and the substitution of electric keys or buttons. The ready adaptability of the electric motor to a wide variety of machine operation and the fact that current may be obtained in nearly every business office from the lighting circuit make this latter development a logical one. While there may have been a tendency to employ the motor where the conditions did not call for its use, yet the spirit of enterprise which prompted its trial was certainly commendable.

One instance of the application of the electric motor to office machine work is found in the electric typewriter. In this a small motor is incorporated as a part of the machine and furnishes the power to move the parts. A very slight pressure of the keys serves to print the letters, and the carriage travels to either side when the proper button is pressed. The machine is connected to an incandescent light socket, and the motor may be stopped or started by means of a convenient switch.

The adding machine is another well-known adjunct of the up-to-date office, and to this also the electric motor has been applied. The distinctive feature of this later development is the combination of an automatic totaling device with a continuously running motor. By turning a switch at the front of the machine it is ready for operation. The usual hand lever at the side is done away with, and an appreciable saving in time may thus be made.

With the motor-driven phonograph everyone is familiar, and while it has been in use for a number of years for recording and reproducing vocal and instrumental music, it is but recently that it has come into use for office dictation work. As in the other machines mentioned in the foregoing, it needs but a connection to a lighting socket to be ready for operation.

Another use of the phonograph is for recording telephone messages when the occupant of an office is absent. The call of the central office sets the phonograph in motion and the person at the other end is greeted with, "Mr. A. is not in. This is a phonograph talking, which will record your message."

The telautograph, while not an example of development from hand-operated machines, is a further instance of the use of electricity in office work. A prominent railroad is now using this device for the transmission of bulletins, and in another case it is used for important communication between offices where some record of the business is necessary.

In the discussion of N. J. Neall's paper on "Lightning Protection for High-Voltage Circuits," recently read before the New York Electrical Society, and referred to elsewhere in this issue, F. W. Jones mentioned a peculiar action of the lightning discharge in fusing the wire between the poles on the lines of the Postal Telegraph Company in the Western States. This action has also occurred frequently on the wires of other telegraph companies in different parts of this country, but so far as we are aware has not been noticed on the lines of the long-distance power transmission circuits, although shattered poles and damaged insulators due to lightning are not rare on those lines. In the case of a No. 14 B. & S. copper telegraph wire, this effect indicates a current loop of about 200 amperes according to Preece's formula. If it be assumed that in the observed instances of fusing of telegraph wires the copper was free from flaws at the point of fusing, it may then be assumed that the current due to lightning discharges does not reach the strength necessary to fuse the larger wires used in power transmission. It would be of general interest to learn more definitely if similar fusing effect to that mentioned has been observed on the latter lines.

Official Investigation of Fire Risks

THE National Board of Fire Underwriters, in order to further the work of the introduction of improved and safe methods of building construction, recently appointed a committee charged with the duty of organizing an engineering department composed of engineers of recognized ability to investigate conditions and make recommendations for improvements that will minimize fire hazards. Such a staff of engineers has been organized and data are being collected in four different cities.

The chief engineer is E. G. Hopson, of New York. Capt. Greely S. Curtis, of Boston, is engineer in charge of the investigations of the fire departments and their auxiliaries. The entire work of the committee is under the direct supervision of Herbert Wilmerding, the secretary, with offices at 135 William street, New York.

The federal government has detailed two engineers of the United States Army to investigate and review the reports from each city. These men are in no way connected with the business of fire insurance, and their criticism will be valuable to the department.

The Hotel Astor, in New York City, is equipped with a telautograph system for transmitting orders from the eighth floor, where all the large dinners are held, to the ground floor.

The British Royal Commission on coal supplies estimates that there are available in the proved coal fields of the United Kingdom 100,914,668,167 tons. Four thousand feet was adopted as the limit of practical depth in working.

Cement in Central Station Design

By EUGENE B. CLARK

A Paper Read Before the Chicago Branch of the American Institute of Electrical Engineers

THE Illinois Steel Company has just completed and placed in operation at its plant in South Chicago, a new power house for the supply of power to its various mills at South Chicago, and at Buffington, 10 miles distant. This station contains, at the present time, two units, each consisting of a 2000-K. W., 25-cycle, 2200-volt, three-phase generator, direct driven by a 24-inch by 60-inch by 48-inch horizontal-vertical, cross-compound engine. The addition of two more generating units, of a capacity of 4000 K. W. each, is contemplated in the near future. This alternating-current station operates in conjunction with a direct-current station which has been in operation for some time.

The two power houses are connected by means of synchronous converters. Both stations take steam from blast furnace boiler houses, in which the fuel is excess blast furnace gas. The supply of this excess gas is quite variable at times, and it is desirable under such conditions to be able to shift load from one station to the other, as desired. Such an arrangement gives the opportunity of utilizing completely all excess blast furnace gas at either point. The principal points of interest with which we are concerned deal entirely with the use of cement in the building of this and other power houses.

FOUNDATIONS

The foundations for the machinery and the building rest upon piles and are made of slag concrete, consisting of one part cement, three parts torpedo sand and seven parts crushed slag. The cement used for those parts of the foundations which are not exposed was of the brand known as "Puzzolan"; for those parts which are exposed, Universal Portland cement was used. The foundations were started in the coldest weather of last winter, and the concrete, which had to be mixed with warm water and warm sand, to keep from freezing in the mixer, did freeze immediately after being tamped into place. Filling was used to follow up the foundations as rapidly as they were put in place, so that the concrete was not permitted alternately to freeze and thaw as the warmer weather came on. The result was to obtain a thoroughly solid foundation, the concrete setting up firmly as it gradually thawed during the spring months. About the middle of summer the foundation was tested by drilling a hole several feet deep into that part which had originally been frozen. It was found that it had set up to make an extremely solid and strong concrete.

FLOOR CONSTRUCTION

A considerable amount of time and attention were devoted to determining the most desirable method of floor construction. The power-house apparatus is controlled by electrically-operated switching devices. The electrically-operated switches, together with the bus-bars, control pedestals, instrument posts and feeder panels, required for their accommodation the construction of galleries at one end of the engine room. Two of these galleries were built, and the engine-room floor was used as another gallery. On the engine-room floor were located the generator switches; on the first gallery were located the bus-bars, the instrument posts, generator-control pedestals, feeder panels, etc.; on the third gallery were located the feeder switches and the lightning arresters.

A transmission line, carrying a pressure of 20,000 volts, was necessary to transmit the required amount of power to Buffington, located 10 miles south of South Chicago. At least 4500 K. W. of transformers had to be located in the power house. It was decided best to place these on the engine-room floor, under the first gallery, constructing an isolated transformer room for that purpose. The transformer room was isolated from the rest of the apparatus on the engine-room floor by means of a wall about 3 inches thick and 17 feet high, built of reinforced concrete, in accordance with the method to be described later. This wall proved, after erection, to be thoroughly solid and substantial; as rigid, in fact, as would have been a masonry wall 12 inches or 14 inches thick. It then became necessary to take wires carrying a pressure of 20,000 volts through the operator's position on the first gallery. In order to harmonize these various requirements, it soon became evident that much additional space would be required if it should prove necessary to have the usual steel beams in the gallery floors, inasmuch as the beams would be in the way of the many wires which it would be necessary to take through these floors.

These conditions pointed to the advisability of using a floor construction of concrete slabs or fireproof tile. Careful consideration of the subject proved that, even with the comparatively long spans for such heavy loads, the concrete construction would be far preferable, both from the standpoint of cost and from the standpoint of fireproofing. Experience at the Baltimore fire had shown that properly constructed concrete floors had withstood the test of fire and water better than any other kind of floors.

To make certain of the safety and conservatism of the proposed design, a section of the floor, as proposed, was built and tested prior to the final decision as to the construction of the floor for the building and galleries. After being allowed to set twenty-one days, this section of floor was tested by piling pig iron upon it, to the extent of 500 pounds per square foot. The test slab was 7 inches thick and of a 15-foot span, made of concrete, consisting of one part Universal cement, two parts Torpedo sand and four parts 0.5 to 1-inch crushed limestone, reinforced with 0.5-inch steel rods, spaced 5 inches apart and laid on top of No. 10 gauge expanded metal, placed 1 inch from the bottom of the slab. Upon test, the slab collapsed under a load of 550 pounds per square foot. An even distribution of the load over the surface was obtained by covering the top of the slab with about 4 inches of sand, upon which was piled the pig iron. Deflections were measured as the load increased. The deflection at the center had risen to about 1.5 inches by the time the slab failed.

It was determined that the expanded metal was comparatively valueless for purposes of reinforcement when used in conjunction with the 0.5-inch round rods, as all the tension was taken by the rods. These rods were bent at the ends for a distance of about

10 or 12 inches through an angle of 180 degrees, thereby insuring that they would not pull out at these points. It was found necessary to bend the rod through 180 degrees, and not through 90 degrees; for those which were bent only 90 degrees showed a very decided tendency to crack the concrete at the corners and then to pull out. Round rods were used in preference to twisted or notched, or any other form of rods designed to prevent slipping or pulling out of the concrete, and for two reasons:—First, the round rods are far cheaper; secondly, it was decided that nothing was gained by preventing the rods from pulling out of the concrete, provided they were properly fastened at each end. The mixture used in all the floor construction was one part Universal Portland cement, two parts Torpedo sand and four parts crushed limestone, 0.5 to 1-inch mesh. The shoring under all floors was permitted to remain 28 days before removal. In the engine-room floor, for the very long spans, some floor beams were used, but in all cases they were entirely covered with concrete, to give thorough fireproofing.

CEMENT COVERS FOR GENERATOR AND FLY-WHEEL PITS

Wherever generator pits or fly-wheel pits were to be covered, such covers were made of cement castings, reinforced with expanded metal, rather than of cast iron. These cover plates were made to exact fit for each place as the work progressed, no drawings being necessary. The carpenter made a small mould of the correct size, in which the cement worker cast his floor plate and finished it exactly as the rest of the floor. The gallery floors were completed and the shoring removed before any work was done on the installation of the electrical control apparatus or the supports therefor. Each gallery was treated as independent of the one under it, so far as support was concerned, though, in building up the switch cells, the bus-bar construction and the barriers, the practical result was to give additional support to each floor from the one under it.

The switch structure was also constructed in such a way as practically to be a beam in itself. Round iron rods were cast into the lower part of the structure and allowed to extend through from the first switch in the row to the last. The result was to provide a construction of the switch cells which, being in itself a beam, would distribute the load to those points where the load might best be taken. In addition to this fact, the barrier which rose from the switch cell to the ceiling above, taken in conjunction with the lateral barriers—all of which were built monolithically with the wall rising from the switch structure—formed a column of great strength. It would probably not be poor engineering to depend, in a measure, upon the strength of this column to support the floor above it; but in the case which is being described this was not done.

Even though no attempt was made to utilize the switch structure as a column, still the fact was taken into consideration that there would be a natural tendency, by reason of the presence of the switch structure, to transmit load from one floor to the one under it, and therefore to impose a greater load upon the lower floor than would be accounted for by the weight actually upon that floor. This effect was compensated for by giving the lowest floor additional supporting columns, which were placed between the basement and the engine-room floor. These columns were covered with expanded metal and a cement plaster to insure against failure, in case a fire should occur, due to the storing of inflammable materials. It had not been contemplated that such materials should be stored in the basement, but it was thought wise to provide against this contingency.

CEMENT ROOFS

The roof of the engine house was constructed of concrete laid in place as is usual for sidewalks. In each bay a removable wooden frame was secured to the structural roof cords in such a way as to permit of ready removal by knocking out wedges after the roof was in place. A thin layer of cement mortar, consisting of cement and sand, was placed on the top of this woodwork support. The function of this thin layer was to give a smooth coat for the finished interior of the roof The expanded metal reinforcement was laid immediately on top of this preliminary coat, and was covered with about 2 inches of concrete of about the same mixture as was used for the floors. On top of this was placed a thin layer of rich mixture, which was given a sidewalk finish on the side exposed to the weather. After 28 days the wooden supports were removed from the inside, by knocking out wedges, and were lowered to the engine-room floor.

The roof, made in this way, developed cracks after drying out. These cracks were filled by pouring into them a thin grout consisting of cement and sand. The result was to stop all leaks and insure a roof which was cheap and thoroughly fireproof. It has the disadvantage of being heavy and requires rather heavier roof trusses than does a tile or slate roof; it is very strong and is not damaged by men walking upon it, or by falling pieces of stone or other materials. The latter consideration is an important one in the case described, because the station is located near blast furnaces, which, unfortunately, have the habit of throwing stone and ore out of the top at times. The advantage of using expanded metal on such a place as a roof, rested entirely in the economy of labor in handling the material. The writer believes the disposition of material in expanded metal to be uneconomical and, at times, disadvantageous. All of that material which lies transversely to the strain is wasted, and furthermore, it is the author's belief that there is a tendency on the part of expanded metal, when subjected to strain, to elongate the diamond-shaped meshes and to shear off the concrete between the meshes. The tendency to shear the concrete would be trifling and unimportant if, in addition to this, there were not a tendency to break the concrete which is always placed below the expanded metal for fireproofing purposes. This lower section of concrete is generally about 1 inch thick; being in tension, it is apt to crack when the floor is heavily loaded. After the lower section of concrete cracks, there is a tendency for the expanded metal to shift in position, and therefore become ineffective. This belief of the author's arises from observations of heavy beams reinforced with concrete and tested to the breaking point. He does not mean to convey the impression that for light beams, loaded comparatively lightly, expanded metal is not a desirable reinforcing material.

The electrically - operated oil switches, which are usually mounted in a brickwork cell structure, were mounted in a cell structure built up of concrete. A collapsible wooden mould was made, set up in the proper position for the switch, and filled with concrete from the top. This mould was built similarly to a hinged flask standing on end, and was made large enough to allow of casting two switches at one setting. The mould was properly lined up, leveled and braced to prevent moving while tamping the concrete. The bolts for holding the switches in place were set in the concrete of the cell structure by means of a template on top of the mould, just as foundation posts for engines are set.

The concrete mixture was one part Universal cement, two parts Torpedo sand and three parts screened limestone, which would go through a $\frac{3}{8}$-inch mesh. After the mould was constructed, the only skilled labor required was that of the carpenter, who lined up the mould each time it was moved into a new position. After the concrete had set for approximately 48 hours, the mould was stripped and again set up for the next two switches. After all the switches of a row had been cast, and the moulds removed, the cement worker went over them to point up any voids which might have occurred in the corners and to give the whole structure a finished appearance.

The result was a pleasing one. It was decided that the mould—which in this case was built of dressed lumber, in the attempt to give a smooth and finished appearance to the concrete work—might better have been of rough lumber, in which case it could have been built for about $50. In case a large number of switches were to be built, however, the speaker would recommend the construction of a metal mould, which perhaps would cost $100. A mould constructed of metal would be free from liability to warp, which always exists in the case of a wooden mould.

The wires leading from the oil switches were separated from each other by means of barriers built up of thin slabs of concrete. The methods of construction of these barriers were simple and effective. Pipes, or 0.5-inch rods, were set up and tied together with wire in the form of the proposed compartment construction. A light metal lath, such as is used for plaster partitions in building construction, was then wired to the light frame work. A cement mortar was then applied, in the same way as the plaster.

The cement worker became so expert in doing this class of work that he could build these compartments more rapidly than a draughtsman could make the drawings for them. The bus-bar structure was built up in the same way as was the cell structure for the oil switches. Where lines left the building, or where they were run in any horizontal position, barriers were suspended from the ceiling by allowing a piece of metal lath to project down at the time the floors were put in. The barrier was plastered to this piece of lath in the same way as just described. Where conductor wires were taken through the floor, which, of course, was frequently necessary, the insulators were set into the concrete as the floor construction progressed; therefore, when the floor and switch construction was completed, the wiremen had the insulators through which the wires were to be run properly located.

One great advantage of this form of construction rests in the economy of space which it makes possible. Any brick wall must necessarily be 4 inches thick, whereas a concrete wall may be put up only 2 inches thick, provided it is reinforced. In case brick constructions are employed, where thin partitions are desired, they must be built of soapstone or marble. The concrete is just as effective in most cases, and is much cheaper.

In constructing the switch cells and bus-bar structures, an attempt was made to obtain a perfectly smooth finish by dressing the mould smooth and coating it with shellac, as is customary for patterns. This was found to be a mistake, as the bubbles of excess water contained in the web mixture tended to gather on the smooth surface and make a rough finish to the work. It was found preferable to leave the mould rough and to finish the work with a final float coat.

The generator leads were brought from the machines in 3-inch bituminized fibre conduits, laid in the cement floor of the basement. Under the generator switches, they were brought from the basement floor to the engine-room floor in a solid concrete wall. The lead sheathing was removed from the cables, and additional coating, consisting of paper and shellac, was provided. After allowing a few days for this to dry, the cables were built into a wall of concrete. Inasmuch as the wall was only a few inches thick, little difficulty would be encountered in cutting the cables out, if necessary; in fact, three cables were cut out, under the mistaken impression that they were improperly connected. Little difficulty and slight expense were involved in the operation, and the cables were found to be in perfect condition. In the basement, no important wire or cable was permitted to be exposed. The result is that if a fire should start in any material which might be stored there it could not affect the connections to the generators or instruments, nor could it cause the collapse of the structure, due to the failure of exposed steel columns.

SAWDUST CEMENT FOR BURYING WIRES

The instrument leads and the control wires for the switches are buried in cement. It was originally intended to use for this purpose lead-covered cable run in an iron-armored conduit, the latter being imbedded in the floors. It was decided later, however, to do without the iron-armored conduit and to lay the cables directly in the cement floor. For this purpose a top coat of 2.5-inch of cement on the floor was allowed, in addition to the original cement floor which was designed to support the full loads. Of this top dressing, 2 inches consisted of a mixture of cement, sand and sawdust, in the proportions of one of cement, one of sand and two of sawdust. The method of installation consisted of laying the conductor cables on the top of the original supporting floor. When all the instrument wiring was completed and tested, the cables were covered and imbedded in this mixture of sawdust cement, and on top of all was laid a 0.5-inch finishing coat for the floor. The mixture of sawdust cement is soft enough to permit of chopping a cable out at any time without damage to the cable or to surrounding cables. The repair of the floor is very simple, and the floor is perfectly solid, and to all intents and purposes the same as if constructed wholly of concrete. The necessity for chopping out cables is very remote, because, once properly installed, there is no chance for movement or damaging of the cables. The item of labor saved by making it unnecessary to draw into the conduit the very great number of cables which are required for the installation of electrically-controlled switching apparatus is very considerable.

The 20,000-volt wires, which were led from the transformer room on the first floor to the lightning arresters and building outlets on the top gallery, were provided with thorough protection where they passed through the operator's gallery. For each wire a chimney was built of 10-inch bituminized fibre conduit. The three chimneys carrying the three wires of a circuit were placed close together and were surrounded with a construction of expanded metal lath, covered with cement plaster. The result was, to outward appearance, a rectangular column. In effect, there was a thoroughly insulated duct provided for the conveyance of each high-pressure wire, which acted to prevent entirely the possibility of an operator coming into contact with these wires in any way.

After the installation of all apparatus and connections thereto, the cement work was given a final finishing wash of whiting, glue and a slight amount of dark coloring matter, producing a uniform natural cement color over the whole job. It is impossible to produce this without some such wash, since all cement work will discolor more or less as it dries out.

The final result is most pleasing from both engineering and artistic standpoints. Not much effort was taken at the start to lay out the work with a view to insuring good architectural lines, but even though this was not looked to as it might have been, it was possible, by adding a touch here and there, to get some very satisfactory effects from the standpoint of appearance. Of recent years, most large power houses are designed with a view to obtaining good architectural lines on the exterior, whereas the interior is generally designed from an engineering standpoint only. The possibilities of cement construction in insuring artistic and decorative interior effects, with very slight increased cost, and without sacrificing engineering requirements, have so far received too little consideration.

London and New York Telephony Compared

IN New York, says Herbert Laws Webb in the London "Mail," you see the telephone everywhere and the service is there used for all purposes—in the household as well as in the office. In London the telephone has hardly yet made an impression on the life of the city, unless you spell city with a big C.

What are the reasons for this great difference? In London the history of the telephone is a story of collective obstruction and of individual conservatism. In New York neither the authorities nor the public have made difficulties. As a result there are in New York telephones in proportion of about one to fifteen of population and a highly efficient service, whereas in London there are telephones only in proportion of one to seventy-five of population, and the service becomes daily more difficult to carry on effectively.

One important cause which tends to restrict the use of the telephone service in London is the dull conservatism of many British business men and officials. British bankers will not use the telephone service. In America bankers are wholesale users of the telephone. In London there is not a hotel having telephone service in all the rooms. In New York the hotel which does not have the city telephone service in every room is the exception.

The metropolitan police refuse to use the telephone. The New York police have an elaborate system of their own, and connection with the general system at every station. In New York for years past the police have managed all large processions by telephone. In London the police and the military manage processions by flag signaling.

The broad difference between the American and British public, and their respective authorities, is that the former welcome all devices aiming at saving time and increasing efficiency, while the latter resist them to the last ditch.

An Electrically-Driven "Rolling Road"

THE inclined belt conveyor principle has for years been in common application for carrying passengers and freight from one level to another. It is exemplified in its latest form in the various escalators or moving stairways now used all over the country. But the first application of the same idea to the conveyance of horses and wagons has but recently been made in Cleveland, Ohio.

The "rolling road," as it is called,

THE UPPER END OF THE "ROLLING ROAD" IN CLEVELAND, OHIO. TWO STOPS ARE MADE, ONE FOR DRIVING ON AND THE OTHER FOR DRIVING OFF consists essentially of an endless moving platform, 8 feet wide, passing over a sheave at the top and bottom and supported by four rows of idlers. It is the invention of Col. Isaac D. Smead, and is built by the Cleveland Rolling Road Company, of Cleveland, Ohio. It is shown in operation in the annexed illustrations.

The platform is made up of heavy planking placed crosswise on trucks, each of the latter having two planks bound with metal edges. These are securely fastened and the trucks are connected with metal links. Two cables extend the length of the platform, and at short intervals links are fastened to them and pass up to fasten to the vehicles on the platform.

The road is 420 feet long and rises 65 feet. Four 40-H. P. Westinghouse compound-wound motors, one at each end and two spaced equally between, furnish the motive power. Each is provided with reduction gear of a ratio of 17 to 1, and drives a sprocket chain, 36 feet long, running parallel to the platform. On the outside of these chains are teeth, which engage, both going and returning, with an endless chain on the inside of the platform. The body of the structure is of steel and concrete.

Before the construction of the "rolling road," all teams coming from the "Flat" district of Cleveland to the center of the city had been obliged to use any one of the steep hills in that part. Now the horses simply haul the wagon onto the platform, the motors are started and in from two and one-half to three minutes the top of the hill is reached. The maximum capacity is the greatest number that can be placed on the platform. As many as eight wagons have been carried at once.

THE "ROLLING ROAD" AVOIDS THE NECESSITY OF A PULL UP A LONG, STEEP HILL. AS MANY AS EIGHT WAGONS MAY BE CARRIED AT ONE TIME

New Subway Routes for New York City

A COMMITTEE on plans of the New York Rapid Transit Commission, in a recent report, recommended the laying out of nineteen new subway routes. Proposals to construct routes were submitted to the committee by the Metropolitan Street Railway Company, the Interborough Rapid Transit Company and others, and because these conflicted it was decided to recommend an elaborate scheme of new routes. Many of these, while interfering with each other, will tend to increase competition, because the competitors can pick out combinations which will allow them to offer to construct trunk systems on the east and west sides of Manhattan and to Brooklyn and the Bronx, making junctions with existing lines.

The committee frankly admits that it has been led to recommend the laying out of so large a system by the anxiety of other companies besides the Metropolitan and Interborough to compete for part of the subways. Out of all the bids the commission will choose that which offers the greatest inducements to the public, and the route to which that bid applies will be that which the commission will authorize.

The Induction Motor in the Spice Mill

By GEORGE L. CLARK

THAT the induction motor is coming more and more to the front in isolated plant work cannot be questioned by anyone who is in close touch with this particular branch of electrical engineering. In the December issue, last year, of THE ELECTRICAL AGE, the advantages of this type of motor for carpet mill driving were discussed at some length, and mention was made of the use of induction motors in the propulsion of coffee roasters and spice-grinding machinery. While there are similar points of advantage in the use of induction motors in characteristically different industries, their good points in reference to the operation of spice-mill equipment deserve more than passing notice.

The preparation of food products according to the best modern methods demands cleanliness in every stage of the process as a prime requisite. Particularly is this true in a coffee-roasting and spice-grinding establishment. It is imperative to the continued success of the business that scrupulous neatness shall be observed from the time the bags of raw material are emptied into the sifters and separating screens to the time when the packages of finished product leave the factory for the retail houses. The discovery of a foreign substance in a box of spice is often enough, so much a matter of personal taste is the choice of brands, to divert even an old customer to another house. Hence arises an advantage in the electric driving of the spice mill, in comparison with the older operation by belts, often dirty and greasy, running to numerous pulleys and line shafts. The induction motor here scores an additional point over its direct-current prototype through its greater simplicity and consequent decreased supervision required. The absence of the commutator means less necessary inspection and adjustment, and therefore less climbing over work tables and machinery, and less getting about with step-ladders, and not always immaculate clothing and shoes, in the immediate vicinity of the food product. In fact, beyond an occasional inspection of bearings, say once or twice a year, the induction motor requires little, if any, attention.

In a modern spice mill the atmospheric conditions are unfavorable to the operation of commutator motors without supervision. The grinding of cinnamon, pepper and the like involves the creation of considerable dust in the air surrounding the machinery, which in time becomes deposited upon the motor frame, journal boxes, and sifted into the spaces between brush holders, field coils, armature coils and commutator leads. Frequent blowing out is necessary, and the cost of this supervision in the long run goes a good way toward paying the fixed charges upon the additional cost of the induction motor over the direct-current machine of the same rating. Doubtless there is a tendency to fall short in the matter of blowing out induction motors operating in spice mills, but there is no question that these machines will run even when well saturated with cayenne pepper dust, the removal of which is by no means a task for the uninitiated.

In comparing the relative first cost of induction and direct-current equipments, it is important to remember the saving of 25 per cent. in copper effected by the use of three-phase as against two-wire distribution at a given voltage, as ordinarily found in isolated-plant power circuits. Then, too, the controlling mechanism of the direct-current motor is more likely to give trouble through getting out of order or through careless use than is the induction motor starter. In fact, the smaller sizes of induction motors, say from 2 H.P. down, are started by the simple throwing in of the line switch, without the use of an external starting device. In the spice mill these smaller sizes find a ready use in driving sample grinders and roasters, small hoists, light machine tools, such as lathes and grind-stones, and also screeners and sifters. The larger mills and grinders call for greater power, two or three being grouped for driving by motors as high as 10 H. P. in normal rating.

Wherever the induction motor is used, the fire risk is materially lessened, and this species of insurance is certainly worth having in the spice mill, although it is in the textile industry, mines and similar situations that the question of fire hazard presents itself more forcibly. In regard to operating even 220-volt incandescent lamps from the same bus-bars, it has proved perfectly feasible to do so, and in cases where the number of motors is large in comparison with the lighting load, the steadiness of the lights shows little or no variation if the circuits are intelligently designed. The load represented by spice-mill equipment is not subject to the severe fluctuations so frequently encountered in such lines of motor application as machine-tool driving, for instance. The process of sorting, roasting, grinding and packing is remarkably continuous. Even combined passenger and freight elevator service in such plants can readily be handled by induction motors.

In making the foregoing comments, the object has been to point out the as yet far from generally appreciated advantages of the induction motor in a class of work to which it seems peculiarly adapted. It is, of course, possible to operate spice mills with direct-current motors, and it is important to bear in mind all the known and prospective conditions of operation in such establishments before committing oneself to either type of machinery. As an instance of the relative first cost of the two types, it may be remarked that at the present time a 10-H. P., 220-volt, 60-cycle, three-phase induction motor costs about $240, against $180 for direct-current motor of the same rated output. The cost of attendance must be balanced against the fixed charges upon this excess of $60 per 10-H. P. motor operated in the given plant in getting at the relative financial economy of the two motors.

The fact that spice-mill machinery generally extends through several floors, in order to secure that harmonious sequence in the operation of processes which makes for the low-production cost, emphasizes the importance of taking the feeder system into the problem of choosing the type of motors to be adopted. In the light of recent practice, however, the outlook for the induction motor in new spice-mill installations is exceedingly favorable.

The first electric street railway in Manila, in the Philippine Islands, was formally opened for traffic on April 10.

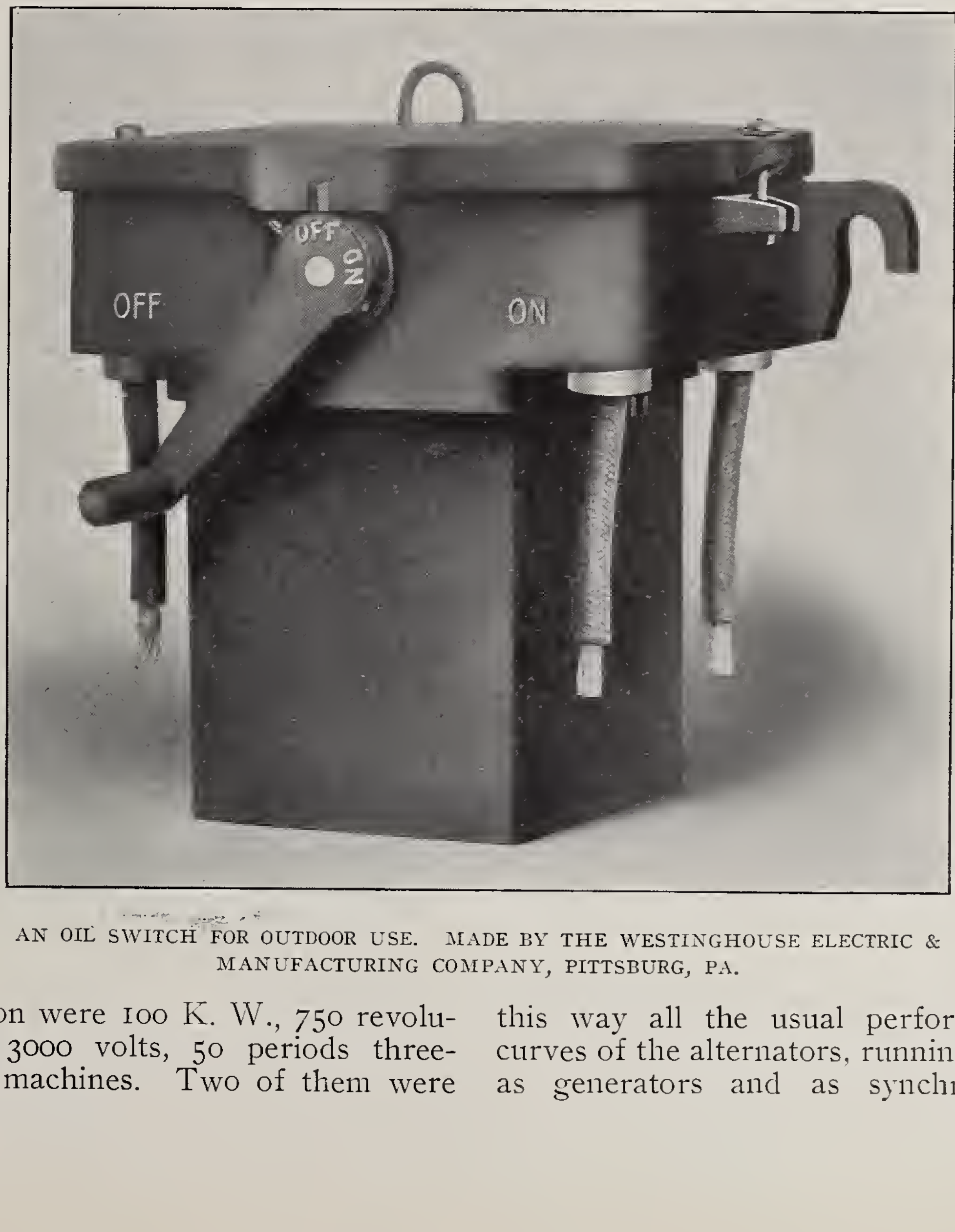
Electrical and Mechanical Progress

An Oil Switch for Out-Door Use

THE demand for a serviceable out-door type of oil switch adapted for use with alternating-current, series arc-lighting systems, for cutting out banks of transformers, isolating underground or overhead feeders and mains from main systems and operating inductive loads of all kinds, led the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., to put on the market a switch which, it is claimed, meets all these requirements. As may be seen in the annexed illustration, it is a double-pole, single-throw switch, mounted in a weather proof case which may be easily attached to poles or cross arms in the case of overhead systems, or may be hung in man-holes where underground systems are used.

The essential features consist of knife-blade contacts submerged in oil and high insulation between poles and between frame and live parts. Knife-blade contacts are used, as they insure the best contact for low-temperature rise. Each jaw has a detachable arcing piece which takes the final break, thus preventing any possibility of arcing between the jaws and blades. These arcing pieces may be removed very easily when worn out or burnt away.

Suitable barriers are placed between the poles, which prevent the arcs from communicating. The switch is compact and light, weighing but 40 pounds, and has a maximum capacity of 300 amperes at 3300 volts. When so ordered a special oil may be furnished with this switch, which is especially suitable for use in cold weather, as it has a very much lower congealing point than any oil now on the market which is otherwise suitable for oil switch work. One and one-half gallons are required to fill the tank.



AN OIL SWITCH FOR OUTDOOR USE. MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

A Novel Method of Testing Turbo-Generators

A SIMPLE method of testing hydraulic turbo-generators is described in the "Zeitschrift für Elektrotechnik." The generators in question were 100 K. W., 750 revolutions, 3000 volts, 50 periods three-phase machines. Two of them were erected close together in the station, and each was directly coupled to a 150-H. P. Pelton wheel. Each generator had its own exciter directly coupled to it.

During the test one of the alternators was used as a synchronous motor running in the reversed direction from the normal, so that by opening the water inlet valves more or less on this reversed machine the water wheel acted as a brake, absorbing power. In this way all the usual performance curves of the alternators, running both as generators and as synchronous motors, were very readily obtained.

Synchronizing was accomplished by connecting the two machines by means of a light belt, and running them up together until a sufficient speed was reached for the synchronizing action to become effective. This occurred at about half speed, above which the belt could be discarded, and the one machine continued to run as a synchronous motor driven by the other as a generatoı.

In order to carry out a test by this method, it is only necessary to reverse the relation of the phases of the armature winding on the machine which is to act as motor, to cross the shunt connections of the exciter of the latter machine, to provide a light belt, and to connect the terminals of the two machines electrically before the commencement of the test. Some modification of the method might be applied to steam turbo-generators, the driven machine, for example, being allowed to compress air.

Ice-Making for the Household by Electric Energy

IN one of its recent monthly bulletins entitled "The Brooklyn Edison," the Edison Electric Illuminating Company, of Brooklyn, N. Y., refers, under the above head, to an outfit for hygienic ice-making and sanitary refrigeration by the aid of electric energy,—a combined plant for household use, brought out by the Brunswick Refrigerating Company, of New Brunswick, N. J.

Just at present it may be a trifle too expensive for ordinary use by the average family—$300 is more than everybody can afford to pay even for a machine which, while making its owner independent of the iceman's tender mercies, supplies him with superior ice and a clean and pure mechanical refrigeration at an equal or less cost than the iceman's weekly bills. But there are still many to whom $300 is not much and an ice-making machine of this kind would be a good deal. Besides, the price of this machine is bound to become lower and less in time, just as did the price of the sewing machine and the bicycle.

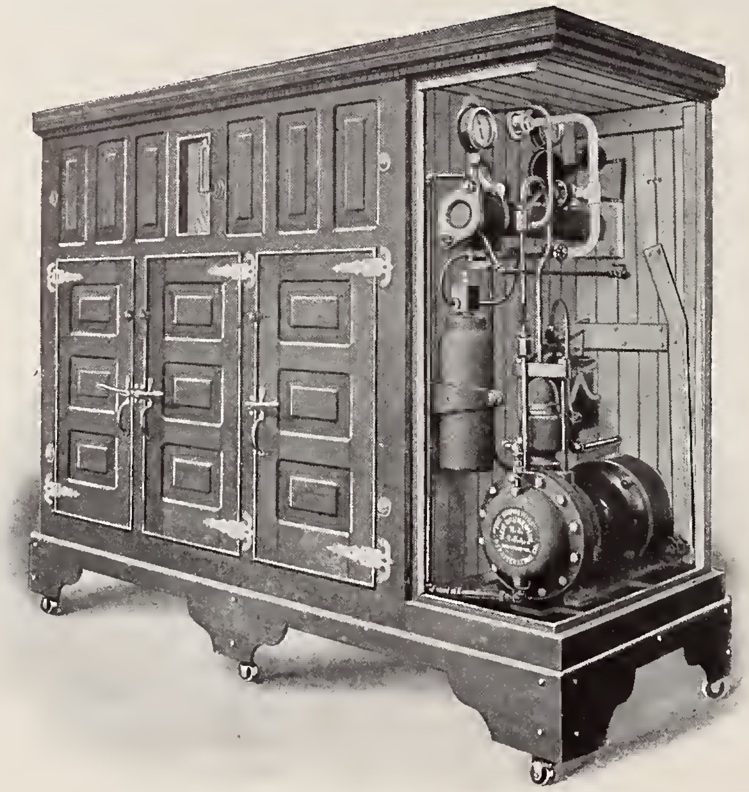


FIG. 1.—A MOTOR-DRIVEN REFRIGERATING PLANT FOR HOUSEHOLD USE. MADE BY THE BRUNSWICK REFRIGERATING COMPANY, NEW BRUNSWICK, N. J.

The New Brunswick machine is made in various sizes. The one which sells for $300 and is shown in Fig. 2 on this page, is operated by a $\frac{1}{2}$-H. P. electric motor, makes from 20 to 40 pounds of ice a day and refrigerates two storage compartments, each about $1\frac{1}{2}$ foot square and 26 inches high, to a temperature of from 35 to 38 degrees F., maintaining these temperatures through the night, when the machine is idle.

Fig. 1 shows a refrigerator box arranged for refrigeration only. The entire space in the box is divided into three compartments, and temperatures are held at from 35 to 40 degrees F. The compressor is motor driven, requiring less than $\frac{1}{2}$ H. P. The machine is automatic throughout and can be operated by any person of ordinary intelligence.

In size it measures 90 inches long, 35 inches wide and 62 inches high. Each compartment is 22 inches deep, 18 inches wide and 30 inches high. The cost of this machine is $350. It is mounted on wheels so as to be easily moved about.

A Small Direct-Current, Alternating-Current Generator

A NEW generator recently placed on the market by the R. M. Cornwell Company, of Syracuse, N. Y., and shown in the annexed illustration, is wound for both direct

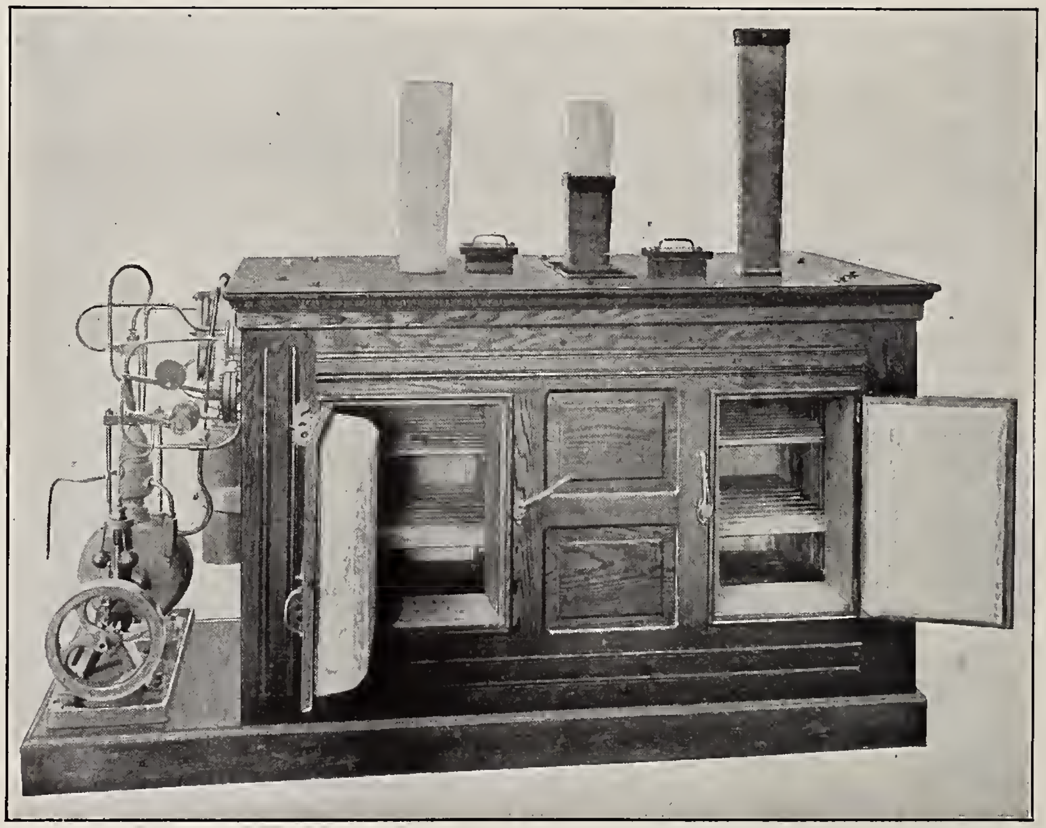


FIG. 2.—ANOTHER TYPE OF MOTOR-DRIVEN REFRIGERATING PLANT FOR HOUSEHOLD USE

current and alternating current use.

It has an output of 12 watts, and is wound for either 4, 6, 8 or 10 volts. Special windings may be had to order. The weight of the machine is 4½

A NEW DIRECT-CURRENT, ALTERNATING-CURRENT GENERATOR MADE BY THE R. M. CORNWELL COMPANY, SYRACUSE, N. Y.

pounds, the height is 4½ inches and the shaft is 6¼ inches long.

The frame is made of a special grade of soft cast iron, the bearings are of heavy brass and are interchangeable. The armature is of the drum laminated type, made up of thin soft iron. The commutator is made up of eight sections of a special grade of copper, and the brushes are of thin sheets of copper.

This generator, known as the "Wonder," is furnished without hand power for $6.50, and with hand power and belt for $10. A 6-candle-power lamp, with cord and receptacle, are also furnished for 60 cents.

New Magnetic Speed Accelerators and Clutches

A NEW magnetic speed accelerating device designed by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., is shown in the annexed illustrations. A subsidiary company, known as the Cutler-Hammer Clutch Company, has been organized to manufacture and sell this device.

The accelerator is composed of three parts—a field, an armature and an oil casing. The field is made up of the back plate, outer and inner field rings, magnetizing coil and contact rings. The back plate is a cast-steel plate, with a hub bored and key-seated to receive the shaft or sleeve on which the device is to be mounted. The plate has an annular groove which carries the magnetizing coil, the contact rings, to which the coil terminals are attached, being mounted on the hub. The back plate is also faced off to receive the field rings.

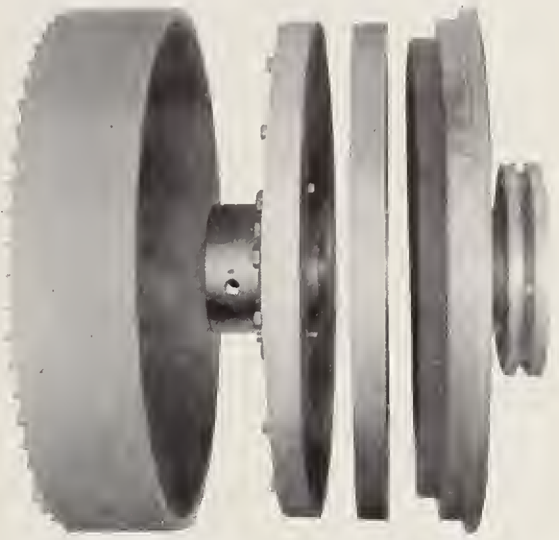
The field rings are cast-steel rings having radially projecting poles. When assembled, the polar projections of the outer and inner rings intermesh, the inter-polar spaces being filled with some non-magnetic metal, such as babbitt metal. When thus assembled and finished, the inner and outer field rings, with polar projections separated by babbitt, form a continuous surface for the bearing face. When mounted on the back plate they afford excellent protection for the magnetizing coil, which, while not surrounded by a complete magnetic circuit, is, nevertheless, completely enclosed.

The armature is a cast-iron plate adapted to be drawn into engagement with the field when the latter is energized. It is bolted on the outer circumference to a disc of steel plate, which in turn is bolted to a flange on the hub. This hub may be either keyed or loose, according as the device is used as a coupling, or to carry a gear or pulley, but has practically no end play in either case.

When properly mounted, the spacing is such that there is a small clearance between the face of the armature and the field, so that when out of engagement there is no drag, due to the faces coming in contact, and not the slightest tendency to start the idle member. When the accelerator is energized, there is sufficient spring in the steel plate to allow the armature to move laterally and engage the field. This springing of the plate acts to release the clutch instantly when the circuit is opened.

The oil casing is a cast-iron shell, bolted to the back plate and enclosing the armature. It is provided with tapped holes for filling and draining, and carries oil for lubricating the faces. The oil also serves as a cooling medium, absorbing heat and giving it off through the walls of the casing, which is provided with ribs to increase the radiating surface and also act as fan blades.

Owing to the multipolar construction of the field an unequal distribution of magnetism is set up in the armature, and this induces eddy currents in the latter whenever there is a difference in speed between the two members, being a maximum when one is at rest and the other at full speed. The

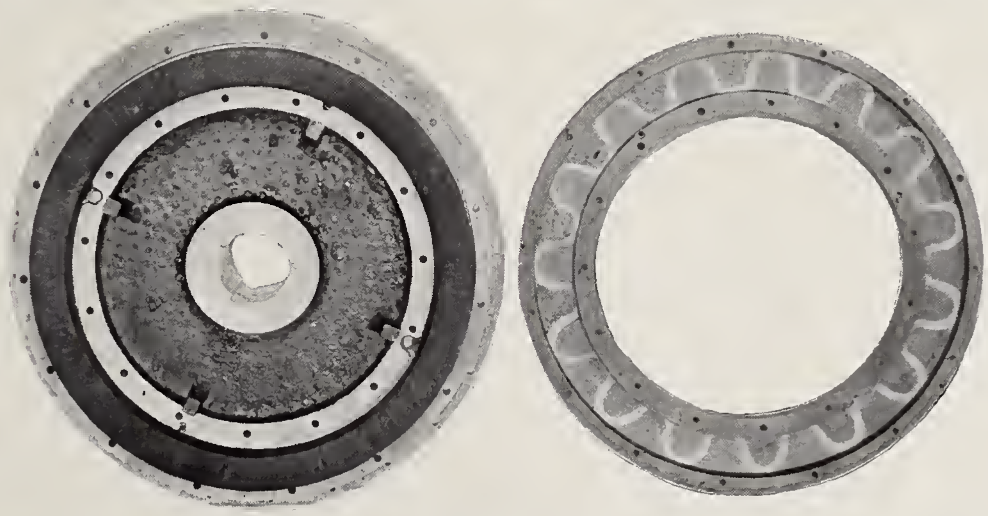


A NEW MAGNETIC SPEED ACCELERATOR MADE BY THE CUTLER-HAMMER MANUFACTURING COMPANY, MILWAUKEE, WIS. THE PARTS ARE HERE SHOWN READY FOR ASSEMBLING

reaction between these eddy currents and the field which induces them, causes a torque in exactly the same way that torque is produced in an induction motor by the reaction between the field set up in primary windings and the currents induced by it in the secondary or armature.

In operation, the accelerator may be energized by closing the circuit directly to the line, with no resistance in series, without endangering the driven machinery through undue shock or jar. The magnetism set up in the field attracts the armature, which moves laterally, closing the gap between them. The film of oil on the faces prevents it from taking hold suddenly, and the starting torque is largely that due to the magnetic drag between field and armature. This torque decreases as the driven member attains speed, which is the condition necessary for smooth starting.

As the oil becomes squeezed out from between the faces, and the torque



THE BACK PLATE WITH MAGNETIZING COIL AND THE FIELD OF THE CUTLER-HAMMER ACCELERATOR

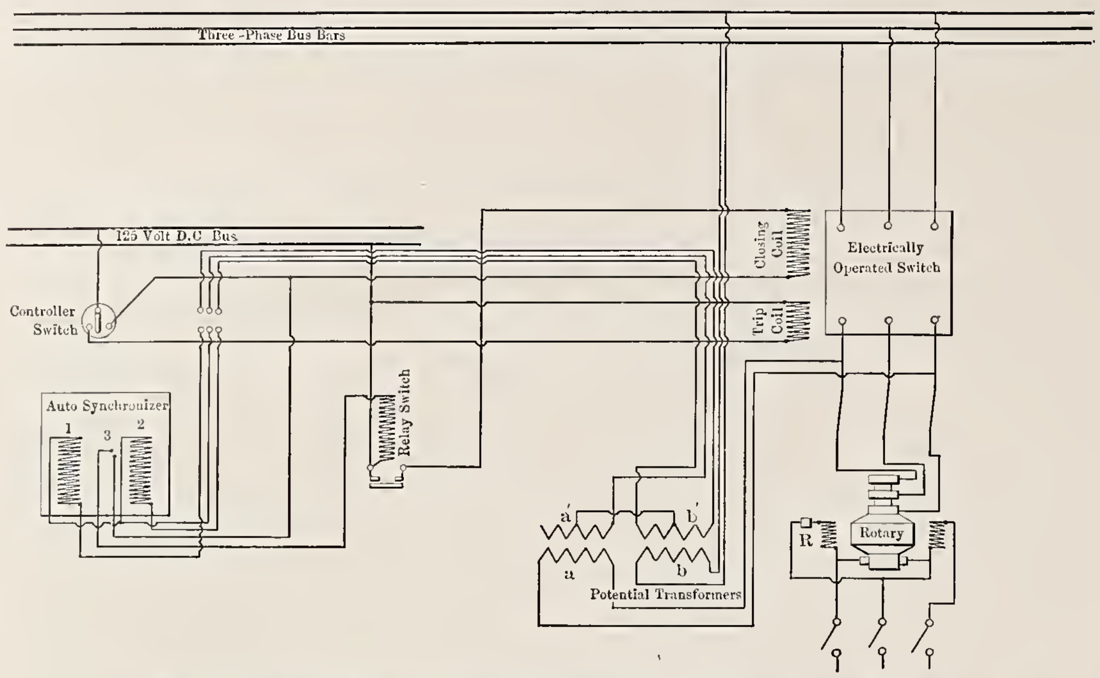


DIAGRAM OF CONNECTIONS FOR A NEW AUTOMATIC SYNCHRONIZER MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

due to induction decreases, the torque due to friction between the faces increases and brings the driven member up to full speed. The result is a smooth, easy start. Smoothness of acceleration, however, should not be confused with slowness or gradual acceleration. In cases where a slow acceleration, or one under the operator's control, is desired, a rheostat is used to regulate the energizing current. By this means the time of acceleration is considerably lengthened and may be varied by the operator over a wide range.

The device used as a clutch only—which is not illustrated—consists of two cast-steel rings, carried on steel plate webs, which are bolted to the shafts to be coupled. One of these rings, called the field ring, has an annular slot in which the magnetizing coil is secured; the other, which acts as the armature or keeper, is so mounted as to be separated from the field member, when the coupling is not energized, by an air gap of from 1-16 to 3-16 inch. The spring of the steel-plate webs carrying the field and armature allows these members to spring together when the coil circuit is closed, the magnetism induced holding them by a strong pressure. When the circuit is interrupted, the spring of the plates separates the surfaces.

The Westinghouse Automatic Synchronizer

TO start alternators or rotary converters quickly, and to bring them from a standstill to full running condition within the briefest possible period is one of the essentials of modern service, and, consequently, the ability to quickly synchronize machines which are to operate in parallel is a matter of importance. Two factors have to be taken into consideration—phase and voltage. Numerous devices are in use to determine the instant when the proper relation of these factors exists between two machines for connecting them together.

Incandescent lamps connected between the incoming machine and those running have been most frequently used in the past to indicate the phase relation by the pulsation of the light. This arrangement does not fulfill the the requirements of modern service, however, as the phase difference is only roughly shown, and, furthermore, there is no indication whether the incoming machine is running too fast or too slow, the fact of synchronism being indicated by dimming of the lamps, at which time the operator throws the generator switch. During the time required to close the switch, the machines are liable to pass the point of synchronism, which would cause the surging of the currents between the machines.

By the use of the one made by the Westinghouse Electrical & Manufacturing Company, of Pittsburg, it is possible to determine not only when there is a phase difference, but its amount, whether the incoming machine is too fast or too slow, and the exact moment when the machines are running synchronously and may be paralleled. Although the synchroscope was a long stride in advance of the older methods of indicating synchronism, it has limitations in service, as it has no value further than visually indicating the conditions of the incoming machine, the throwing in of the switch being dependent on hand operation.

The automatic synchronizer which is applicable to installations using electrically-operated or electro-pneumatic switches, or to which such switches may be added, provides a means whereby the operation of the coupling switch will not lag behind the moment of synchronism. An adjustment is introduced whereby the contacts close at a predetermined time before the incoming machine makes synchronous speed. As automatic switches require a certain period of time to close, it is necessary that the closing operation begin in advance of synchronism, so that the switch will close at the instant synchronism is reached. If the speeds of the machines vary too much, this instrument prevents the coupling taking place. The adjustment of the synchronizer may be changed to coincide with the time element of any particular form of switch which may be used.

The automatic synchronizer consists essentially of a metal case in which are mounted two solenoids, the upper ends of whose cores are flexibly connected to either end of a lever which is swung centrally on a shaft. Attached to the shaft is a suitable contact arrangement which is normally open. The function of this contact device is to close a circuit through the closing coil of an electrically-operated or electro-pneumatic switch. Current to actuate the switch is taken from a source independent of the generators, such as the exciter. Current to energize the solenoids is taken from the bus-bars and from loads connected to the incoming generator or rotary converter through potential transformers.

In effect, the mechanism holds the contacts of the switch-operating circuit open until the incoming machine arrives nearly at synchronism, and, taking into proper consideration the time element, causes it to close at synchronism, connecting the machines together. A controlling and a relay switch are interposed in circuit with the synchronizer and electrically-operated switch. By means of the controlling switch the main or electrically-operated switch may be tripped, but cannot be closed, as the closing coil is normally out of circuit until the synchronizer is in the position assured at the synchronous operation of the generators or rotaries, which closes the relay switch circuit and completes the path of the current through the controller and electrically-operated switches. The relay switch is provided with carbon break and is intended to relieve the contacts of the synchronizer from excessive currents.

In the diagrammatic view of the instrument connections with a rotary converter installation on this page, the automatic synchronizer, controller switch, relay switch, electrically operated switch, rotary converter, potential transformers and bus-bars are clearly indicated. Assume that it is desired to start the rotary converter—which is accomplished by an induction motor not shown in the figure—and bring it up to approximate speed ready to connect in circuit. It will be seen that the primary *b* of the potential transformer is connected across the bus-bars, and the primary *a* of the other transformer is connected to corresponding terminals of the rotary converter behind the electrically-operated switch, that is, between the switch and the rotary. It will be noted from the diagram that the coils of the automatic synchronizer are so connected as to alternately pull their cores down, the left-hand coil pulling when the phase difference is 180 degrees, and the right-hand coil pulling when the phases of the machines coincide.

There is a very ingenious device connected to the contacts of the synchronizer which withdraws one of the contact brushes when the machines differ too much in speed. As the difference in speed becomes less, this device acts in such a way as to allow the contact to be made sufficiently in advance of coincidence of phases, corresponding to the time required for the switch to actuate. As the machines differ less in speed, the advance in the contact is correspondingly less. The contacts never have to break any current, and, when properly adjusted, they will last indefinitely. The machines are coupled by this instrument without the least sparking or strain, the ammeters connected to the incoming machines showing hardly any deflection.

For rotary work a simple form of electrically-operated switch should be used with the automatic synchronizing system, combining the functions of switch and automatic circuit breaker, thus omitting the knife switches and fuses. For high-voltage work automatic oil switches are used. The wiring of the various devices forms a complete interlocking system, preventing coupling of the machines under unfavorable circumstances, and avoiding the danger of any damage resulting.

The Deutsch System of Electric Train Lighting

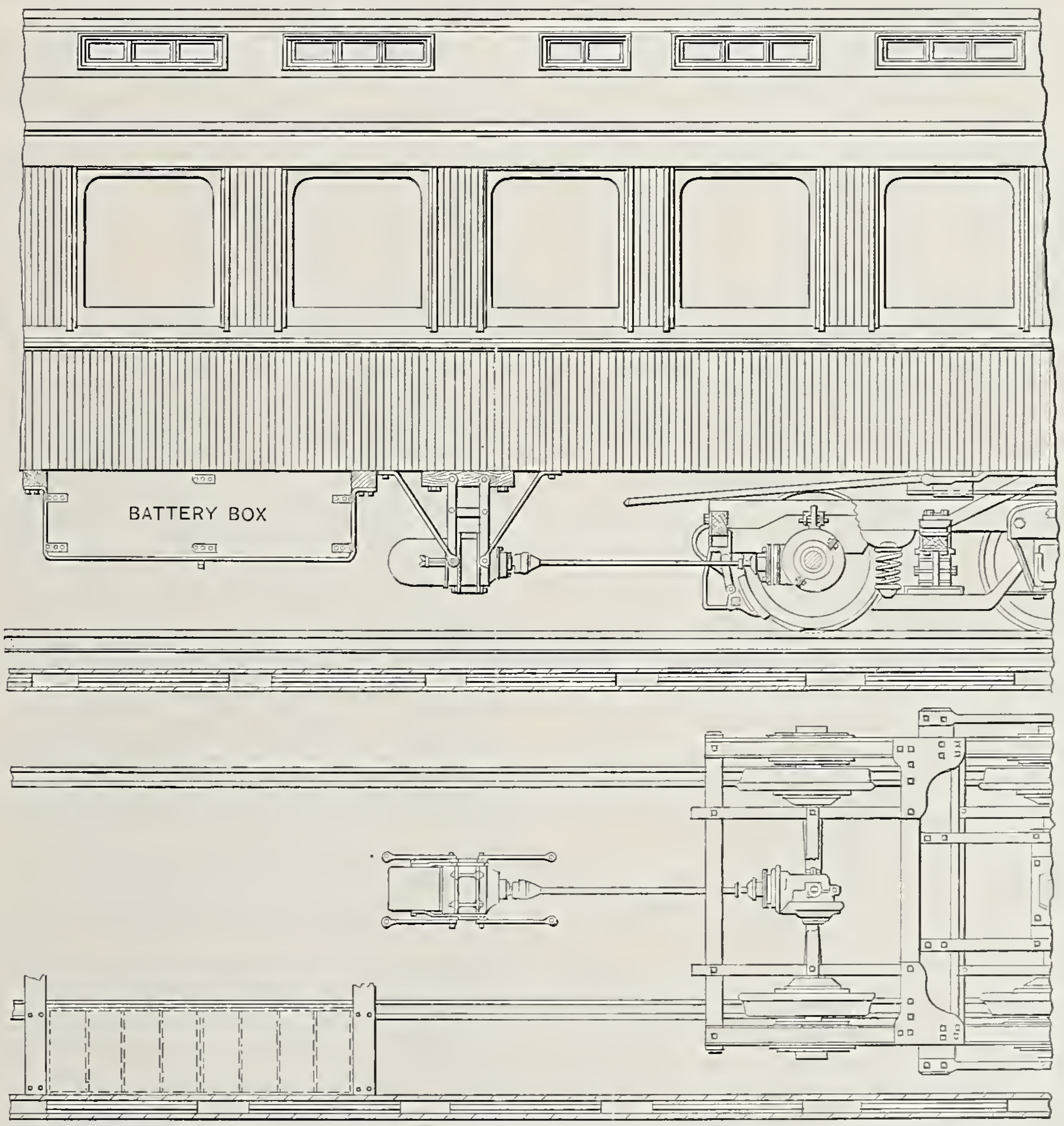
THE Deutsch axle-lighting system for railroad trains, for which the Electric Controller & Supply Company, of Cleveland, Ohio, are the licensees for the United States, Canada and Mexico, includes a generator hung from a car body, a regulator located in any convenient place in the car, a transmission or drive and the usual storage batteries intended to supply current for the lights when the train is standing or running at less than a specified speed. A general view of the equipment is given in the diagram on this page.

The battery can be relied upon to perform this service if it is properly charged when the train is running. It sometimes happens with a belted machine, however, that the belts slip or come off the pulleys, so that the batteries are not properly charged. If this continues, the batteries do not act satisfactorily and are consequently blamed for the trouble. In winter months, especially when escaping steam or condensed moisture on the pulley faces makes them slippery, and when the lighting demand is heaviest, this trouble is greatest. Under these conditions batteries do not last as long as they otherwise would, nor is their capacity near that rated, consequently it may be said that, in order to derive the greatest value from the most expensive part of an axle-lighting equipment and to maintain that portion in its highest state of efficiency, a drive must be used which can be depended upon to do its work uniformly and reliably. For this reason, in a great number of cases where two sets of batteries are necessary with a belted equipment, one set will answer the purpose if used with a properly designed gear drive.

The drive in the Deutsch system consists of a steel bevel gear attached to the axle and provided with a suitable hub extension, forming a bearing immediately adjacent to the tooth face. Encircling the bearing is a steel strap to which a stud is electrically welded. This stud forms a bearing support for a rawhide pinion, which meshes with the steel gear, and to which is fastened the shaft for driving the dynamo.

The shaft is telescopic and provided with universal joints to allow for axle play and side motion of the truck on curves. Any tendency of the strap to revolve with the gear around the car axle is counteracted by a rod or arm projecting upward from the strap and flexibly supported by the truck frame. A steel gear casing is cast integral with the strap, the gear casing, strap and pinion bearing being in two pieces, which are bolted together and carried by the hub bearing of the gear. The gear and pinion are thus supported directly from the axle.

The dynamo is rigidly suspended under the car body, no springs or de-



THE DEUTSCH SYSTEM OF TRAIN LIGHTING, OF WHICH THE ELECTRIC CONTROLLER & SUPPLY COMPANY, CLEVELAND, OHIO, ARE LICENSEES

AN ELECTRIC AUTOMOBILE STREET SPRINKLER, BUILT BY THE ELECTRIC VEHICLE COMPANY, NEW YORK, FOR SERVICE IN HARTFORD, CONN.

vices permitting motion being required. The bearings are self-aligning and ring oiled. The wear on the bearings, it is claimed, is insignificant since there are no strains due to belt pull, and the flexible nature of the shaft connection prevents any shock from being transmitted to the dynamo.

The parts are easily accessible. The armature can be removed, a new one substituted and everything put in proper shape for immediate service, it is claimed, in fifteen minutes. Both bearings are the same size, and all screws holding removable parts are standard and of the same size. The casing can be quickly removed, completely exposing the machine for inspection by simply slacking two wing nuts, and the armature or bushings can be renewed without disturbing a single electrical connection.

The essential parts of the regulator are an automatic switch, a controlling solenoid, an air valve, a cylinder, a piston working in the cylinder and carrying electrical contacts on the piston rod, and a resistance located in the shunt field circuit of the dynamo.

The automatic switch cuts the dynamo in and out of the lamp circuit above and below a specified train speed. When the train runs below the specified speed, the lights are on the storage battery, and above that speed, they are on the dynamo. As the train speed increases and as the dynamo turns faster than the speed required for maximum output, the controlling solenoid opens the air valve and admits air to the back of the piston, which rises and carries with it the electrical contacts attached to its rod and cuts resistance in the shunt field circuit of the dynamo, thus reducing its output. When the train speed decreases, the air valve is closed by the controlling solenoid and the piston drops by gravity, thus cutting resistance out of the field circuit until the dynamo output is again at its normal.

The regulator does not depend upon electrical means for its operation, but is driven by compressed air from the brake mechanism. A very small volume of air is required at about 15 pounds pressure. Its working is noiseless, and there is no motion except when the train speed materially changes. There are no rotating parts to cause trouble and all electrical connections are simply and conveniently arranged.

These machines are furnished with all parts made to gauge and all corresponding parts interchangeable, thus insuring maximum of speed and minimum of cost in making renewals.

An Electric Automobile Street Sprinkler

WHILE the electric automobile is now in common use for pleasure purposes and the conveying of goods, it is but recently that it has been used in the sprinkling of city streets. A vehicle for this purpose was recently built by the Electric Vehicle Company, of New York, for the Edward Balf Company, street sprinkling contractors of Hartford, Conn. An illustration of it is given on this page.

In general style the sprinkler resembles the ordinary build of the horse-drawn sprinkler. The iron water tank is of the usual boiler pattern and has a capacity of 600 gallons. This tank is mounted on a medium weight truck chassis, power being derived from an underslung battery of 44 cells. Two motors are provided, normally rated at from 8 to 10 H. P., and the normal speed is 6 miles per hour.

The machine covers from 30 to 40 miles daily in actual use, or about twice the mileage of a two-horse sprinkler with one change of horses; in other words, the machine does about double the work of four horses.

As this is the first attempt to substitute automobiles for horses in street sprinkling, the outcome of the experiment will be watched with a great deal of interest. From present indications it will be thoroughly successful. One most obvious advantage is, at times when the sprinkler cannot be used on account of the season or wet weather, the owner is not obliged to maintain horses in idleness. The maintenance of the storage battery should cost but little, as the service it has to perform is light.

A New Storage Battery

AS the result of several years' work on the part of Joseph Bijur, of New York, a new form of storage battery has been produced which, while retaining the well-tried electrochemical combination of lead and sulphuric acid, differs radically in design, construction and results from forms

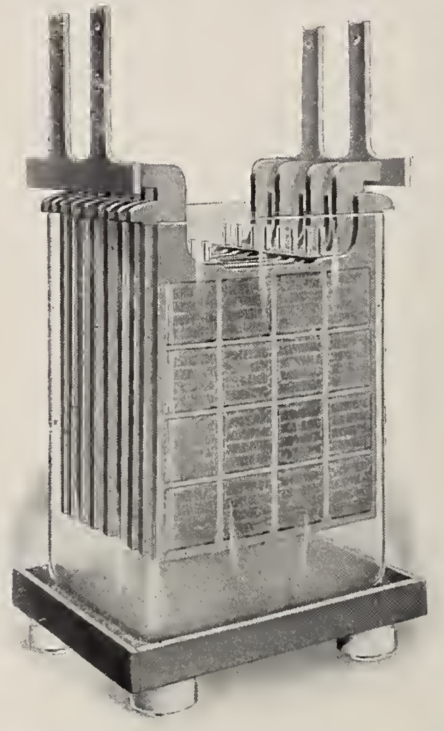


FIG. I.—A NEW STORAGE BATTERY CELL MADE BY THE GENERAL STORAGE BATTERY COMPANY, NEW YORK

hitherto known in the storage battery art.

With the collaboration of Dr. J. S. C. Wells, of Columbia University, in the earlier stages of the work, Mr. Bijur set out to produce a storage battery plate according to an ideal design which should be both mechanically and chemically perfect. This design embodied a rigid structure, freedom from tendency to distortion, perfect acid diffusion, active material incapable of being displaced, high specific capacity, high rates of charge and discharge, high efficiency, good regulation and freedom from "sulphation," buckling or any other destructive action, save ordinary and unavoidable wear and tear. These char-

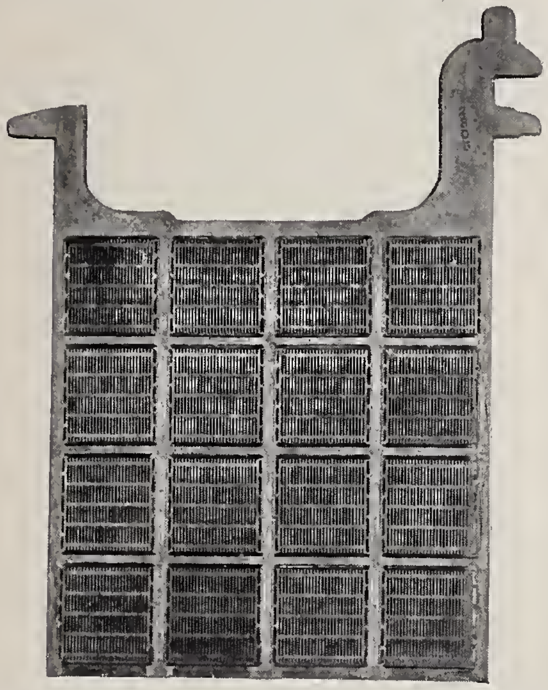


FIG. 2.—A PLATE OF THE STORAGE CELL MADE BY THE GENERAL STORAGE BATTERY COMPANY

acteristics could exist only in a form of plate made up of small, finely subdivided structures, each free to expand unrestrainedly and firmly welded to a strong supporting and conducting grid.

The Bijur plates are composed of multiples of pure lead structures in the shape of gratings or "grills." These are welded to, and in one piece with a stiff frame made of lead and antimony only. The weld goes clear through the plates and is produced without the use of tin, solder flux or any extraneous material. The frame merges into the grill without joints. At each end of the grill a space is provided for its elongation by expansion, and provision is also made for expansion sidewise. The result is a plate such as shown in Fig. 2, which has the stiffness, strength and inoxidizable support of the alloy grid, rigidly held active parts, yet complete provision for their expansion without the setting up of any strains that could produce buckling.

The grills are composed of a multitude of minute openings or cells, open through from face to face. In the untreated metallic state these grills, of which one is shown in Fig. 3, are very open structures; they have a large number of component ribbons running in the vertical direction, supported by heavier cross members running horizontally, which serve as conductors and give lateral stiffness.

During the formation process, part of the metallic lead is converted into oxide, which, by reason of the large increase in volume, nearly fills the openings. The ribbons on the positive elements have a large amount of metal left as a reserve for the oxidization which is attendant on the normal action of every storage battery.

When the oxide is formed in the rectangular cells, it assumes a slightly elliptical shape, which, expanding into the rectangular containing space, produces a locking-in so positive that nothing short of destruction of the plate can dislodge the material. At the same time, even when the oxidization is carried to the point of apparently completely filling the cells, the tendency of the ellipse to grow larger along both its axes insures the presence of a minute slot through the center of the oxide mass, which allows the flow of electrolyte to take place freely through it. The resultant oxidized plate, a section of which is shown in Fig. 2, is therefore rigid, the grills are firmly held, they expand without producing strains, each particle of oxide is firmly pressed against the lead from which it is grown, and the entire plate is open through from face to face for circulation and diffusion of the electrolyte.

Owing to the character of the design and the structure of the oxide formed, the plates possess several features hitherto unattained, it is claimed, in battery practice. Buckling cannot take place, and so far, repeated attempts to intentionally produce distor-

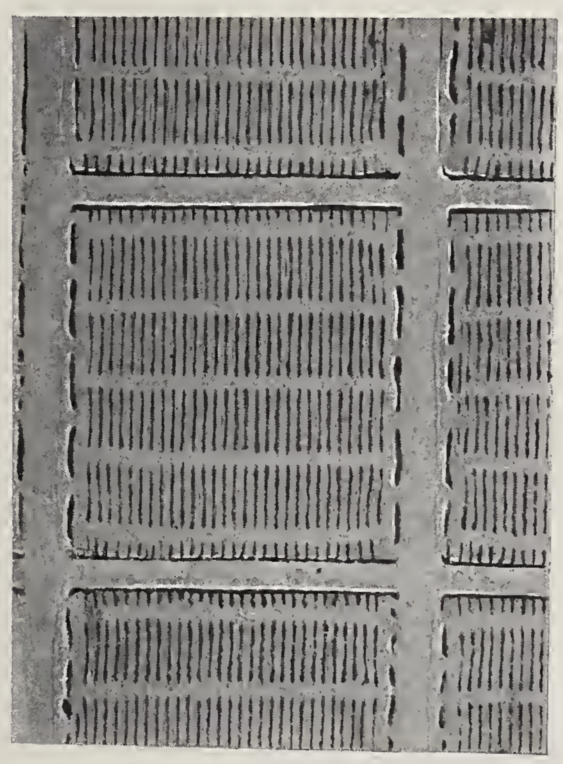


FIG. 3.—A SECTION OF OXIDIZED PLATE OF A CELL

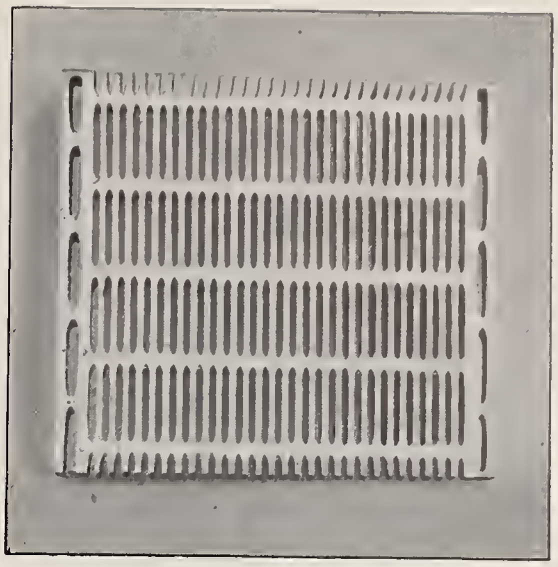


FIG. 4.—A GRILL OF THE PLATE SHOWN IN FIG. 2 BEFORE OXIDIZATION

tion are said to have failed. Also, since the perfect diffusion through the plate prevents high acid concentration in the pores, deleterious sulphation does not take place even when an effort is made to produce it.

One of the important advantages claimed by this form of design is that, in a plate of given dimensions, 20 per cent. greater capacity can be obtained with about 10 per cent. more reserve lead than in any form of plate hitherto constructed. The fine sub-division of the oxide into small masses, combined with the fact that the surfaces of the plates are composed of ribbons on edge, precludes the possibility of blistering or shrinkage which is liable to occur when plates contain oxides in large masses.

The makers claim that, owing to the rapid acid diffusion, full charge may be given the batteries at a voltage of 2.4 to 2.5 volts instead of 2.7 volts per cell as is usually required. This low charging voltage results in increase of efficiency and reduces the size of boosters required to charge. The structure of the plate forms a conducting network to all parts, insuring equality of action all over its surface, and this, together with the facility for escape of gas without dislodging active material, favors the ability to stand very high rates of charge and overcharge without marked deterioration.

The General Storage Battery Company, which is now putting elements of this type on the market under the name of the Bijur "high duty" battery, has recently equipped a factory at Boonton, N. J., with special automatic machinery for the cheap and rapid production of storage batteries. One of their cells, complete, is illustrated in Fig. 1. The battery plates are made of standard size and can be used, if desired, to replace the worn-out or damaged plates of batteries of other makes.

The company has also developed a

new and complete line of automatic regulating boosters, end cell switches and other auxiliary apparatus for all classes of central station work and power plants.

New High-Tension Oil Switches

IN the construction of high-tension alternating-current systems a definite demand has arisen for an oil switch and circuit breaker which can be installed directly on the back

FIG. 1.—A SINGLE-POLE ELEMENT OF THE HIGH-TENSION OIL SWITCH MADE BY THE HARTMAN CIRCUIT BREAKER COMPANY, MANSFIELD, OHIO

of the switchboard and operated by hand from the front of the board. Simplicity and reliability usually go hand in hand; it is therefore always advisable to choose the simplicity of the hand operation when possible, as a certain degree of complexity and intricacy is unavoidable with all methods employing auxiliary means for the operation of the switch.

The Hartman Circuit Breaker Company, of Mansfield, Ohio, has for the past four years been developing a complete line of high-tension oil switches and circuit breakers, and in the design illustrated on this page particular attention has been given to the insulation of the live parts of the switch from the operating mechanism in order that the switch might be installed on the back of the switchboard and used for very high voltages with entire safety to the operator. This has been accomplished by using a new material in oil-switch construction, namely, moulded fibre, treated by a process which is claimed to give to it insulating qualities substantially equal to porcelain. Each pole of the switch is enclosed in a separate tank or cell made of this fibre. The cover of the tank with its two insulators is also made of treated fibre, and the live parts which are enclosed in the tank are thus completely insulated from the metal supporting frame and operating mechanism. In switches intended for voltages above 6600, the oil tank is moulded in such a way that, together with the wooden switch rod, a complete barrier is interposed between the two arcing points of the switch element.

Two, three and four-pole combinations are made up of the single-pole element shown in Fig. 1. These are clamped side by side to sections of seamless steel tubing, which is fastened rigidly to the switchboard plate. This construction permits of liberal spacing between the poles without increasing the weight of the switch.

In the automatic switch or circuit breaker two types are made. In the one type, shown in Fig. 2, the overload coils are mounted on spools of

FIG. 2.—AN AUTOMATIC HIGH-TENSION OIL SWITCH MADE BY THE HARTMAN CIRCUIT BREAKER COMPANY

treated wood and are operated directly from the high-potential circuit. This dispenses with the use of current transformers and effects a corresponding reduction in the price of the circuit breaker. The insulation of these coils has been worked out with great care and is entirely adequate for the voltages for which these circuit breakers are recommended.

In the second type of circuit breaker which is made, the overload coils are mounted substantially as shown in Fig. 3, and are energized from the secondaries of series transformers. This circuit breaker is made for potentials up to 22,000 volts. Both of these circuit breakers possess the feature that they cannot be closed while an overload exists on any phase of the line.

While these switches and circuit breakers were mainly designed for installing on the switchboard, they can also be installed apart from the panel and operated manually by a simple system of cranks and rods, or they can be operated electrically by means of

FIG. 3.—ANOTHER TYPE OF HARTMAN AUTOMATIC HIGH-TENSION OIL SWITCH

solenoid control. In this case the operating current is derived from the exciters, a storage battery or any convenient source of direct-current supply.

Incandescent Lamp Novelties

SEVERAL interesting electric incandescent lamp novelties, recently introduced by the Sterling Electrical Manufacturing Company, of Warren, Ohio, have been described in "The Electric City," published by the Chicago Edison Company, from which the following particulars and the accompanying illustrations have been reproduced:—

The lamps, three in number, are "real burning" lamps, and may be used in any standard Edison socket. The pig is called "Gorgon Graham's Pig," after the famous "Self-Made Merchant" of fiction. It is made in two sizes, the smaller being fitted with "candelabra" size base. Like the

"GORGON GRAHAM'S PIG" LAMP. MADE BY THE STERLING ELECTRICAL MANUFACTURING COMPANY, WARREN, OHIO other two lamps, it is frosted, or covered with a coating which gives it the appearance of ground glass. This serves to distribute the light of the filament evenly throughout the lamp, and makes it stand out clear and distinct.

The Stag's Head is quite a realistic bit of glass work. It stands out as if

STAG'S HEAD LAMP

mounted in regular fashion when screwed into a horizontal socket, and has found a ready sale.

The third novelty is an Easter Egg lamp. This is about the size and shape of a hen's egg, and the word Easter is blown lightly in the glass on both sides. It is provided with candelabra, or miniature, base, and looks well in almost all positions.

This lamp is suitable for store windows as an attraction during the Easter trade season. It might also be used to advantage for any decorative electric light scheme at that time of the year.

It is quite possible to originate new and striking incandescent lamps by painting on ground or frosted globes with water-colors. Goblins, clowns' faces, flowers, animals, caricatures, and conventional or grotesque designs may be pictured on the white back-ground. It is necessary, for this

EASTER EGG INCANDESCENT LAMP

purpose, to apply the colors evenly, and rather thick, as their proximity to the strong light will make them weak and indistinct otherwise.

A den decorated with a few of these lamps would be something enough out of the ordinary to be worth a few evenings' labor in working up these effects. The egg lamp described above would be very easily turned into a speckled egg, or tinted prettily, like a robin's egg. Another use to which it might be put is that of representing a foot-ball, and as such would be quite acceptable as a gift to college men and "co-eds."

The International Association of Municipal Electricians

THE proceedings of the ninth annual convention of the International Association of Municipal Electricians, held in St. Louis in September, 1904, have recently appeared in book form. Four papers were read at the convention:—"Street Lighting," by A. S. Hatch; "The Limitations of the Telephone for Fire Alarm Purposes," by Adam Bosch; "The Inspection of Theatres from an Electrical Standpoint," by W. H. Thompson, and "Methods of Testing," by W. M. Petty. The officers elected were:—President, W. M. Petty, Rutherford, N. J.; vice-presidents, J. B. Yeakle, Indianapolis, Ind.; C. E. Diehl, Harrisburg, Pa.; Charles Greenwald, New Brunswick, N. J.; secretary, F. P. Foster, Corning, N. Y.; treasurer, C. F. MacDonald, Ottawa, Canada.

The tenth annual convention of the association will be held at Erie, Pa., August 29, 30 and 31, 1905.

For this meeting the following papers are promised:—"Electrical Induction, Its Effects and the Application of Methods Used to Counteract It;" "Advisability or Inadvisability of Fusing Fire and Police Telegraph Boxes;" "Suggested Improvements in Fire Alarm Telegraphs;" "Underground Construction;" "The Necessity of a Rigid Inspection by the Municipality;" "Electric Light Engineering;" "Electric Light Plants." These papers have been assigned to men thoroughly conversant with the subjects. The papers that have been presented in the past are available to all members, and cover almost the entire field of the city electrician or superintendent of fire or police telegraph. Frank P. Foster, Corning, N. Y., is secretary of the association.

A bill has been introduced in the New York Legislature making the use of profane or objectionable language over the telephone a misdemeanor.

Personal

George Howe, until recently of the power department of the New York Edison Company, is now general manager of the Metropolitan Engineering Company, of Brooklyn, N. Y. This company are makers of electric signs of the kind which latterly have become so popular for large, brilliant display advertising at night.

F. O. Blackwell recently read a paper on "Niagara Power" before the Toronto branch of the American Institute of Electrical Engineers.

Bion J. Arnold has been retained by the Grand Trunk Railroad to report on a system of electric traction to replace steam in the Port Huron tunnel.

Dr. Cary T. Hutchinson, consulting electrical engineer, on May 1, removed his offices to 60 Wall street, New York City.

George H. Barrus, expert and consulting engineer of Boston, whose work in boiler, engine and steam plant testing is well known, is at the present time engaged in the examination and improvement of the steam and power plants belonging to the United States

GEORGE H. BARRUS

Rubber Company, having for its main object the saving of fuel and cost of operation. This company has seventeen factories scattered about the Eastern States.

J. Walter Gillette has resigned the management of the Schuylkill Valley Illuminating Company, the Consolidated Schuylkill Gas Company and the Montgomery & Chester Electric Railway Company, of Phœnixville, Pa., to assume the duties of general sales manager for the National Battery Company, of Buffalo, N. Y. Mr. Gillette has had a varied experience of twelve years in designing, constructing and managing electric light and railway properties in the States and South America.

Dr. Arthur E. Kennelly's latest practical engineering work, just previous to his assuming the chair of electrical engineering at Harvard University, was the laying of the submarine telegraph cables from Vera Cruz

ARTHUR E. KENNELLY

to Frontera and Campeche, for the Safety Insulated Wire & Cable Company, of New York, and the Mexican Government. Since then—1902—university demands have wholly absorbed his time.

W. A. Layman, manager and treasurer of the Wagner Electric Manufacturing Company, of St. Louis, is at present in California. He is not expected to return for a month or two.

J. H. Hallberg last month delivered a lecture before the Electrical Engineering Society of Columbia University, on the application of electricity to heavy freight and trunk line railways. Brief reference to this is made elsewhere in this issue.

William Le Roy Emmet, of the engineering staff of the General Electric Company, at Schenectady, N. Y., is a graduate of the United States Naval Academy—class of 1881. He entered the electrical field in 1887, and since 1892 has been active in inventing and designing and commercial engineering

W. L. R. EMMET

for the General Electric Company. He has been in charge of all the Niagara Falls work of the company, and has been prominently identified also with its steam turbine department.

W. S. Murray has been appointed electrical engineer of the New York, New Haven & Hartford Railroad, with headquarters at New Haven. Mr. Murray is a graduate of Lehigh University, and has had a wide experience in electric railroading and long-distance power transmission work. For a time he was connected with the Westinghouse interest, but for several years past has been engaged in independent consulting engineering, with offices in the Exchange Building, Boston.

W. J. Clark, of the railway department of the General Electric Company, was appointed by President Roosevelt an official delegate to represent the government of the International Railway Congress held at Washington during the first two weeks of this month.

B. H. Warren, president of Allis-Chalmers Company, having had his policy of extension and concentration of the works at Milwaukee adopted by the directors, as announced in recent official statements wherein it is shown that three million dollars will be expended on new buildings and equipment, is now in Europe in connection with plans for the expansion of the company's business there. He will visit the leading engineering works of the continent, and after certain important consultations to which he has been called in Germany, he will return to Milwaukee, by which time work on the new buildings, the plans of which were decided upon before he went abroad, will be well under way. The extensions will double the present size of the Allis-Chalmers works at Milwaukee. Electrical work of the largest size will be carried out there.

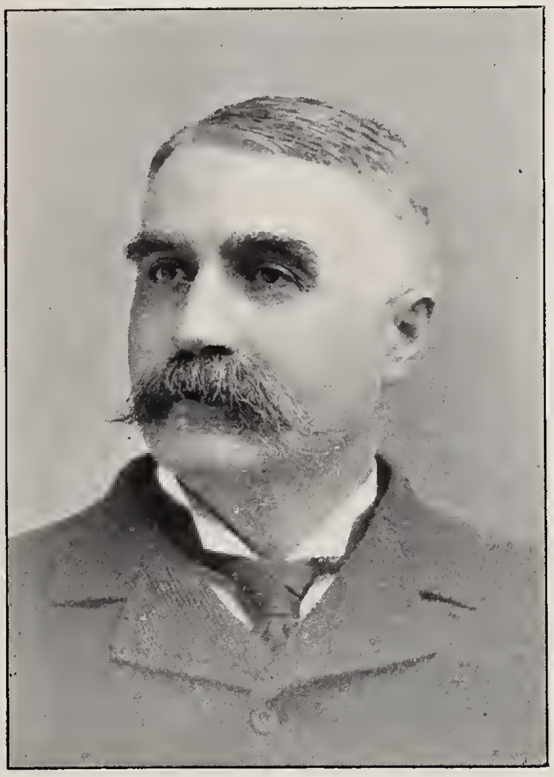
According to "The Elektrotechnische Zeitschrift," the Administrative County of London and District Electric Power Company, which is responsible to a committee of the British House of Lords, is planning to construct three electric plants for generating current to supply the whole of London and those suburbs controlled by the London County Council. Each plant is to consist of six turbo-generators, each of 10,000-K. W. normal and 20,000 maximum capacity, making a maximum total of 360,000 K. W. As these power units are larger than any ever constructed, experts have been appointed to decide upon the practicability of units of this size. The electrical expert chosen for this important problem is C. F. L. Brown, of Brown, Boveri & Cie, of Baden, Switzerland. To this it may be added that the Crocker-Wheeler Company, of Ampere, N. J., are the American licensees of the above firm, who act as their consulting engineers on alternating-current propositions.

George Gibbs, first vice-president of Westinghouse, Church, Kerr & Co., of New York, is posted for membership in the American Institute of Electrical Engineers. Mr. Gibbs is a

GEORGE GIBBS

Stevens man (class of 1882), in the front rank of the profession, and will be a most welcome addition to the Institute's list.

Dr. Charles F. Brush, of Cleveland, of arc lamp fame, has contributed to "The Century" an article on "The Arc Light," detailing his early experiences and experiments. It was Dr. Brush's invention of the famous series arc lamp having a regulating shunt circuit of high resistance which first made commercial arc lighting from central stations possible. On this invention are based all the arc light systems in use throughout the world. Among Mr. Brush's other inventions of early date may be mentioned his copper-plated carbons for arc lights; his automatic cut-out for arc lamps; his compound



DR. CHARLES F. BRUSH

series-shunt winding for dynamo-electric machines, now very generally used for lighting by incandescence and in power transmission, and his multiple-carbon arc lamp for all-night burning.

Charles Ducas, formerly editor of the "Railroad Gazette," has become associated with Ray D. Lillibridge, of New York, in the business of technical publicity.

Archer Richards, recently chief draughtsman for the Wason Car Company, of Springfield, Mass., has resigned that position to accept that of chief draughtsman for the Roberts & Abbott Company, engineers, of Cleveland, Ohio. Mr. Richards has had exceptional experience in both the structural and decorative design of cars, having been with the Wason Manufacturing Company six years and with the Jackson & Sharp plant of the American Car & Foundry Company for fourteen years. He was also in the engineers' office of the Chicago, Milwaukee & St. Paul, in the department of bridges and buildings. Prior to such time he was with the Enterprise Hydraulic Works, of Philadelphia, and afterwards chief examiner of drawings of structural steel work in the Edgemoor Iron Works, Wilmington, Del. Also for two years he was in Europe, studying and practicing decorative art.

A. G. Wessling, of the Bullock Electric Manufacturing Company, Cincinnati, which is the electrical department of the Allis-Chalmers Company, of Milwaukee, recently made a tour of some of the colleges of the country where technical instruction is given in applied mechanics, namely:—Cornell, Lenigh, Columbia, Harvard, Massachusetts Institute of Technology, Ann Arbor, Purdue, University of Illinois and the Rose Polytechnic Institute. At each of these he delivered a lecture on "Methods of Control for Variable-Speed Motors," treating of the subject with especial reference to motors for driving machinery tools. Mr. Wessling gave a history of the growth and development of the various methods used by the Bullock Company for obtaining variable speed. He began by explaining the old and now obsolete system of rheostatic form of control. He then pointed out the possibilities of the well-known type "O" system, formerly in use by the Bullock Company, a feature of which was the double windings on the armature of the motor, and ended by describing the system of multiple-voltage control which has superseded it. His explanation included both the three and four-wire methods.

Gaston Harbison has assumed charge of the advertising and publicity department of the National Battery Company, of Buffalo, N. Y. Mr. Harbison for the past seven years has been employed in the sales department of the Electric Storage Battery Company in their Cleveland, Baltimore and Philadelphia offices, during which time he has had valuable experience in the storage battery field.

Andrew Carnegie made a bequest a few weeks ago,—the largest thus far by him,—for which too much praise cannot be given. It is a pension fund of $10,000,000 for college professors in the United States, Canada, and Newfoundland who, by reason of old age or other disability, are unable to continue in active service. Announcement of the gift was made about two weeks ago, the day after Mr. Carnegie and his wife sailed for Europe, and it was universally praised as one of his most worthy benefactions, inasmuch as no class of men is so poorly paid and so little capable of providing for the future as the pedagogues of the great American institutions of learning. Mr. Carnegie named as trustees of the fund the presidents of nearly all the important universities and colleges of the country, and all have gladly accepted the administration of the trust.

At the annual meeting of the stockholders of the Joseph Dixon Crucible Company the old board, consisting of Edward F. C. Young, John A. Walker, Edward L. Young, William Murray, George T. Smith, Joseph D. Bedle and George E. Long, was unanimously re-elected. The board of directors re-elected the former officers, namely, Edward F. C. Young, president; John A. Walker, vice-president and treasurer; George E. Long, secretary. Judge Joseph D. Bedle was also re-elected as counsel.

Frederick Pearce, manufacturing electrician and dealer in telegraph, telephone and electric light apparatus, of New York City, has incorporated his business, which will be conducted henceforth by the Frederick Pearce Company. Frederick Pearce is the president of the company; Charles F. Pearce is vice-president; George H. Tamlyn, secretary and treasurer, and Walter H. Pearce one of the directors. It is a close corporation, controlled by Frederick Pearce as the principal stockholder.

D. B. Rushmore, lately connected with the Stanley Electric Manufacturing Company, of Pittsfield, Mass., has joined the railway department of the General Electric Company at Schenectady.

W. F. Kingman, who has for some time been general manager of the Sault Ste. Marie Edison Light & Power Company, has accepted a position as manager of the power department of the Detroit Edison Company.

Major Edmund L. Zalinski, U. S. A. (retired), of dynamite gun fame, is president and treasurer of the Illuminating Engineering Company, of New York City, and in this capacity has been prominently identified with working out the problem of satisfactorily lighting the New York Subway, treated of in an article elsewhere in this issue.

Trade News

The Brown Corliss Engine Company, of Corliss, Wis., have secured an order from the National Tube Company to furnish their McKeesport, Pa., plant with two 30-inch and 70-inch by 60-inch tandem compound rolling mill engines for special heavy work. A 30-inch and 60-inch by 48-

inch combined vertical and horizontal condensing engine also has been shipped to the Illinois Steel Company's Joliet plant, and a 30-inch and 60-inch by 48-inch tandem compound engine to the Jones & Laughlins Steel Company, at Pittsburg, Pa. The Brown Corliss Company now have twenty-six engines going through their shop, including a twenty-million gallon pumping engine for the city of Milwaukee.

The American Electric & Controller Company, heretofore located at 12 Dey street, New York City, have taken offices in the Electrical Exchange Building, 136 Liberty street, where they have on exhibition a line of their specialties. They have ready for distribution a number of pamphlets which will be sent on application for them. They relate to their "Rheocrat"; applications of the "Rheocrat"; electrically-operated switches; automatic starters for induction motors; applications of automatic starters; solenoids for direct and alternating service, and applications of solenoids.

The J. G. Brill Company, of Philadelphia, recently received an order from the British Columbia Electric Railway, Vancouver, B. C., for a number of its No. 27-E high-speed trucks. This truck has a cushioned side swing which, at the entrance to curves, draws the car body gently out of the line of its momentum into the new direction without the usual jar and lurch which wrenches the body, and in all its history has never been derailed except in collisions. An order from the Boston Elevated Railway Company calls for forty cars mounted on this type of truck to be used for high-speed service on surface suburban lines.

A growing tendency among those connected with large corporations to organize for the purpose of mutual improvement, is noticeable in all lines of trade. An interesting organization has just been perfected by those connected with the B. F. Sturtevant Company, of Boston, Mass., its object being to consider questions of engineering and commercial interest, and to increase the mutual acquaintance of the members. Its character is well suggested by its title, The Progress Club. Its membership is open to all, high or low, who are in any way associated with the company. Its membership, however, is classified into seniors and juniors, the former including those who are twenty-one or over, who have had charge of the work of others, or who have been juniors in regular standing for three years. Control is placed in the council, consisting of president, vice-president, secretary, treasurer, and three members at large, whose duty it is to arrange programmes for the meetings, publish and distribute necessary reports of the proceedings, and generally direct the affairs of the club. It will be a distinct purpose of the club to associate in its membership those in the branch houses and local offices, as well as those connected with the plant at Hyde Park. A very successful future is anticipated for this new organization.

Messrs. Dodge & Day, of Philadelphia, who have for the past three years designed the electrical equipment for operating the hoisting and conveying machinery built by the Dodge Coal Storage Company, will have charge of similar work in connection with the telpherage apparatus that will now be manufactured by the Dodge Coal Storage Company as a result of their acquisition of the United Telpherage Company's interests.

The Cuyahoga Construction Company, of Cleveland, Ohio, recently contracted with the Allis-Chalmers Company, of Milwaukee, for the equipment of three sub-stations of the Sandusky, Norwalk & Mansfield Railway, the headquarters of which are at Norwalk, Ohio. Each of these stations will be equipped with one 300-K. W. compound-wound Bullock rotary converter, three 110-K. W. static transformers and complete switchboard apparatus, including lightning arresters. Five car equipments, each consisting of four Bullock 50-H. P. railway motors, with controllers, etc., have also been ordered. The Cambria Steel Company has also purchased two 800-K. W. Bullock generators for its new power house. These will be built by Allis-Chalmers Company at their electrical works in Cincinnati, and are intended to furnish power for large ore-handling cranes. Other orders are from the Obion Lighting Company, Obion, Tenn., for one Reliance engine with cylinder 40 inches in diameter and 24-inch stroke, 175-K. W., two-phase Bullock alternator with 4-K. W. exciter, together with switchboard, boiler, duplex feed-water pump, arc lamps and regulator; the American Cereal Company, of Cedar Rapids, Iowa, for one 800-K. W., 60-cycle, three-phase, alternating-current Bullock generator, and one 30-K. W. Bullock belted exciter, the engine formerly in use having been shipped to Milwaukee to be rebuilt; Bernard F. Weber, of Chicago, Ill., two heavy duty Reynolds Corliss engines, cylinders 26 inches and stroke 48 inches, running non-condensing at 90 revolutions per minute with 125 pounds steam pressure; Walter Baker & Co., of Milton, Mass., the complete equipment for a new power plant at their factory in Dorchester, Mass., including two 750-K. W. Bullock alternating-current generators, for direct connection to Reynolds Corliss vertical cross-compound engines, and two 125-K. W. Bullock generators with exciters. The cylinders of the engines will be 22 and 48 inches in diameter and they will have a 48-inch stroke. The two large generators are designed to operate at 120 revolutions and the smaller at 277 revolutions per minute. The electrical apparatus is to be built at Cincinnati, and the engines will be furnished from the West Allis, Milwaukee, plant of the company.

Following closely upon the expiration of some of the Tesla polyphase patents, on May 1, the Westinghouse Electric & Manufacturing Company has issued a notice calling the attention of the public to numerous other patents relative to polyphase induction and synchronous motors, dating from December 3, 1889, to May 4, 1904, which it proposes to protect from infringement in the future as in the past. Twenty-four patents in all are enumerated, among them many of the most important of the Tesla patents, and patents to Stanley, Hutin and Leblanc, Lamme, Nolan and Dusinberre, covering various features of alternating-current systems.

The Wisconsin Light & Power Company, of La Crosse, Wis., have placed orders with the Westinghouse companies covering the entire equipment of a large light and power plant. Besides two alternating-current generators with an output of 400 K. W. each, which will be driven by Westinghouse-Parsons steam turbines, there are three Westinghouse vertical steam engines, one of which will be connected to a 25-K. W. direct-current generator. The order includes also two motor-generator sets, each consisting of a 7½-K. W. direct-current generator and a 15-H. P. induction motor; three 10-K. W. and three 15-K. W. transformers; one 6600-volt 10-panel switchboard and one 220-volt arc lamp panel; fifteen low-equivalent lightning arresters and choke coils, and 25,000 incandescent lamps with Edison base. Roney stokers, manufactured by the Westinghouse Machine Company, will be used in the boiler installation. The activity in the application of motors to cranes, hoists and machine tools of every description is indicated by the following recent orders:—The Morgan Engineering Company, of Alliance, Ohio, eight railway type crane motors with a total of 250 H. P.; the Pond Machine Tool

Company, of Plainfield, N. J., twenty-eight induction motors; Niles Tool Works, of Hamilton, Ohio, five direct-current motors; Long & Allstatter Company, of Hamilton, Ohio, thirteen motors; the Delaware, Lackawanna & Western Railway, twenty induction motors; United States Hoe & Tool Company, of Columbus, Ohio, eight direct-current motors, and the Austin Powder Company, ten induction motors.

The Canadian Westinghouse Company, Limited, recently sold to the Edmonton (Alberta) Street Railway Company a 200-K. W. railway generator and a number of double equipments of railway motors. The city of Edmonton is the most northerly point on the American continent to operate an electric street railway. Another recent sale made by the Canadian Westinghouse Company, Limited, was that of a 500-K. W. enclosed type turbo-generator unit to the Canadian Pacific Railway Company. This unit is to be installed at Fort William, on the Canadian Pacific, and is to be used for supplying power to the various grain elevators at that point. The unit is to operate three-phase, 600-volt, at 7200 alternations, and 3600 revolutions per minute.

H. M. Byllesby & Company, of Chicago, have been appointed managers and engineers of the gas and electric properties of the San Diego Consolidated Gas & Electric Company, of San Diego, California.

A new co-operative scheme has been entered into between the officers of the Crocker-Wheeler Electric Company, of East Orange, N. J., and its employees. It is in the nature of a benefit association. The men pay 10 cents a week. Each member is entitled to $10 a week for 20 weeks during disability, and his family will receive $100 when he dies. The company will contribute an amount equal to the dues paid to the association.

The Stanley Electric Manufacturing Company, of Pittsfield, Mass., and the General Incandescent Arc Light Company, of New York City, have consolidated. The corporate title of the combined interest will be "Stanley-G. I. Electric Manufacturing Company." The Stanley Company, as engineers and manufacturers of the well-known S. K. C. system, have acquired the reputation of turning out high-class electrical apparatus. The S. K. C. system comprises the latest develments and improvements in generators, transformers, rotary converters, motor-generator sets, switchboard apparatus, induction motors, etc. The General Incandescent Arc Light Company have been well known as builders of high-grade arc and incandescent lamps, alternating and direct-current motors and general electric supplies. The engineers of this concern have for years made a special study of electric lighting, and the new concern cannot help but occupy a high rank in the field of electrical illumination. The officers are Wm. Murray Crane, president; C. C. Chesney, first vice-president; M. D. Barr, second vice-president, and M. J. Insull, third vice-president.

The Stirling Company, maker of the Stirling water-tube boiler, announces the removal of its executive and accounting departments from the Pullman Building, Chicago, to the Trinity Building, New York City. It will continue, however, to maintain its present offices in the Pullman Building, Chicago, for the convenience of its friends and trade in the West.

New Catalogues

A circular sent out by the Gisholt Machine Company, of Madison, Wis., shows an early type of turret lathe and one of modern build.

The inter-pole variable-speed motor built by the Electro-Dynamic Company, of Bayonne, N. J., is illustrated and described in a new pamphlet.

The Stombaugh guy anchor, made by W. N. Matthews & Bro., of St. Louis, Mo., is illustrated and described in a catalogue recently issued. Results of tests of holding capacity of these anchors by Prof. R. C. Carpenter are given.

The Electric Machinery Company, of Minneapolis, Minn., have issued a bulletin devoted to revolving-field, alternating-current generators and rotary converters. Illustrations are given of these machines, together with a description of their distinguishing features.

A pamphlet entitled "Electricity on Steam Railroads for High-Speed Service" has been sent out by the General Electric Company, of Schenectady, N. Y. Several illustrations are given of electric locomotives in use on steam roads, with data of tests. The pamphlet sets forth fully the advantages of the electric locomotive for this work. A new bulletin also issued by the company is devoted to induction motors. Slow and moderate-speed direct-current motors are similarly illustrated in still another bulletin. A third one deals with starting compensators for alternating-current motors, diagrams showing the connections for a variety of service. A flyer deals with red core wire and cable, a folder with automatic carbon-break circuit breakers and a price-list with prices of fan motors.

Electrical supplies made by the Bryant Electric Company, of Bridgeport, Conn., are illustrated and described in a neat pamphlet just issued. They include special and standard incandescent lamp sockets, porcelain receptacles, rosettes and switches, cutouts, enclosed fuses and a variety of fittings, cleats and connectors.

Automobile tires are illustrated and described in a new catalogue issued by the Diamond Rubber Company, of Akron, Ohio. Besides various forms of tires and the methods of adjusting, a soft cover battery jar is illustrated. This has an 1/8-inch wall—3-32 of hard rubber and 1-32 of soft rubber to ease any shock given to the jar.

A pamphlet just issued by the Cincinnati Electrical Tool Company, of Cincinnati, Ohio, illustrates and describes portable electric drills and grinders. The former is made in three sizes, having a maximum chuck capacity of 1/4 inch, 3/8 inch and 1/2 inch, respectively. The latter is provided with a bar for holding in the tool post of a lathe, planer or shaper. It may also be fitted with a universal tooth rest and an internal grinding attachment.

High-vacuum apparatus made by the Alberger Condenser Company, of New York, is illustrated and described in a catalogue recently sent out. The apparatus includes dry vacuum pumps, one and two-stage, condensers, barometric and surface, cooling towers and centrifugal pumps. One of the last-named is shown direct connected to an electric motor.

Generating units ranging in capacity from 3 to 100 K. W. are illustrated and described in a new catalogue sent out by the B. F. Sturtevant Company, of Boston, Mass. The engines are of three types—vertical single, vertical compound and horizontal. The first-named range in capacity from 3 to 50 K. W., the second from 17½ to 100, and the last from 15 to 100.

"Induction Integrating Wattmeters, and Their Use," is the title of a paper read by A. A. Serva before the Colorado Electric Light, Power and Railway Association, and issued in pamphlet form by the Fort Wayne Electric Works, of Fort Wayne, Ind. A number of types of meters made by the company are illustrated. An attractive pamphlet bearing the title "Summer Comforts" has also been sent out, being devoted to showing the many ways in which motor-driven fans may be used to make the humidity and heat of summer more endurable.

A pamphlet recently issued by the Peerless Motor Car Company, of Cleveland, Ohio, describes the trip made by a Peerless gasoline automobile over the great Continental Divide that separates Montana from Idaho and the Pacific from the Gulf. Illustrations are given of objects of interest along the route.

Generators, motors, and desk and ceiling fans made by the Robbins & Myers Company, of Springfield, Ohio, are illustrated in what the company calls its "autograph and picture book." The engravings all are excellent and are left, in large part, to tell their own stories.

Locomotive cranes of various designs are shown in a series of bulletins issued by the Browning Engineering Company, of Cleveland, Ohio. General and detail illustrations are given together with corresponding data.

A circular just issued by the Prometheus Electric Company, of New York, illustrates and describes the "Electrotherm," an electrical substitute for a hot-water bag. It consists of wires insulated and protected by asbestos, woven into a light and flexible pad, which, when connected to the ordinary lamp socket, offers sufficient resistance to the current to produce the requisite degree of heat.

The "New Yankee" drill grinder, made by the Wilmarth & Morman Company, of Grand Rapids, Mich., is illustrated and described in a catalogue recently issued. The first part of the pamphlet deals with the proper grinding of drills, and a general outline of the advantages of this machine for the work. Besides a number of styles of grinders, two types of motor-driven machines are illustrated and described. A reamer grinder, an arbor press and a friction counter-shaft are similarly treated of.

A neat leather bill fold and memorandum book combined, bearing the imprint of the Electric Controller & Supply Company, of Cleveland, Ohio, is being sent out by that company as a reminder of its several products. These comprise magnetic switches, brakes and clutches, variable-speed motor drives for planers, solenoids, controllers for electric motors for all kinds of service, and the lifting magnets for which the company is widely known. The little pocket convenience is well made and attractive, and is sure to excellently serve its purpose.

A new catalogue devoted to theater dimmers has recently been issued by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis. The type illustrated is named "Simplicity," and differs from former types in that it is designed to meet the demand for a dimmer of a price little in excess of the non-interlocking type, and yet having all the desirable qualities of the interlocking "Universal" dimmer. The unit capacity per plate is also considerably smaller, being for fifty 16-candle-power lamps.

The Cooper Hewitt mercury vapor lamp is illustrated and described in a new well-illustrated catalogue just issued by the Cooper Hewitt Electric Company, of New York. The extensive field in which this lamp may be used is shown in views of installations in a machine shop, railroad pier, warehouse, draughting room, pressroom and photographic studio. The sizes of the lamps are given in a separate circular, together with illustrations of reflectors for use with them. Another folder gives the prices for the various sizes of lamps for general illumination, photography, photo-engraving and blue printing.

Single-phase motors for elevator, hoist and traveling crane service are described in a bulletin just issued by the Wagner Electric Manufacturing Company, of St. Louis, Mo. An illustration shows a combined freight and passenger elevator hoist in service in St. Louis. The bulletin deals briefly with the conditions obtaining in hoisting and crane work.

A pamphlet just sent out by the Rolfe Electric Company, of Rochester, illustrates and describes bells for telephone service and railroad signal work, buzzers and fuse boxes. A good part of the pamphlet contains electrical laws and rules of practice, tables being given of wire sizes, weight and resistance.

Cost of Electric Street Railways in England

IN a paper read at a recent meeting of the Tramways & Light Railways Association the cost of building electric street railways in England per mile, single line, was stated to range from £4000 to £6000 ($19,467 to $29,209). The proportionate costs of the various kinds of work were figured as follows:—For rails and fastenings, 22 per cent.; special work, 10 per cent.; paving material, 30 per cent.; cement, sand and broken stone, 14 per cent.; labor, 15 per cent.; bonds, cartage and miscellaneous items, 9 per cent.

The Forthcoming Meeting of the National Electric Light Association

THE following preliminary programme has been issued for the coming Denver meeting of the National Electric Light Association:—

MONDAY, JUNE 5

Arrival of delegates. Reception by local committee. Informal reception, with music, at headquarters, the Brown Palace Hotel.

TUESDAY, JUNE 6

Morning.—Business session in ordinary of Brown Hotel. Addresses of welcome by Governor Jessie F. McDonald, Mayor Speer, of Denver, and Mayor Hall, of Colorado Springs.

Afternoon. — Business session. Country Club luncheon for ladies.

Evening.—Theatre party at Elitch's Gardens.

WEDNESDAY, JUNE 7

Morning.—Business session.

Afternoon.—Broncho-busting contest at D. A. C. Park.

Evening.—Business session until 10 P. M. At 10:30 P. M. an "athletic" smoker at either the Democratic Club or Coliseum Hall. Party at Orpheum for the ladies (if theatre is open).

THURSDAY, JUNE 8

Morning.—Business.

Afternoon.—Business. Street car rides for the ladies.

Evening.—Business. Serenade by the George W. Cook drum corps.

FRIDAY, JUNE 9

Morning.—Entire party transported to Colorado Springs.

Afternoon.—At Colorado Springs—drives to all of the famous scenic points. Visits to the power plants. Trips up Pike's Peak.

Evening.—Dance and concert at the Broadmoor Casino.

SATURDAY, JUNE 10

All Day.—Special trains to the Cripple Creek district and return.

SUNDAY, JUNE 11

All Day.—Trips to the scenic points about Colorado Springs, each delegate taking those he was unable to take on Friday.

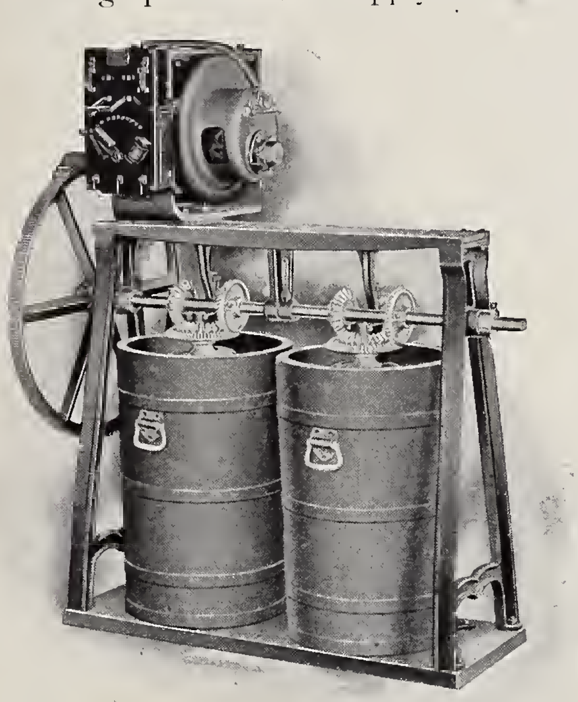
Monday and Tuesday will be devoted to excursion parties arranged for those desiring to go over the Moffat Road and the Loop.

The Schenectady Railway Company has been sold to New York Central and Delaware & Hudson interests. It was on the Ballston division of this road, it will be remembered, that the General Electric Company ran an experimental car on the single-phase system.

The Electric Motor in Hotel Service

By H. S. KNOWLTON

THE modern city hotel, like the office building, is a structure with many complex functions. Each is a community in itself, and each has the need of an intricate civilized organization for all the conveniences and facilities which the engineering specialist can supply. Hence



AN ELECTRICALLY DRIVEN DOUBLE ICE-CREAM FREEZER, MADE BY F. E. WHITNEY, BOSTON, MASS. THE MOTOR IS OF GENERAL ELECTRIC MAKE

it is that the use of electricity in transportation, communication, illumination and power supply has increased so rapidly of late years in establishments designed to cater on a large scale to the wants of the public.

The unique advantages of the electric motor over other forms of prime movers are especially forceful in hotel practice. The labor item in a large city hotel is a heavy expense, sometimes rising as high as 1.5 employees per guest. For this reason the adoption of efficient machinery capable of replacing human labor is a matter of the greatest consequence in an establishment where operating economy receives its due from the management. Although such replacement usually means a reduction in the total operating cost of a given department, the installation of motors is also justified in cases where the total expense of operation is increased, provided that the volume of work done is thereby made greater per unit of expense. This is a point often overlooked in propositions to apply motors to different services. The cost per unit of output is the significant figure.

Organization is the vital factor in the preservation of dividends in a large hotel. It would be difficult to name a business in which the division of labor has been carried farther. Thus, in some of the largest houses, employees are occupied solely in the boiling of eggs. It is the more remarkable, therefore, that with all this care to utilize human labor systematically, there should in many cases be so little appreciation of less expensive substitutes for muscular power, and, in others, so little grasp of economical methods of machine operation.

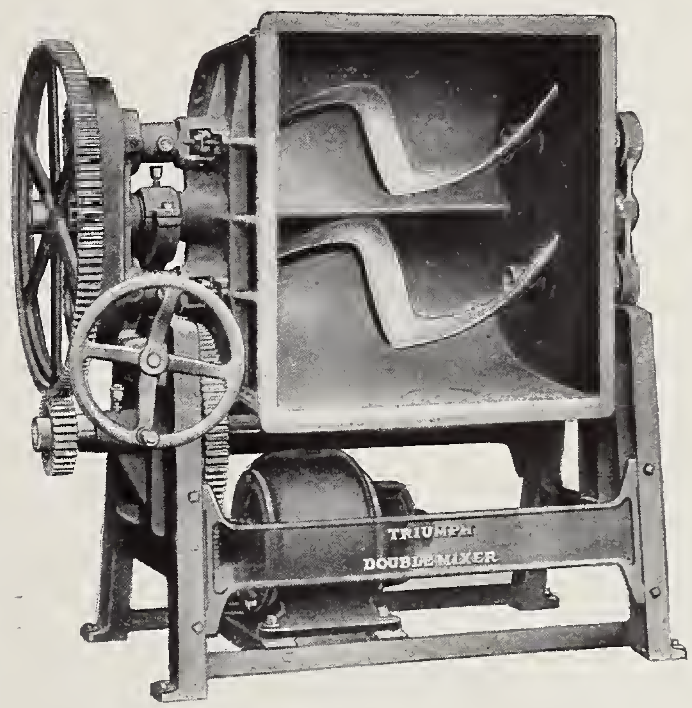
Although the machinery of a large hotel is to a great extent out of sight of the patrons of the house, it is a mistake to permit the basement and its environs to fall below the upstairs standards of cleanliness and efficiency. Here the electric motor steps in with special fitness. When properly installed and maintained it is the cleanest power available, and in the hotel kitchen and storerooms the accumulation of dirt cannot be tolerated. The direct connection between a food supply bearing the slightest traces of uncleanliness and the withdrawal of patronage and loss of reputation is obvious.

The saving in floor space required for a given output is a striking advantage of the electric motor in hotel service. Floor space is exceedingly valuable in most large city hotels, and a compact disposition of equipment is a valuable feature of a properly designed layout. In the vast majority of motor-driven machines the space occupied by the motor is so small a percentage of that required by the machine as to be insignificant,—in fact, many machines are operated by motors occupying no floor space whatever.

Just as in the manufacturing plant, machinery driven by motors can be located with the utmost freedom in regard to light, the sequence of operations and facility in handling raw material and the finished product, so in the operating department of a modern hotel can the equipment be installed independently of line shafts, away from ranges, ovens, broilers and other apparatus constantly visited by employees, and in that corner of the kitchen or storeroom best suited to its peculiar requirements, access to the pantry, cold storage chests, café, etc.

When a motor-driven machine is standing still the only expenses it entails are fixed charges—a decided contrast to the conditions prevalent where other forms of motive power are in use. Condensation loss in steam pipes under full pressure has no parallel in electric power circuits. Similarly, the effect of a shut-down on account of the failure of the prime mover is far more serious in the case of a steam engine driving all the hotel machinery by line shafting than is an interruption of service through the breakdown of a single motor which ties up but one or two machines.

It is also a great advantage from



DOUGH MIXER EQUIPPED WITH A CROCKER-WHEELER MOTOR

the standpoint of power cost to be able to operate a motor-driven machine overtime without the expense of running line shafts using up considerable power on their own account. This is a cardinal feature of all motor work—the bills represent power consumed only when machines are run-

ICE-CREAM FREEZER DRIVEN BY A WESTERN ELECTRIC COMPANY (CHICAGO) MOTOR

ning. There is a vast difference between paying wages at an hour rate and meeting the expense of a definite amount of utilized power plus the loss in the wiring and machinery. Although the cost of power may be a small percentage of the total cost of hotel operation, it is well worth reducing if it can be done without sacrificing the work accomplished.

Another special advantage in the use of motors in hotels, which is also found in many other installations, is the low cost of maintenance in comparison with that of other kinds of power machinery. Electric motors have attained a brilliant reputation for giving continuous and reliable service in all sorts of trying situations, and so great have been the efforts of designers to give satisfaction in this particular that it would be hard to mention a standard make which it would be unsafe to buy on the supposition that for several years repairs would be almost nominal, provided that the motor was intelligently adapted to the work required of it, supplied with power at or near the designated voltage and subjected to no serious ill usage. There are always numberless things to be done in the way of light repairs and maintenance in a hotel, and for this reason the small amount of attention which motors require is an especially valuable feature in the conduct of the business, tending to reduce the cost of labor in the engineer's or electrician's department, depending upon the organization of the house.

The electric elevator is without doubt one of the largest power consumers in the modern hotel. Motors of 20-H. P. rating or over are frequently required for such service, which is extremely variable in its demands. The current fluctuations are probably more violent than in any other application of electric motors. For this reason the choice of elevator equipment is a problem not to be solved offhand, and in some cases there is considerable question as to whether some form of hydraulic elevator with motor or steam-driven pumps is not preferable to the straight motor-driven types. The problem of control, the class of travel, distance between floors, cost of power and labor, continuity of service and available space for the installation must all be considered. Generally speaking, if a hotel is not many stories in height, if the cost of power is low and the speed of operation not great, the electric elevator of the simple worm-and-drum type admirably serves the purpose.

A very strong point in favor of the electric motor in elevator service is its characteristic of taking power only in proportion to its load, in comparison with the hydraulic machine's consumption of full power regardless of the load in the car. The ability of the motor to stand severe and sudden overloads without injury is also noteworthy. In cases where good practice selects the electric elevator in preference to any other type, after a careful study of the conditions obtaining, all the general advantages of cleanliness, compactness, easy control and efficient operation common to electric motors in severe service are certain to be realized if the equipment is chosen from standard makes and is of proper capacity.

In connection with small apartment houses an interesting application of the electric motor is found in the type of electric elevator which requires no attendant. These machines are designed to start from the lower floor upon the pressing of a button at some other floor, thence automatically coming to a stop at the floor desired. The doors cannot be opened until the elevator is at the particular floor where people wish to get on or off, the interlocking mechanism making the elevator perfectly safe. In a large hotel, elevators are always operated by attendants, but the automatic type is interesting as a special case. Electrically driven dumbwaiters have been used with signal success in hotels, the remote control being a specially advantageous feature. An installation of unique interest is in operation at the Hotel St. Regis, New York, in which the dumbwaiters are controlled by push buttons and dials in the basement, pilot lamps being used to show the arrival of the waiters at the desired floors. A unique feature of the installation is the use of 1-H. P. electric heaters on the waiters to keep the food warm during transit.

Bread-mixing machinery offers a favorable field for motor driving in hotel service. Mixing dough is a process requiring considerable power, and, in view of the constant shifting of the center of gravity in such machines, it has been found advantageous to resort to chain driving. The hammering of the motor bearings is likely to be severe if geared connections are used. A 1400-pound mixer now on the market requires a 50-H. P. motor for driving. The time for mixing averages 25 minutes. Such an equipment means an immense saving over the old methods of hand mixing, with the added advantages of cleanliness and uninterrupted work.

The model bakery exhibit of Joseph Baker & Sons, English engineers, in the Palace of Agriculture at the St. Louis Fair, was an interesting example of the adaptability of the electric drive to domestic use. Chocolate wafers were automatically manufactured from the crude material, and delivered in paper bags turned out while the chocolate cakes were being made, by an arrangement of mixers, refiners, tapping machines, and weighing machines, driven by five

THE FAIRY FLOSS CANDY MACHINE, MADE BY THE ELECTRIC CANDY MACHINE COMPANY, NASHVILLE, TENN.

Westinghouse motors ranging from 3 to 6 H. P.

The bakery machinery was driven by a 15-H. P. motor, direct connected to a long transmission shaft under the floor, from which were driven fruit cleaners, bread molds, caramel mixers and cutters, candy-pulling devices, pumps for sugar boilers, machines for pressing and cooling candies of all sorts, "roller boys"—for stick candies—and ice-cream freezers. Dough was mechanically kneaded in a great box by the operation of a 6-H. P. motor.

The whole display was arranged on the plan of a model kitchen. The arrangement of the shaft was not such as to interfere in any way with an appearance of neatness and simplicity, and the belts were in all instances short and suitably protected. It is unlikely that the hotel proprietor, chef, or housewife found any of the thousands of exhibits in the Palace of Agriculture of more absorbing interest or promise.

Motors are largely used in modern laundry machine driving, both in and outside of hotels. The Hotel Astor, in New York, has two 3-H. P. and one 15-H. P. motors in its laundry department; the new Bellevue-Stratford Hotel, in Philadelphia, has five laundry motors aggregating 62 H. P., and in Boston, the Hotel Somerset has a 15-H. P. motor in use, driving a mangle, an extractor and two washers. Perhaps the cleanliness of motor driving is its strong point in laundry work, as power free from dirt is worth installing at almost any price under such conditions.

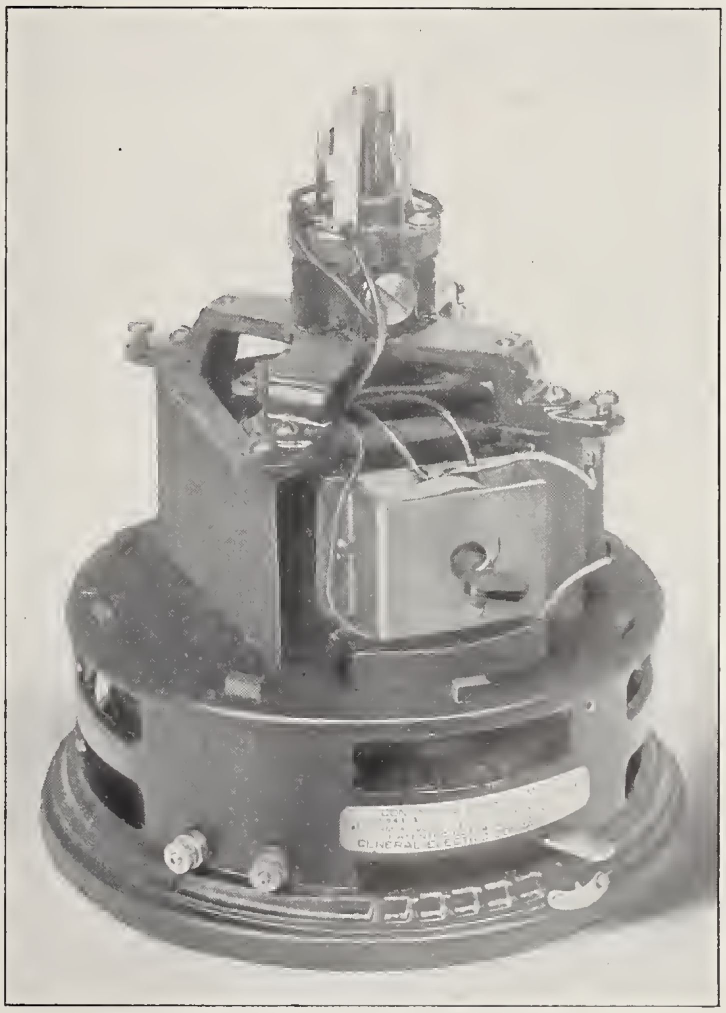
The driving of ice-cream freezers by motors is constantly growing in favor in large hotels. A $4\frac{1}{2}$-gallon single freezer operated by a $\frac{1}{2}$-H. P. motor through spur and bevel gearing can be purchased for about $150, while a 9-gallon outfit driven by a 1-H. P. motor costs in the vicinity of $200. In these equipments the motor is bolted to the freezer frame, and a rawhide pinion is keyed to the armature shaft, meshing with a cut gear which turns the freezer shaft at about 90 revolutions per minute. A recent test made under the supervision of the Boston Ice Cream Company showed that, with a double $4\frac{1}{2}$-gallon outfit, 9 gallons of frozen cream were produced in 18 minutes, the average power consumption being 577 watts. At 10 cents per kilowatt-hour, the cost of freezing the 9 gallons was about a cent and three-quarters, making the cost per gallon about a fifth of a cent—a decided economy over human labor at 15 or 20 cents an hour. Either direct or alternating motors are used for this service.

In the Hotel Essex, in Boston, a 2-H. P. freezer equipment is used with success, and the Hotel Somerset, in the same city, has an equipment of about the same size. The Bellevue-Stratford, in Philadelphia, uses a double 3-H. P. outfit, while the Hotel Astor, in New York, operates one of 5 H. P. The Alamo Hotel, at Colorado Springs, is also said to have adopted motor-driven freezers.

Dish conveyors are frequently seen in advanced hotel practice. These are driven by small motors, 3 H. P., or thereabouts, and are important labor savers. An item worth mentioning in the case of the dish conveyor is the freedom from breakage of dishes through

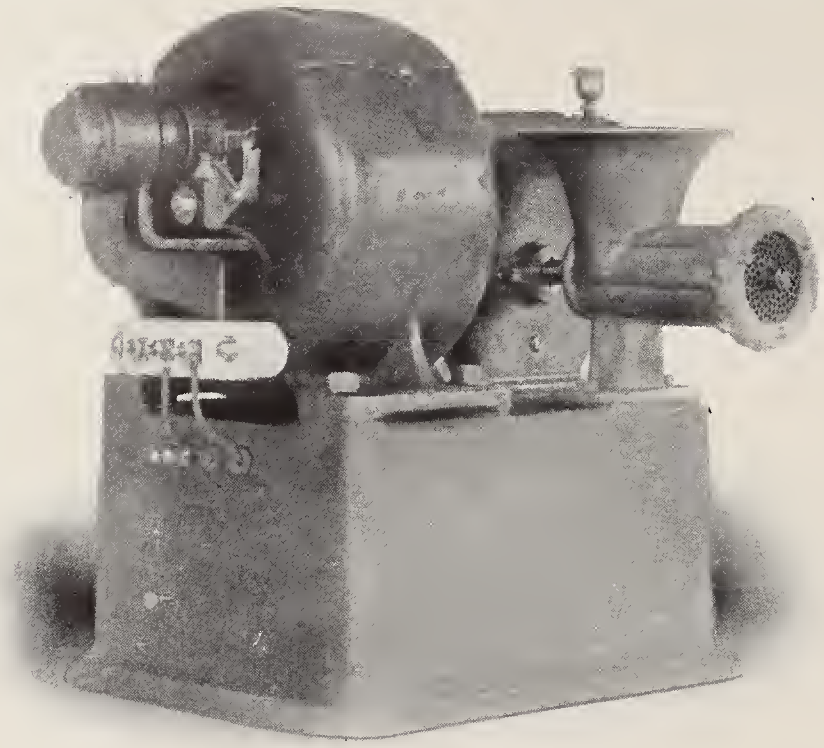
THE FAIRY FLOSS CANDY MACHINE MOTOR IN SERVICE FORM

the dropping of loaded trays en route between the dining room, kitchen or pantry—an occurrence by no means uncommon when the dishes are carried by colliding human waiters. In connection with this, it is worth mentioning that in some hotels motors are used in driving coal conveyors, the results being as satisfactory as in larger electric plants. Ash hoists are frequently motor driven, the Hotel Essex, in Boston, for example,



THE FAIRY FLOSS CANDY MACHINE MOTOR, WITH CASING REMOVED, MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

having one of 1500-pound lifting capacity, operated by a 2-H. P., 220-volt motor. The same hotel has a 2-H. P. motor-driven dumb-waiter running from the office to the tenth floor.



A MEAT GRINDER, DRIVEN BY A MOTOR BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Among the smaller motor-driven outfits which have been found useful in hotels, the coffee grinder and pulverizing mill takes a prominent place. One of these, fitted with a $\frac{1}{4}$-H. P. motor, and occupying a space 22 inches long, 14 inches wide and 30 inches high, weighs but 115 pounds complete, and will granulate 1 pound of coffee per minute, pulverizing $\frac{1}{4}$ pound per minute. The machine is furnished for either direct or alternating current, and is well adapted to spice grinding and other requirements of a small hotel or restaurant. The hopper holds 4 pounds of coffee, and the compactness of the machine enables it to be installed in many corners where a hand-driven grinder would be too bulky. A mill suited to the needs of a large hotel occupies a space 45 inches high, 36 inches long and 34 inches wide, being equipped with a 2-H. P. alternating or direct-current motor and having a hopper capacity of 20 pounds of coffee. The grinding capacity is 9 pounds of coffee granulated per minute, and the machine weighs 650 pounds.

Like the coffee and spice mill, the meat and food chopper is readily driven by a motor, and the output of such a machine is really marvelous in comparison with the work which five or six persons could do in the same time. Thus, a chopper weighing but 400 pounds and occupying only 750 square inches of floor space, with a height of 27 inches, equipped with a 1-H. P. alternating or direct-current motor, will chop 400 pounds of beef or 750 pounds of pork in an hour. These machines are often equipped with a pulley for driving a mixer or a grindstone when the chopper is not in use, and when fitted with a 2-H. P. motor will drive both the chopping knives and the stone. The motor is geared directly to the chopper, and there are no dirty belts or oily line shafts overhead to sully the product. Muscular labor is here released for more selective tasks, with a notable increase in operating efficiency, wherever large quantities of food are to be handled.

A MOTOR-DRIVEN BUFFER FOR POLISHING SILVERWARE, MADE BY THE NORTHERN ELECTRICAL MANUFACTURING COMPANY, MADISON, WIS.

The washing and drying of dishes in a modern hotel is a large task, and if it were not possible to perform it at small expense by the aid of special machinery, the burden of such work would be most annoying and the cost excessive. In a large establishment, a power-driven dish washer is an absolute necessity, and in this the electric motor offers peculiar advantages.

In the Shirley Hotel, in Denver, an interesting installation of this kind is in service. The dish washer is belt driven from a 2-H. P. motor running 1130 revolutions per minute at 230 volts. The dishes are set on racks which slide into a housing, after which current is turned on and the motor drives a pump which deluges them with soft soap suds for about three minutes. An attendant then opens a valve, admitting scalding water to rinse the dishes, which are then dried immediately by evaporation. The machine has a capacity of 3000 dishes per hour, or enough for 200 persons, fifteen dishes on the average being allowed per person in this hotel. In the Hotel Somerset, in Boston, a dish washer is installed, driven by a 1-H. P. shunt motor; the Bellevue-Stratford, in Philadelphia, has 10 H. P. in dish-washing motors, and other large hotels are equipped in a similar manner.

The cleaning of cutlery and silver is another important problem in hotel operation which has been best solved with the aid of the motor. A combined buffing and scraping machine is in use in some hotels, and it gives great satisfaction. It is driven direct by a 3-H. P. motor. On one end of the shaft is a felt disc, against which the silverware is held by the attendant for polishing. The other end of the shaft carries a stiff wire brush or swab, which is used in cleaning out the bottoms of earthen or glass jugs, pitchers, etc. It is an easy matter to clean from twenty to thirty silver dish covers and platters in an hour with this machine.

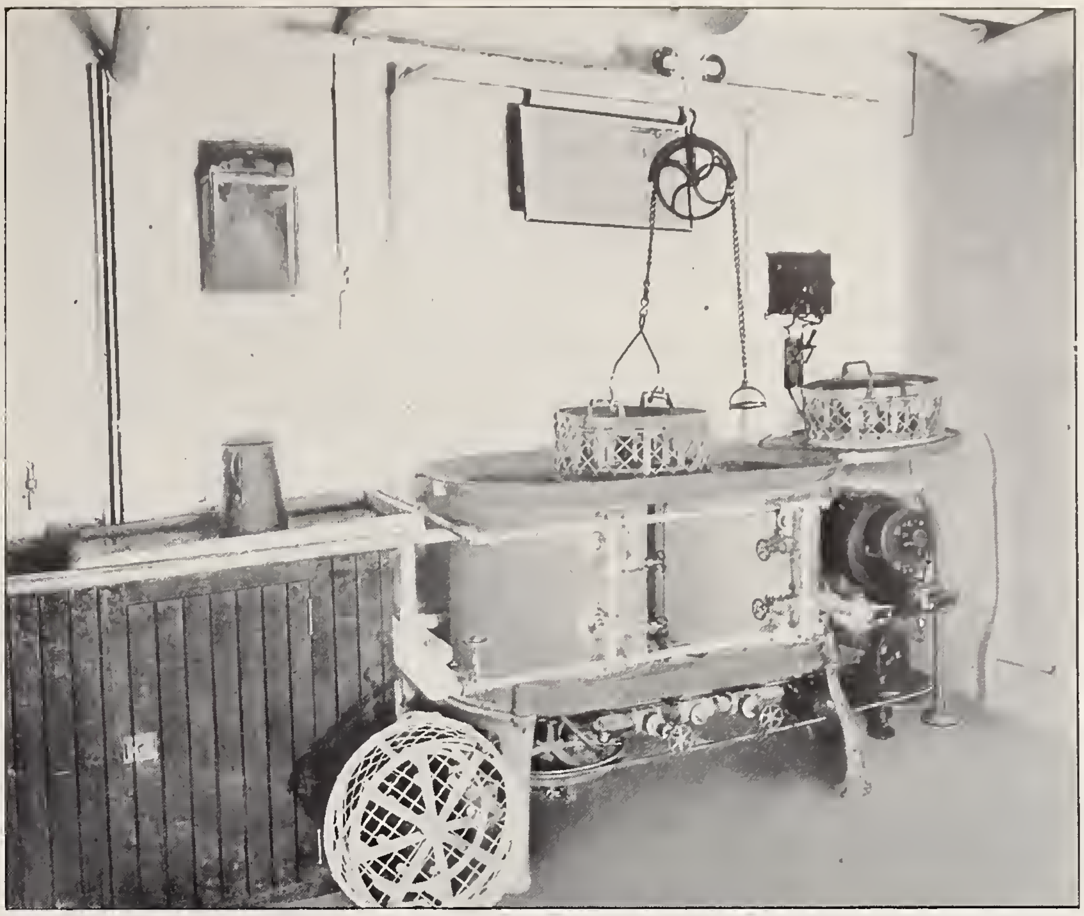
Sometimes this equipment is combined with a knife-cleaning machine, which consists of emery or corundum rolls through which steel knives are passed two or three times each by the operator. Five hundred knives an hour can readily be brightened in this way by a 2-H. P. cleaner. The Hotel Touraine, in Boston, is well equipped in this way. Ice crushers are driven by motors in the more recent installations of hotel machinery, one machine delivering the ice in small cubes for goblet use.

In hotels which print their own menus a motor-driven press is of special convenience. To many patrons the make-up and appearance of a menu is a direct indication of the quality of the café management. Hence, a first-class hotel can afford to take no chances of smudging its menus in the process of printing, through the dripping of oil or falling of dust from belts and shafts. The fine speed control of a motor-driven press also enables the output to be forced to the limit of the particular work in type. As the work of the press is intermittent, the motor is particularly adapted to handle it, especially as temporary overloads can be easily carried without injury.

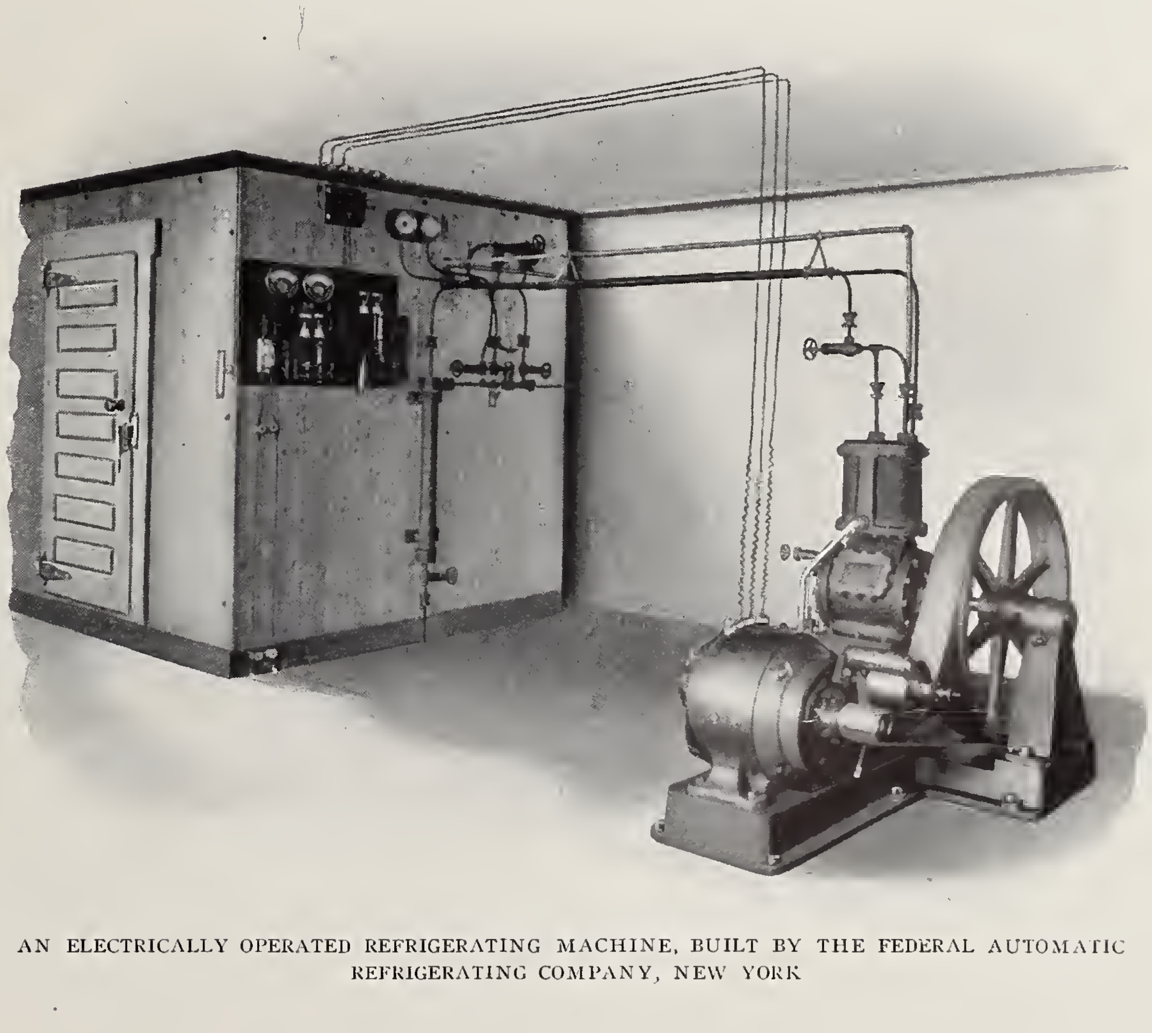
Here, as elsewhere in motor work, the expense of power ceases when the press stops running. There is no shifting of belts by the operator from tight to loose pulleys, with the chances of soiling his hands and spoiling the work when it is touched. With any other form of power transmission, friction, condensation or leakage losses are nearly constant. The location of the motor-driven press is exceedingly flexible with reference to light, air and sequence of operations, and the absence of belts is a safeguard against accident to employees, particularly where women attendants are at work.

The driving of refrigerating apparatus by motors is growing more and more common in large hotels, and the same facility with which motors are applied to cold storage work in other establishments is readily invoked in hotel installations. The superiority of the electric motor for this service over steam, gas or oil engines in point of maintenance, attendance and repairs has been a great incentive to the development of refrigerating machinery on both a small and a medium scale. To cite a single installation, a 25-H. P. motor installed in the Hotel Essex, in Boston, operates a cold-storage system rated at 15 tons capacity in 24 hours.

The refrigerating field is so large that a special article would be required to properly discuss it in reference to the duty required and the motor design and capacity necessary for each particular service. Similarly, electric motors are used in many hotels to drive pumps of all sorts and conditions. Boiler feed, brine, circulating, house tank, drinking water, fire, ammonia, and sump pumps may all be found motor driven in progressive installations. As a special case of the hotel, the modern ocean steamship



DISH-WASHING APPARATUS OPERATED BY A GENERAL ELECTRIC MOTOR



AN ELECTRICALLY OPERATED REFRIGERATING MACHINE, BUILT BY THE FEDERAL AUTOMATIC REFRIGERATING COMPANY, NEW YORK offers numerous interesting uses of the electric motor for hoisting and other purposes.

Among the smaller applications may be cited the 2-volt, clock-winding motors in use in hotels for automatically keeping the timepieces in motion. These are operated from two or three cells of dry battery, and are interesting examples of the refinement to which motor practice has been carried. Other small motors are used in hotels for driving the ringing generators of the private branch telephone exchanges which serve the establishment. Still others drive air compressors for housecleaning.

Ventilation is one of the most important matters to be considered in connection with modern hotel practice. It is of the utmost consequence that the odors of the kitchen and dining room shall not be wafted promiscuously through the lobbies, corridors and guest rooms. Here the electric motor occupies an ideal position, and it has been applied to the propulsion of blowers and exhaust fans with the same success as in ventilation in other lines of work. Some of the more important applications are:—Blowers for the supply of fresh air to the kitchens, pantries, basement and engine room, fire room, ball rooms, cafés and barber shop; exhausters for the withdrawal of impure air from the kitchen, toilet rooms, assembly rooms and other portions of the hotel subjected to vitiated atmosphere; fans for the withdrawal of smoke from private and public fireplaces, removal of tobacco smoke from cafés and banquet halls; and fans for ventilating guest rooms.

It will be seen from the foregoing that the opportunities for the use of electric motors in modern hotels are almost myriad. Even the small lathe in the basement repair shop and the sewing machines of the linen department are operated by electricity in the best installations. Although the installation of a first-class motor equipment lightens the inspection work of the hotel staff, it is still important to keep an eye upon the machinery with regular examinations from time to time. Wherever the equipment is extensive, an ammeter of the portable type should form part of the hotel outfit, for the purpose of checking up the current consumption and therefore the condition of the machinery. To the central station man anxious to better his load factor by increasing his power output, to the isolated plant designer desirous of operating his machinery at full capacity, and to the hotel manager looking for the far-reaching economy of improved appliances, the electric motor in hotel service solves many problems.

Lightning Protection for High-Voltage Circuits

DISCUSSED BEFORE THE NEW YORK ELECTRICAL SOCIETY

At a meeting of the New York Electrical Society, held on April 26, an interesting paper on "Lightning Protection for High-Voltage Circuits" was read by N. J. Neall, of Pittsburg, Pa.

One of the expressed objects of Mr. Neall's paper was to endeavor to bring about co-operation between the different workers and the users of lightning arresters in high-tension practice rather than to go on working at cross purposes, as was now sometimes the case. To this end it was very desirable that the most complete data possible should be gathered relative to the causes of the success or failure of lightning arresters now in use.

One of the important points upon which more light was desirable was the efficiency of the grounds. Mr. Neall's paper discussed the various types of lightning protectors now on the market and in use on high-potential circuits,—30,000, 50,000 volts and over. Amongst these are the horn lightning arrester, the fixed coherer type, the non-arcing type, the water-column type and the skin-effect arrester.

The author of the paper contended that as it was impossible to reproduce the static conditions existing on high-potential lines due to lightning discharges, the next best thing attainable was to imitate these conditions as far as possible in the laboratory or in the power house. Mr. Neall believed that the equivalent spark gap arrangement which he described, and with which he has carried on many interesting experiments, was a fairly satisfactory device for this purpose. An important advantage of the equivalent spark gap arrangement was that it provided a duration test of the apparatus.

While Mr. Neall admitted that the problem of a successful high-tension lightning arrester was not yet solved, he thought the best chances of success lay in the direction of the horn type, the fixed coherer type and the non-arcing type. The non-arcing type, however, was not suitable for the high-tension continuous current circuits of 60,000 or 70,000 volts now under way in Europe.

The discussion was participated in by F. W. Jones, H. C. Wirt, H. G. Stott, Ralph D. Mershon and others.

Mr. Jones spoke of the experience of the Postal Telegraph Company on the Western plains with the ground wires employed on poles to protect the pole which was not favorable to their employment. He said the telegraph people had succeeded very well in protecting their apparatus from lightning discharges, but they had suffered considerably from the crossing of their wires with high-tension power circuits in various parts of the country. Mr. Jones also called attention to a singular action of the electric discharge in fusing the telegraph line wire between poles.

Mr. Stott said he thought the only test of a lightning arrester worth considering was the actual line test. Mr. Mershon did not agree with Mr. Neall as to the utility of the equivalent spark gap for determining the efficiency of a lightning arrester. He thought a matter requiring attention was the inductance of resistance arresters. It was not impossible that the inoperativeness of some arresters might be due to a reactance effect of that apparatus. The cost of line insulators relative to the total cost of the line was insignificant, and in view of the importance of this piece of apparatus it was suggested that manufacturers might devote more attention to the details of its construction, which would result in more reliable service. He thought the oil-insulated transformers on high-tension power lines were very well protected from the effects of lightning discharges. He saw no reason why insulators might not be constructed to meet any voltage that transformers could withstand. The lightning arresters for high-tension circuits must be simpler than they are at present, and he surmised that the horn type of arrester was the one most likely to attain permanent success.

In speaking recently of his tour of the United States last fall on the occasion of the American visit of the British Institution of Electrical Engineers, Col. R. E. Crompton, the well-known English electrical engineer, said that there was one point on which all who took part in the tour were agreed, and that was the immense superiority of the American telephone system in all towns to anything they had in England. The telephone in America he considered a delight and a luxury which one feels all the more as soon as one returns to the miseries of the London system.

The jury of awards of the St. Louis Exposition awarded the National Electric Light Association a gold medal for its publications and its work in the electric lighting industry.

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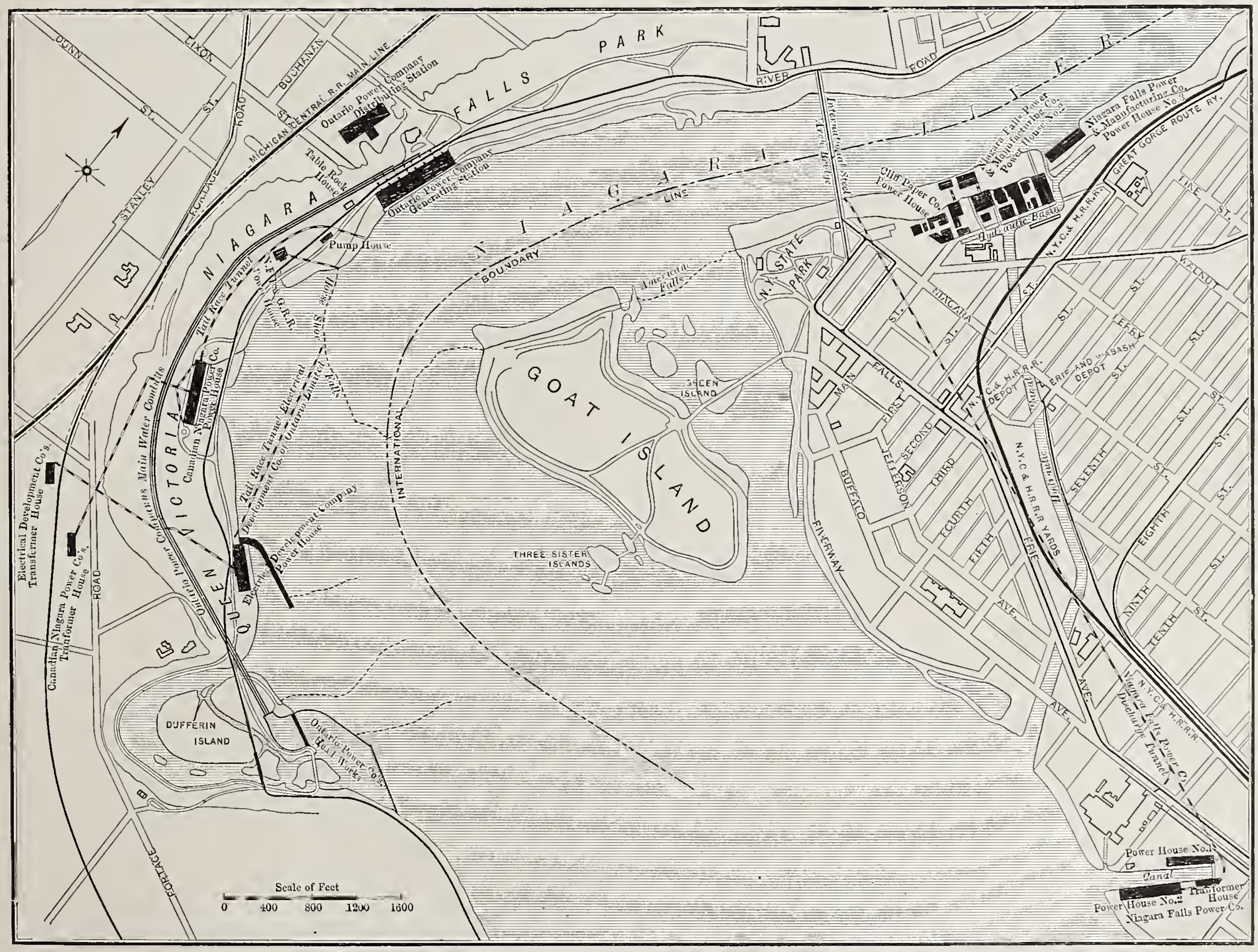
New York and London

Niagara Generators and Turbines

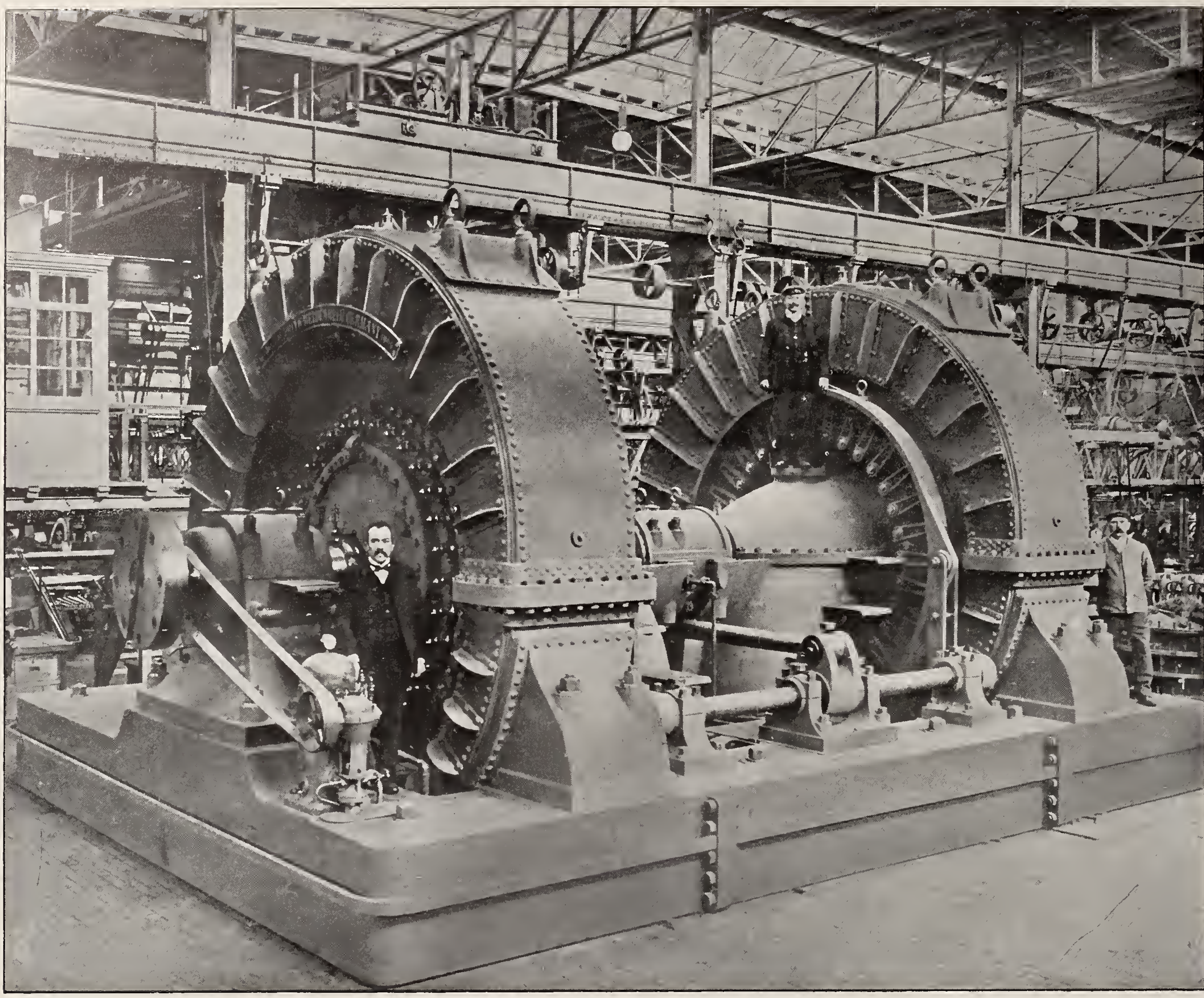
By ALTON D. ADAMS

ELECTRIC generators of 453,000-K. W. combined capacity are to operate in the six great power plants at Niagara Falls. As these plants are all within about a mile of the Falls, their generators will form a group whose capacity cannot be duplicated at any other point in the world.

These generators are all of the alternating type, all have rotating magnets and stationary armatures, and all operate at 25 cycles per second; but here their similarity ends. In all, twenty-one are located in the two stations of the Niagara Falls Power Company, and have a total capacity of 78,550 K. W. In the new plant of the Hydraulic Power & Manufacturing Company there will be fourteen generators with a combined rating of 70,000 K. W. Across the river the power house of the Ontario Power Company is to have a capacity of 135,000 K. W. in eighteen generators. On the Canadian



A MAP OF NIAGARA FALLS, SHOWING ELECTRIC POWER DEVELOPMENTS



FRANCIS TYPE TURBINES NO. I OF THE ONTARIO POWER COMPANY, 11,400 H. P., TO WORK UNDER 175 FEET EFFECTIVE HEAD. BUILT BY J. M. VOITH, HEIDENHEIM, GERMANY. EACH PAIR OF TURBINES DRIVES A 7500-K. W. GENERATOR BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG

side there are also the station of the Toronto Niagara Power Company, designed to contain eleven generators of 88,000-K. W. capacity, and the plant of the Canadian Niagara Power Company for 82,500 K. W. in eleven generating units.

At four of the stations, those of the Niagara Falls Power Company, the Canadian Niagara Power Company and the Toronto Niagara Power Company, the forty-three generators are all of the vertical type, each mounted at the top of a shaft that rises from the wheel pit beneath. Two of the stations, owned respectively by the Ontario Power Company and the Hydraulic Power & Manufacturing Company, will contain thirty-two generators of 205,000 K. W. total rating, and each of these will be direct connected on the shaft of a pair of horizontal wheels. In the two stations of the Niagara Falls Power Company the first sixteen generators have revolving magnets external to the armatures, but the remaining sixty generators of all these plants are of the type with external armature.

All of the forty-three generators that are mounted at the tops of vertical shafts have the uniform speed of 250 revolutions per minute; the generators of the Ontario Power Company will operate at 187½ revolutions per minute, and those of the Hydraulic Power & Manufacturing Company at 300 revolutions per minute. Each generator in all of these stations develops current of 25 cycles per second, so that those operating at 250 revolutions per minute have 12 poles each, those operating at 187½ revolutions per minute have 16 poles each, and those operating at 300 revolutions per minute have 10 poles each.

The twenty-one generators of the Niagara Falls Power Company operate at 2200 volts, two-phase, but the fifty-four generators belonging to the other companies are all three-phase, and develop 11,000 to 12,000 volts. It has been found that so low a voltage as 2200 made necessary a very large investment in conductors for the distribution of large units of power about Niagara Falls, and the pressures of 11,000 and 12,000 volts have been adopted in the newer plants for local distribution only, and not for any long transmission.

The frequency of 25 cycles per second adopted in the first three alternators of the Niagara Falls Power Company, which were designed in 1893, was followed in the later generators of that company and in those of the allied Canadian Niagara Power Company for the sake of parallel working of all these machines. In all of the other plants above named, the lead of the earlier ones as to 25-cycle current seems to have been followed because this frequency has become in a large degree standard for power transmission, and for the sake of uniformity with the earlier stations.

In each of the first three alternators of the Niagara Falls Power Company the weight of the external revolving part which carries the magnets is 78,600 pounds, and the fly-wheel effect of each revolving part, measured by the product of its weight in pounds by its velocity in feet per second, is 1,274,000,000 (18 A. I. E. E., 462). The first of these three alternators went into commercial service in October, 1895, the second some months later and the third in 1897. For alternators 6 to 10 of the company just named, which were designed in 1896, the weight of the revolving part was increased about 2000 pounds by increasing the thickness of the nickel steel ring that carries the twelve inwardly-projecting poles, from 4 7-16 inches to 5 inches, and the new armatures were given 334 bars in the same number of slots, instead of 374 bars in 187 slots, as in the first three machines.

In each of these machines the external diameter of the ring that carries the poles is 11 feet 7⅛ inches, and at 250 revolutions per minute its peripheral speed is about 9300 feet per minute. Tests at full load showed the losses in each to be, for armature core 42 K. W., armature winding, 29.2 K. W., and magnet winding, 11.4 K. W., a total of 82.6 K. W. loss when the electric output was 3730 K. W., so that the efficiency, considering only the electric and magnetic losses, was 97.82 per cent.

For alternators 7 to 10 of the Niagara Falls Power Company, the electrical efficiency was about 98.1 per cent., and for the first ten machines the air and bearing friction amounted to 1.1 per cent., so that the net efficiency of the three earlier machines was 96.7, and the net efficiency of the seven later machines 97 per cent.

It was found on test that the maximum temperature in the armature of each of the ten alternators in the first station of the Niagara Falls Power Company was reached at the end of about four hours' operation under full load, and the rise of temperature was about 65 degrees C. for the first three machines, and about 57 degrees for the seven later machines. Each generator armature showed an additional rise of about 5 degrees in some parts just after it stopped operation, due to the decrease in the amount of ventilation. In the first three of these generators the air gap between pole faces and armature teeth is 1 inch, but in the other seven machines of the first power house the air gap is ⅞ inch.

The second power house of the company last named contains eleven alternators, six of the external and five of the internal magnet type. Each of the external magnet alternators in power house No. 2 is substantially like the seven later machines in the first power house, but all of the generators in the second power house have a regulation of about 10 per cent. as compared with a regulation of 30 per cent. for the machines in the first plant. The external diameter of the magnet ring in the first six alternators of the second power house is 11 feet 10¾ inches, and the height of each machine above its foundation is 11 feet 7¾ inches. For each of the five later alternators in the second power house the outside diameter of the armature is 14 feet 10 inches, and the diameter across the polar faces of the internal magnets is 8 feet 9½ inches. Above its foundation each of these generators stands 9 feet 11 inches.

In the plant of the Canadian Niagara Power Company, each of the 7500-K. W. generators has an outside diameter of 17 feet, or only 2 feet 2 inches more than that of the generators of the same general type, but only 3750-K. W. capacity each, in the second station of the Niagara Falls Power Company. Each of these 7500-K. W. generators stands 12 feet ¼ inch above its foundation, and has a total weight of 314,000 pounds, or nearly 42 pounds per kilowatt, made up of 144,000 pounds in the revolving part and 170,000 pounds in the armature. The revolving magnets have a diameter of 12 feet 4½ inches.

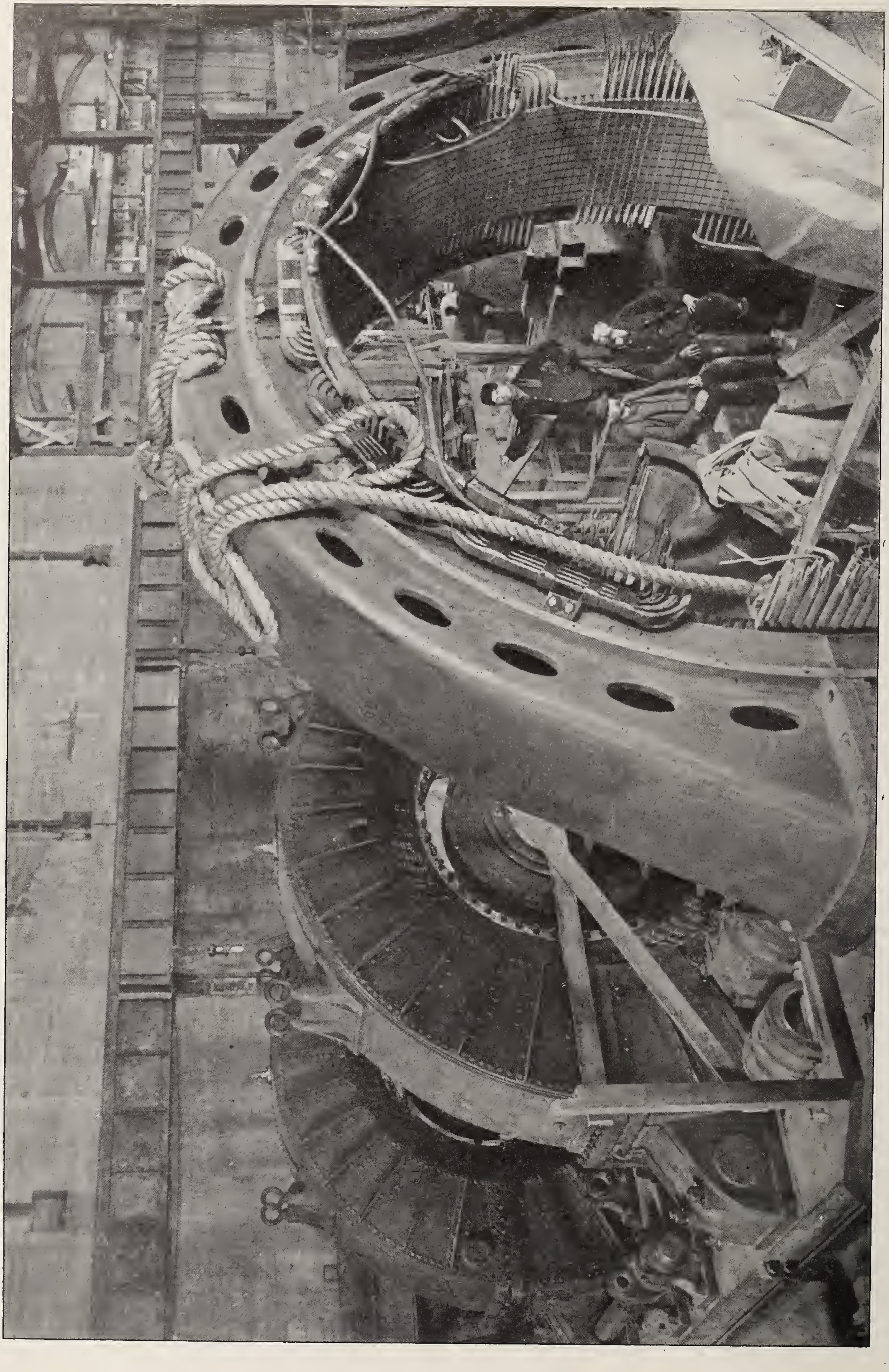
At the station of the Toronto Niagara Power Company, the most recent of the four plants that are equipped with vertical generators, each of the 8000-K. W. machines is to have a weight of about 400,000 pounds, or 50 pounds per kilowatt, and about 141,000 pounds of this will be in the revolving part.

The 7500-K. W. alternators in the plant of the Ontario Power Company each measure 26 feet 7 inches in width of bed at right angles to the shaft, and the length of the generator shaft from the center of the coupling with its driving wheels is 20 feet 2 inches. Each external armature has a diameter of 21 feet 6 inches, and the circular group of ten revolving magnets is 15 feet 2½ inches in diameter. These, in each generator, weigh 165,000 pounds, and the total weight of the machine is 409,000 pounds, or 54 pounds per kilowatt of capacity. In these horizontal generators the slightly greater weight per capacity unit over that of the vertical machines named above is probably due to the lower speed of 187.5 revolutions per minute, instead of the 250 revolutions common to the vertical type.

ONE OF THE 18-FOOT CONDUITS OF THE ONTARIO POWER COMPANY, CARRYING WATER FROM THE HEAD WORKS TO THE POWER HOUSE. SEE MAP ON PAGE 401

The twenty-one generators in the two stations of the Niagara Falls Power Company have their 2200-volt armature windings connected to form two complete independent circuits in each machine, each circuit thus carrying a single-phase current. In the 12,000-volt, three-phase armatures of the 7500-K. W. generators of the Canadian Niagara Power Company, the coils are Y connected.

Between each vertical generator and its direct-connected turbine wheels, in



A CONSTRUCTION VIEW OF ONE OF THE ONTARIO POWER COMPANY'S 7500-K. W. WESTINGHOUSE GENERATORS, DRIVEN BY A TWIN TURBINE SET the pit beneath the power house floor, there is a long steel shaft with the revolving part of the generator secured near its top. In the first plant of the Niagara Falls Power Company the length of each shaft from the center of its wheels in the pit to its top at the generator is about 155 feet. The first three of these shafts were of solid steel and 11 inches in diameter, but each of the later ones was made of three hollow cylinders of nickel steel, 38 inches in diameter, and connected with the turbine, the generator and each other by short lengths of solid 11-inch shaft. At three points between each turbine and its generator, the 11-inch sections of the shaft pass through guide bearings that are supported by steel beams across the pit. The same type of hollow shaft is used in the second plant of the Niagara Falls Power Company, but owing to a greater elevation of the turbine centers, the length of shaft to the top of the generators with external magnets is only about 144 feet.

In the plant of the Canadian Niagara Power Company, the length of each shaft from the wheel center to the top of the 7500-K. W. generator is about 133 feet, and here again the shaft is made up of three hollow sections joined by short, solid lengths and guided by three bearings on steel cross beams. Each shaft has a diameter of 15 inches in its solid parts and 40 inches in the hollow parts.

The steel shafts of the 8000-K. W. generators in the plant of the Toronto Niagara Power Company are about 133 feet long from the turbine centers to the tops of the machines above, and the guide bearings for each of these shafts are supported by concrete arches that span the pit.

For each of the 7500-K. W. generators in the plant of the Ontario Power Company the horizontal shaft is 20 feet 2 inches long and 21 inches in diameter, as stated above. Horizontal shafts, each 17½ feet long from its coupling with the wheel shaft, are used in the 5000-K. W. generators of the Hydraulic Power & Manufacturing Company, and the shaft diameter is about 17 inches. To avoid the use of the long shafts that would be necessary for exciters on the main floors of the power stations, three of the four plants that are equipped with vertical generators have their exciters in chambers excavated at the sides of the wheel pits and some distance from the bottom.

In the first power house of the Niagara Falls Power Company there are four exciters, each having a capacity of 125 K. W. and operating at 550 revolutions per minute. The second power plant of the same company contains four exciters in a chamber at one side of the wheel pit, the floor of this chamber being 146.5 feet below that of the station above. Each of these exciters is direct connected to a vertical turbine, and has a capacity of 150 K. W. The voltage is 230 at 750 revolutions per minute.

At the plant of the Canadian Niagara Power Company there are to be six exciters with a capacity of 250 K. W. and 125 volts each, and these exciters are direct connected to as many vertical wheels. Three are located in each of two chambers in the rock at one side of the wheel pit, and the floors of these chambers are 127.5 feet below that of the power station. Of the five exciting dynamos in the plant of the Toronto Niagara Power Company, two are driven by direct-connected turbines and three by as many induction motors. Each will have a capacity of 300 K. W. and a voltage of 125.

The Ontario Power Company will install six exciters of about 350 K. W. each, at 250 volts, and driven at 300 revolutions per minute by a direct-connected horizontal turbine.

Owing to the fact that Niagara River drops more than 50 feet over a series of rapids before it reaches the crest of the great cataract, the turbine wheels in the six power plants under consideration operate with quite different heads of water. The lack of draft tubes at the first plant of the Niagara Falls Power Company also materially affects the head on its wheels. At the intake of the two plants owned by this company, the water elevation is normally 561 feet above mean low tide, and the wheels of the first power house being without draft tubes have only the head due to the distance of their center elevation below that just named. This head is 136 feet. In the second power plant the turbine centers are 128.25 feet beneath the head water level, but the head is increased by draft tubes to about 155 feet.

The head water level at the forebay of the Canadian Niagara Power Company is normally 516 feet above tide, and the wheel centers are 115 feet below, at an elevation of 401, so that the draft tube action of 25 feet gives a head of 140 feet for operation. Further up stream, in the forebay of the Toronto Niagara Power Company, the water level is 533 feet, or 133 feet above the turbine centers, and the draft tubes increase this head to about 140 feet.

Head water stands at about 553 feet above mean low tide in the forebay of the Ontario Power Company, and the centers of the main turbines, more than a mile down stream, are 180 feet beneath this level. Draft tubes increase this head to 200 feet, but at full load the friction in the long pipes will probably reduce the effective head to not more than 180 feet. At the plant of the Hydraulic Power & Manufacturing Company the total head of water, including that added by the draft tubes, is about 210 feet, with no allowance for friction losses.

Each main generator at the first plant of the Niagara Falls Power Company is driven by twin outward-flow turbines rated to pass 430 cubic feet of water per second. The inside diameter of the wheel is 63 inches, its outside diameter 75 inches and its depth 12 inches. At the full rate of discharge named, the velocity of the water in the vertical steel penstock to each wheel is nearly 10 feet per second, the inside diameter of this penstock being 7.5 feet. Water for the twin turbines in the second plant of this company comes down through penstocks each 7 feet 7 inches in diameter, and draft tubes are used with these wheels, as they are of the internal discharge type.

A vertical steel penstock, 10 feet 2 inches in diameter, carries water down the wheel pit of the Canadian Niagara Power Company for each pair of turbines that drives a 7500-K. W. generator. About 887 cubic feet of water per second is estimated to pass through each pair of these turbines when they are operating at full load, and this water is discharged through a single draft tube.

The pair of vertical turbines that drives each of the 8000-K. W. generators at the plant of the Toronto Niagara Power Company is rated at 12,500 H. P., receives water through a vertical steel penstock 10.5 feet in diameter, and discharges it through a single draft tube. In this plant the turbines are set on the solid rock at the bottom of the wheel pit, instead of being mounted on steel cross beams some distance above it, as in the other three stations that use vertical generators. It is practicable to erect the wheels on the floor of the pit in this case, because the draft tubes discharge the tail water into tunnels on either side, and the bottom of the pit is dry.

Though the heads of water on the wheels in the four power plants last named are about 136 feet, 155 feet, 140 feet and 140 feet, respectively, it is to be noted that all these wheels operate at 250 revolutions per minute, and that the capacity of each pair of wheels under the head of 140 feet is substantially twice that of each pair under the 136 or 155-foot head.

To each pair of horizontal turbines driving a 7500-K. W. generator in the plant of the Ontario Power Company, the water comes down through a steel penstock 9 feet in diameter, but this divides into two branches before it reaches the pair of wheels. Tail water leaves each pair of these turbines through two branches that unite in a common draft tube a few feet from the wheels. At the tips of the runners, each of these wheels has a diameter of $6\frac{1}{2}$ feet, and the speed is $187\frac{1}{2}$ revolutions per minute under a head of not less than 175 feet.

Not all of the equipments above described are now complete. In the two power plants of the Niagara Falls Power Company, the twenty-one generators of 78,550-K. W. combined capacity are in operation. The Canadian Niagara Power Company has several of its 7500-K. W. generators in position, and the same is true of the Ontario Power Company. At the plant of the Toronto Niagara Power Company none of the alternators are yet ready to operate, and the new station of the Niagara Falls Hydraulic Power & Manufacturing Company is still in an incomplete state.

It thus results that of the 453,000-K. W. capacity to be provided in the six great power plants at Niagara Falls, hardly more than one-third is now available. Nearly all of the hydraulic developments in the way of intakes, canals, forebays, wheel pits and tunnels are completed, however, the stations buildings are well under way, and it now remains to add the balance of the generating equipments as the loads demand.

The Electrical Fire Hazard

A VERY interesting and instructive paper on the subject of electrical fire hazard was recently presented before the Electrical Section of the Western Society of Engineers by William T. Benallack, who has for a number of years been State inspector with the Michigan Inspection Bureau.

Among the important points brought out by Mr. Benallack was the fact that while the electrical man is generally held responsible for all fires of electrical origin, in reality a great number of these defects are due to the property-owner himself, who insists on cheapness of construction, and will use inferior material against the advice of the electrician. Frequently, too, in large office buildings and apartment houses the janitor or steam engineer is expected to make all repairs to the electric-lighting system, often with dire results.

The National Electrical Code, he said, is somewhat technical and has grown to such an extent that it is too intricate for many to understand properly who have not sufficient time to master the contents. With this in mind he compiled a few simple rules which, though not intended to cover large installations, will be found to be of great advantage in the majority of smaller equipments. These rules are here quoted:—

"Service wires must, where they enter buildings, be supported on brackets and insulators and have a drip loop on the wires to prevent moisture from entering the tubes.

"Flexible tubings should be used on wires at the front of buildings as a protection from contact with awning frames.

"An approved cut-out (fuse) should be provided on service at a point suitable for safe and convenient location of cut-out.

"An approved main switch should be provided as near as possible to where service enters and within easy reach of floor, so arranged that the entire equipment, including meter, can be disconnected when necessary. This switch should be protected by the main fuses.

"A separate branch cut-out should be provided for each 660 watts, i. e., the equivalent of about 11 or 12 16-candle-power lamps, or one arc lamp. All cut-outs should be of the plug or enclosed cartridge type. It is always good practice to have cut-outs assembled in groups, depending somewhat on the nature of buildings and placed in approved cabinets lined with slate, marble or one-eighth-inch asbestcs.

"For ordinary open work, wires should be mounted on porcelain cleats or knobs, which keep the wires at least one-half inch from the surface wired over and $2\frac{1}{2}$ inches apart; supports to be used at least every $2\frac{1}{2}$ feet.

"Suitable mechanical protection should be provided on all wires running on side walls, either by a substantial boxing, wooden moldings, or preferably metal conduit.

"Flexible cord must not be run on walls or ceilings in place of wire, and is not approved in show windows. Cord is only designed for use as a pendant, and should not hang lower than a distance of five feet from floor. Flexible cord-drops of unnecessary length should be avoided as much as possible and kept clear of contact with wood pipes, etc.; where portable lights are required, cord especially designed for this use can be procured.

"In all wiring, special attention should be paid to the mechanical execution of the work. I would rather see a lot of poor material well put up than the very best approved devices installed in a careless and slipshod manner."

Speaking of theaters, the author said: "I have inspected about 60 theaters, and with the exception of a few of the more recently constructed and those located in the larger cities, not over 10 per cent. would pass inspection."

Deterioration is a factor which should not be ignored, especially in places exposed to dampness, acid or other fumes which injure the wire or insulation. The extent of the deterioration depends largely on the owner.

Speaking of the relation between electrical men and the inspection departments, Mr. Benallack said:

"As a rule, speaking from my own experience, the electrical fraternity feels kindly toward the inspection departments if for no other reason than that the business has increased from the great amount of repair work and remodeling that our inspection has developed, and at the same time efficient inspection makes it more difficult for the unreliable and irresponsible electrician to do business. The only consistent grievance they may have, if any, is due to the lack of uniformity of interpretation and enforcement of rules."

Power Consumption of Electric Lamps

IN a paper recently prepared by Prof. H. T. Davidge for the Junior Institution of Engineers, he summarized the power consumption of different forms of electric lamps as follows:—

Incandescent lamps, $2\frac{1}{4}$ to $4\frac{1}{2}$ watts per candle-power; Nernst lamps, $1\frac{1}{2}$ to $2\frac{1}{2}$ watts per candle-power; enclosed arc lamps, $2\frac{1}{2}$ to 4 watts per candle-power; open arc lamps, 0.8 to $1\frac{1}{2}$ watts per candle-power.

The summer session of the Armour Institute of Technology will be held from June 26 to August 4. The courses open will be mechanical engineering, electrical engineering, telephone engineering, civil engineering, chemical engineering, drawing, shop work, maual training, mathematics and physics.

Mayor Dunne, of Chicago, said recently that if the streets were sufficiently well paved he would consider the advisability of adopting autobuses instead of street cars for operation under municipal ownership.

The Organization of Working Forces in Large Power Houses

By W. P. HANCOCK, of the Edison Electric Illuminating Company, of Boston

A Paper Read at the Recent Annual Meeting at Denver, of the National Electric Light Association

As this paper will deal with the organization of working forces in large power houses, we will assume that we have approved and economical apparatus on both the steam and electrical ends of the system; that being true, it would seem that if we added an organization to operate such a system so that the best results would be obtained from the complete plant, we should find our generating cost per kilowatt-hour satisfactory.

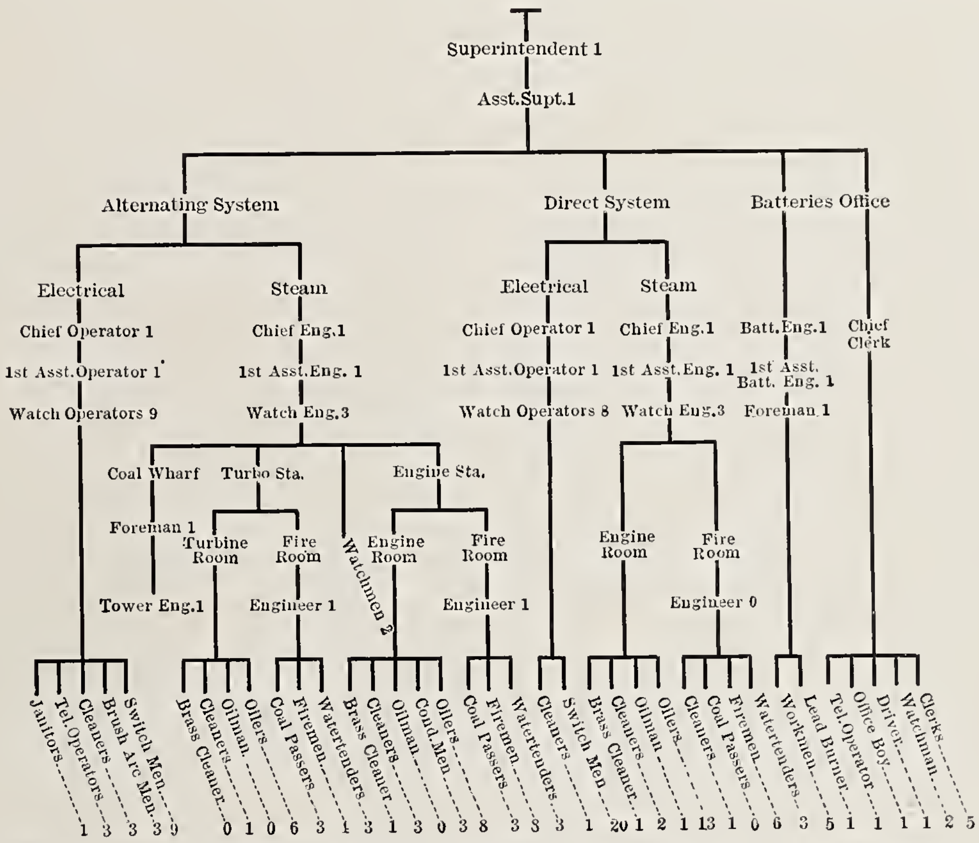
Under the head of "Generating," a department will be dealt with that contemplates the expense of operation and the repairs and renewals of all steam and electrical machinery and apparatus, including storage batteries, necessary to generate and deliver the output of the generating system to the busses and switchboards, the necessary distribution from sub-stations, including, of course, all labor, from the head of department to the errand boy on the office end, from the chief engineer to the coal passers on the steam end, from the chief operator to the cleaners on the electrical end, and the battery engineer, his assistants and workmen. When the total charges are made at the end of the month and are divided by the kilowatts generated, we shall have the legitimate generating cost per kilowatt, so far as an organization for that purpose is concerned. There may be other charges made against the department, but they are not made by reason of being directly connected with that portion of the total system. It may be well to say at this time that the Boston Edison generating department organization is made up as shown in the diagram on this page.

Having seen what the organization seems like on paper, we will follow down the line, beginning with the

STEAM DIVISION

The chief engineer of the steam system is, of course, totally responsible to the head of the department or his representative for the good and economical operation of that system; and in order to be able to assume that responsibility in a manner favorable to the company's interest, and with success for himself, he must have among his various accomplishments a few which are extremely important.

We will assume that he came to us with the necessary license, that he has had a good and varied experience with steam engines and auxiliaries and is a first-class mechanic. Perhaps we know him by reason of his having been employed on a near-by system for some time. If this be the case, we have had the opportunity to see what kind of an organizer he is, what his judgment is in the hiring of men, whether he has the ability to maintain discipline among his men and takes an interest in knowing whether or not it is maintained, and whether he plans the work of his system and passes his orders to his first assistant, to be passed by him down the line, in such a way as to avoid the bad complications caused by conflicting orders given by himself and his first assistant to a watch engineer, or to others of his organization. We can see whether he has favorites among his men by reason of earlier acquaintance with them; if he has and it is apparent, we know there is trouble ahead. We can see what his inclination is when the load is going at the beginning of the summer and the pay-roll will stand a reduction, not in the rate of wages, but in number of men employed. We can see whether or not he has the "hustle and push" to put the system on its feet and keep it there, without having to be reminded that it is for that purpose that he is drawing his salary. We can see also whether or not he takes a keen interest in matters to such a degree that if he does not hear from certain items in his



ORGANIZATION OF THE GENERATING SYSTEM AT THE STATIONS OF THE EDISON ELECTRIC ILLUMINATING COMPANY, OF BOSTON

Output for January, 1905: 6,207,100 K. W. H.

Total men in 3 power houses.	141
Total men in 9 sub-stations...	31
Total men in service...	172

system he will go after them, and not take it for granted that they are all right or he would have heard from them.

If arguments arise between any of the men and their superiors, does he act absolutely on his best judgment, or does he allow it to be warped because the man who is in trouble with his watch engineer is an old man—not in years, but on the system—and he thinks that man can not do wrong? If he does favor the man at such a time and the man has done something irregular he will make the mistake of all his time on that system, with reference to discipline and organization. He will regret that decision for a long time to come, for then and there the man in the ranks practically becomes licensed to disobey his superior next above him, and that fact is very soon known among the men in his and other lines of work on the steam system; the watch engineer is thereafter ignored to a degree by the men over whom he is in charge, and he is not to blame if he leaves his position, rather than lose the reputation that he may have earned by his ability to work his watch successfully and to the interest of his employer.

It is the business, and a valuable part of the business, of the chief engineer to administer such cases in a manner that is just to all concerned, from the interests of his employer down to the interest of the man who was disobedient, and also in such a manner as will preserve the dignity of his position and, at the same time, by reason of just decisions, retain the respect of his whole organization. He should administer justice without fear or favor, and while the way may be rough for a while it will assuredly smooth itself in due season; and what could be more satisfactory to the head of the steam division than the positive assurance that his assistants and men were working in harmony for their own interest, for his interest and for the interest of their employers?

The writer claims that if the head of a steam division has not the ability to take care of these matters on these lines the organization will be far from satisfactory from the standpoint of good service and economy. Almost any chief engineer can continue to hire and discharge men at short intervals and claim that as his only alternative; but if he does, it is a loss to his employers.

FIRST ASSISTANT ENGINEER

The engine-room is in the immediate charge of the first assistant engineer, who directs all of the work from orders given him by the chief engineer. As he, of course, cannot be on watch more than the regular hours, unless in case of emergency, the orders are transmitted by him to the watch engineers, and in absence of the chief engineer these men have, in their consecutive order, absolute control over every piece of steam apparatus and the appurtenances thereto, from the ends of the crank shafts to the outer end of the circulating water intake, including all labor incident to steam operation.

The first assistant and his watch engineers are busy men,—busy, because, if they are not, they are in the wrong place, for on these men we place secondarily the responsibility of the steam apparatus and its operation. The first assistant is especially held responsible for economy of operation, both in labor and material, of the steam system. He must notice and report to his chief any repairs needed, whether large or small, whether it be the keying of cranks or wrists, opening of cylinders, adjustment of pistons, packing leaky valves or glands, leaky steam lines, whether they be mains or drips; he must look after the water lines, the proper working of the air and circulating pumps, the condensers and canals, the undue consumption of cylinder or engine oil and waste, the oil system, and also, incidentally (although he has a watch engineer in charge under him), must notice and criticise the number of boilers in line to operate the number of engines in service when using certain grades of fuel; in fact, it is required that he be a man who can think quickly and not take too much time to execute. He must be thoroughly conversant with every line of steam and water pipe, every valve and its use, and what will probably occur if they are misused.

It is his duty to instruct all of the men under his charge in the working of every piece of apparatus in the steam system, and if he is found to have an inclination to dispense only such information as is absolutely necessary for his men to operate with, with an idea that he knows the system as no other man does, and he thereby hopes to insure his position more permanently, he is not the man for the place, because he is working for his own interest especially and incidentally only for that of the company. On the other hand, he should make especial efforts to have every man under him thoroughly conversant with the system: first, because it is for the best interests of his employers; second, because in a way it will lighten his own labors; third, he will receive the credit due from his men, and those men will appreciate his efforts to place them aright in their work; and, last of all, his chief will appreciate the fact that he knows how to work his men and produce results that the company is looking for, and this without discontent in the ranks.

Again, there are cases of emergency when the first assistant is required to work overtime, and so must his watch engineers as well, and their men, and here the treatment of the men should be thought of. If they are working by the hour and are allowed overtime they will probably be satisfied; if they are working by the week and don't get overtime, but do get a number of days off with salary each year, they may feel that they are losing something by reason of such emergency. In such an emergency the instructions are to see that the men are well fed and that they are given such reasonable time to recuperate as the load demands on the system will admit. It may be said that with this latter method there is no difficulty.

WATCH ENGINEERS

Of the watch engineers we must require as nearly as possible the duties of the first assistant, with the addition that the orders of the latter, as to work to be done during the hours he is absent, are to be strictly obeyed, and the results must show favorably when he again appears on watch. It is in these cases particularly that good discipline among heads of divisions shows itself prominently, and if it does not exist, the repairs on apparatus will fall behind, and little by little we shall begin to find the system in a bad position and one from which it means hard work and long hours to get back into line.

THE OILERS

The oilers come next in line in the engine room, and on these men we rely to keep the engines in operation after once started and to know absolutely that the large number of oil feeders and grease cups found today on reciprocating engines are in proper operation. An oiler must give immediate notice to the watch engineer of any irregularity in the operation of his machine; he must see that he is using enough oil, and not more than enough, and when his machine goes off the line he must wipe it up and clean it ready for the next run. These men are important in their positions, whether the title implies it or not, for power stations, unlike steamboats, cannot afford to shut down to cool hot bearings, nor can we afford to let the customers drift, as the commander might let the ship drift at sea if emergency occurred and weather and sea room were favorable.

The writer considers an oiler important when the question of hiring men comes up in the fall and loses no opportunity to take the name and address of all men who have had experience in that line, finding such a list very useful when the fall load begins to appear.

We should, and on the Boston system we do, pay oilers who can oil an engine properly one rate of wages, and that only to such men as are competent to run the pumps when required; and with beginners on the system we practice the method of moving them along and higher in the matter of wages as they grow more proficient in the work, and lose no proper opportunity to show them that proficiency is the one thing most needful, and that such an acquirement, together with a strict observance of orders from their watch engineers, will lead them to acquire the maximum wages paid for that line of labor.

The cleaners come last in the line of engine room labor, for in the matter of repairs the first assistant and such oilers as are at his command take care of such repairs as can be properly done in the station, while heavy repairs, or those that require machine work, are done by contract by outside parties, the writer's experience being that this is the least expensive method.

The cleaners should be in evidence in every well-regulated power house, for the reason that in these days of modern buildings and machinery, nothing detracts from the appearance of an engine room more than filth. In the writer's opinion, when we consider the vast number of customers we serve and the prospective customers who visit our power houses by virtue of passes given them from our general offices, we can afford to keep our stations clean and add to our reputation in worth more than the cost amounts to. More than this, the cleaner is a general-utility man; he is useful at a great many times when another man or two must be had, and in case of emergency we can, under the eye of the watch engineer, have him oil an engine or do other work not properly in his line.

THE BOILER ROOM

We can now take up the operation of the boiler room, that portion of the system which can be so handled as to assist greatly in paying dividends, and to be largely the means of passing one, especially if the coal supply is uncertain as to quantity and quality, for in this latter case we must necessarily save at every other point in order partially to make good such deficiency. Therefore let us at once have the fire room in charge of a competent man whose immediate superior is the engineer on watch. We need a man for this place who carries a first-class engineer's license; one who has had experience in the engine room and thus understands practically how the load rises and falls; one who will keep in touch with the watch engineer and realize that it is absolutely necessary that he does keep in touch with that man and know as far ahead of the time as possible what his future needs will be.

We need in this man ability to supervise repairs of all kinds in the boiler room, including boilers, pumps, headers, leads, valves, furnace brickwork, grates and all other items in that part of the system. We want him also to be a man of sterling worth in the handling and judging of men. We want him to realize that a fireman is a man, and, as such, is entitled to proper treatment at all times. We want him to have ability to judge whether or not a little encouragement will bring out the best efforts of the man, or whether it is necessary in order to obtain such efforts to place the man strictly on the line and make him understand what results he must obtain if he stays on the pay-roll. We want him to be obedient to his superior and be able when he goes off watch to have his work laid out to cover the time until he again appears; such a man should receive the same salary as a watch engineer, not because he ranks as high in the line, but because he can earn the money.

THE WATER TENDERS

Next come the water tenders, who are in charge of the fire room watches when the foreman is off watch and who, in such periods, are immediately responsible to the watch engineers, and have a quota of firemen under their charge, as well as all other men of the fire-room force. The water tender may be apparently perfectly competent to occupy his position by reason of his coming to you with a proper license and a long list of recommendations from former employers, but the question will arise as to whether he will fill his proposed position as follows:—

Will he pay strict attention to the instructions given him by the foreman of the fire room, or the watch engineer, if that man be in charge, as to the probable demand for steam; does he watch his boiler feed and regulate his boiler feed-water apparatus so that with a heavy demand he is not caught with water too low, and then when absolutely obliged put in water in larger quantities than usual, causing his firemen to do some very heavy work and probably some uneconomical firing, a few repetitions of which will cause complaint and dicontent among his men? And, from the other point, does he pay attention to the decreasing load and work the water up to the proper point, and go along the line and watch the depth of the fires, and instruct his men, as per his instructions from the watch engineer, that the load is "going," and to avail themselves of the opportunity to clean fires, to fire light, or bank, or both?

Does he watch the steam leaks within the limits of his portion of the boiler room, and does he see the small repairs needed and report them to the engineer of the watch, even though he feels sure that the engineer knows of those matters? And, finally, has he the interests of the company in view? If he does not properly deal with these items he is not the kind of water tender we want, no matter what his ability actually is. It is extremely important that the watch engineer take particular notice of the water tender, not only as to his ability to perform his proper duties, but also as to his inclinations, and report to his superior if the man is delinquent in any way.

THE FIREMEN

The firemen are those of the force whom we must select with care, for the type we need must have had experience, and must have judgment and be reliable. That is to say, we cannot afford to have a man with us who is afflicted with pay-day sickness. We want him eight hours a day seven days a week. We want men who will obey the instructions given them by their superiors, and who are free from connection with any organization that would interfere with men that are getting satisfactory wages and treatment and are contented. We want men who, when occasion requires, will hand-fire 2000 pounds of coal an hour, and do so for several hours, if necessary. We want men who will burn coal, 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—two items which should be uniform throughout the fire-room; by this is meant that all first-class licensed firemen should receive the same wages, not because a man comes to you with a license, nor because he claims he is first-class, but he should go on the pay roll at your stated rate for first-class men in his line, and it is for the water tender, or other higher authority, to determine in the first few days whether or not the man can substantiate his claim. If it is found, after due trial, that he cannot perform his portion of the work, then he is not entitled to the rate of wages that the others are who can. Shall we then tell him that he must work for less wages? No, but rather take him off the pay-roll and tell him, in a proper manner, why he is taken off, and at the same time eliminate any chance for the others to argue on different rates of wages and the comparison of abilities. In other words, we do not want a new man to come on the pay-roll and stay there unless he can handle the work as well and to the same amount as his fellows, and we want but one rate of wages for firemen, and that a fair one, and the man who proposes to earn that rate must be equal in ability to any who are classed under the rate.

As to the treatment of the men as a whole, the writer has learned by experience that a small amount of favoritism made apparent in the fire room can and will cause discontent and a tendency to avoid the regular amount of work due to be performed by each man, because an idea is harbored to the effect that the other fellow is having an easier time; as, for instance, a water tender may so conduct his watch as to make the following watch clean fires when his watch should have done it, which entails on the men following a larger amount of work than they should perform, and also causes the latter to use an amount of coal not in proper comparison with the load on the system during the time they are handling the fires. Such matters should result in a hasty but nevertheless thorough investigation, the facts should be gotten at, and those guilty of such practice should receive positive assurance of what would happen if a repetition should occur.

In Boston, fire rooms are operated as closely as is possible on this basis, and no trouble is found in placing first-class help in this line in front of the fires. Good men go off the payroll in the spring, when the load falls off, who leave with good feeling, and by early autumn many of them are back again looking for their old jobs, as they know by experience when the load begins to rise and more men are required.

THE COAL PASSERS

Last among the men classed as boiler-room help come the coal passers. On these men we depend not only for handling coal, but for the cleanliness of the room, and although it is a hard place to keep clean, it can be done to a degree that is eminently satisfactory to all who enter it. 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.

THE ELECTRICAL DIVISION

We can now take up the other half of the system, so to speak, or the electrical portion. This part of the organization is divided into six parts, as the classification diagram shows. We depend on this portion of the labor system for many important items of operation, the most important of which are: first, a uniform pressure at the feeder terminals throughout the entire system; second, the proper and economical loading of machinery under the charge of the division; and, third, the welfare of all electrical machinery, which must be, so far as possible, always ready for operation.

All repairs, except minor ones, in the division are done by outside parties. With the modern stations of to-day, operating, lighting and stationary motors and other low-tension apparatus, and at the same time delivering alternating current to substations, there is involved a vast amount of apparatus, due to the fact that we must have as much flexibility as possible. We must also have several ways of attaining the same result as to the delivery of current, in order to safeguard our customers against interruption of service and, incidentally, preserve our reputation for being a reliable concern to deal with.

It follows then that we need in a chief operator a man who is absolutely reliable, preferably one who has come up from the ranks and has long since become acquainted with the practical side of operation, one who realizes and instills into the minds of his assistant and men that one of their most important duties is so to manipulate the load with reference to machines to be operated that all units will be loaded to just as near the most economical operating point as it is possible to have them under the existing conditions. He must at all times be in close touch with the chief engineer and, so far as possible, give the steam division advance notice of his probable demand for steam units, thereby giving everybody a chance to be ready, and giving the customer the opportunity to verify our claim that we are at all times ready to supply current. Above all other things, he must use good judgment in the selection of his men and the treatment of them, and must conduct his division in a manner that will not only produce satisfactory service, but will be conducive to contentment among his men and will secure for himself their confidence and respect, which once secured and properly held will be a large factor in maintaining what is as nearly as possible ideal operation.

He should always follow the system of hiring new men at the lower end of the line, moving those who have acquired a degree of proficiency along to a proper position in accordance with such proficiency, thereby giving them the encouragement of understanding that the greater their proficiency the more valuable their services will become to the company, up to a certain limit in that line of work.

ASSISTANT OPERATOR

The assistant to the chief operator must be a man who can assist his superior, and to that end he must be thoroughly familiar with all of the electrical apparatus in the division. He must be able to occupy the position of the chief operator when necessary; in fact, he must be a first-class understudy, and must realize the fact, too, or he will lose to some degree the sense of his responsibility. He should visit the sub-stations and correct and report any irregularity noticed in machines or operators; in fact, he should keep his superior constantly in touch with such details as do not come immediately under the notice of the chief operator, and in cases of emergency should come at once to the station and be ready to assist if needed.

The assistant should also be extremely careful in the placing of his orders with the men, and in matters outside of absolute routine should place no orders without the consent of his superior; many mistakes are avoided if every one concerned is conversant with what is to be done, and with the available means of communication in these days, not much time need be lost in giving notice.

WATCH OPERATOR

The heads of watches should be, and necessarily are, men who have come up the line and who understand all the electrical combinations that can be made with machines, switches and lines throughout the system; if they are not, they should not occupy that position, nor should they in any case until we know by actual experience that they have the ability.

To these men the highest wages in the division are paid, with the exception of those of the chief operator and his assistant, and they are uniform in all power stations of the system. By this method of making men fit the position before they occupy it, the desired ability is secured, after it has been proven beyond doubt by a previous practical experience.

It is, in the writer's opinion, a serious mistake to class men alike for the sole reason that they have worked practically side by side on the system for a period of time. Pay the man for what he can deliver to you in brains or manual labor equivalent. It is admitted that the man who cannot deliver the first-named portion of a workingman's capital, and won't deliver the last item, may conclude to get off the pay-roll and identify himself with some organization or other which may demand that all of its members receive the same wages. If he does this, it is his affair; but we cannot afford to pay the same price for ignorance and neglect that we can for ability, aided by push and a desire for further knowledge. In making this statement no reflection is cast on a man who may have less ability than others; it is made from a purely business point of view. The chief operator when hiring men should be particular to move along the best ones, and be still more particular when he takes in his green workmen to observe to the best of his ability, and satisfy himself thereby, of the apparent future value of the men.

This is the proper method to adopt in order to keep the organization up to standard; that is to say, it is the proper beginning. Let it extend down to the end of the line, even to the cleaners, for there are good cleaners and bad ones, especially on electrical machinery.

STORAGE-BATTERY DIVISION

Of the organization to operate storage batteries, the writer believes that the cheapest man to have at the head is one who is both technical and practical in that line of work, and that he should be possessed of the same qualifications as are necessary in other heads of divisions with reference to handling men; but there is this to add, that it is seldom that men will work in the general line of storage-battery repairs for any considerable length of time, in that such work is not of the sort that attracts the average man, and they do not stay long enough to actually show of what value they might be after a reasonable period of service.

HEAD OF DEPARTMENT

The writer has refrained from speaking of the head of the generating system and the assistant to that person, for the reason that it seemed proper to look over what there was in the nature of organization and operation that the head and his assistant were called upon to look after. The head of the department has the very important responsibility of the organization of his department. If that be correct, or as nearly so as conditions will permit, the operating responsibility, broadly speaking, will not seem as serious to the head of the department as it would under the more unfavorable condition of lax discipline in the handling of heads of divisions and men who have severally decided that the head of the department is in his position for the sole purpose of bearing his title instead of directing the operation of the generating system. He should not only pass his orders on operation to his assistant, but in addition should see to it that they are carried out. He should carefully observe the result, and be ready to devise, if possible, methods of saving to his several accounts, as the total of these will represent his total generating cost.

He should not, however, overdo the looking after of small details, because he has an assistant and several heads of divisions, who occupy positions and are paid salaries for the purpose of looking out for that portion of the business, and if they don't do it and relieve him in that direction, then either the organization or the discipline, or both, are not correct. It is absolutely useless for him to expect to proceed on a successful basis until his own error, whether caused by neglect, or otherwise, is corrected, and his people understand in a thorough manner that the head of the department is there to direct its operation.

The head of the department should also keep in touch with the intentions of his heads of divisions relative to their hiring of men, and not only confer with them in a general way on such matters, but lay down a rule that men connected in any way with matters detrimental to the interests of the corporation should not be hired in any event. He should include in such a rule a stipulation that if men of such type get inside the organization, notwithstanding proper precaution has been taken, they should be relieved from further connection with the department at once and be replaced by men of a different class.

The writer has found by years of experience that to pay one line of work a standard wage, whether it be lower or higher than the so-called "union" scale, is productive of more contentment and better sentiment toward the employer than anything else; but in order to do this consistently we must, as mentioned before, be careful to select a class of men who are very nearly alike with reference to the amount and quality of work which they can perform. Such a thing can be done easily, as actual experience has proved.

It does not seem necessary to say that the head of the department should not absent himself from the system or from his office for any length of time without giving notice where he can be found in case of emergency, and the assistant and heads of divisions should be required to observe the same rule; for while such a rule may seem to be somewhat of a hardship at first, on second thought we can easily imagine cases where it would be most unfortunate not to be able to avail oneself of the services of one of the best men in his department just because one is unable to locate him; and, besides, such a rule removes any chance of inference being drawn which might be detrimental to the man.

The head of the department has at times to go farther than his office to get at the reason of the rise in some account which seems abnormal. He must, after exhausting other methods, simply get in and dig it out, get the reason, and see if it is a proper one, and if not, apply the remedy. If the reason is proper he is entitled to rest content, because he has assured himself that the rise in the account is not the result of reckless expenditure; if he finds a poor reason, he will strengthen his organization by taking the matter up with the proper person and going into it in a manner that cannot be misunderstood, and show where it is to the advantage of all concerned to make that expense nearer the proper amount.

It sometimes happens that difficulty occurs between some of the men and their superior, in which the man from the ranks feels that he has been misused, that his superior has been too hard on him because his advantage of position has given him the privilege. In such cases, after the man has taken his trouble to the chief of his division and even then feels that he has a grievance, it is good policy to allow him to see the head of the department as a last resort, and for the head to call in all persons concerned at one time and hear the several stories, one at a time, and decide the matter. Of course, if the superior has used his position properly there can be but one result; if he has not, and you have to decide that the man is not to blame, then be sure you have that man understand beyond a doubt that he cannot and must not mistake a just decision for a license to disobey in the future, but that he is bound to work for and obey the same superior, just as much as he was previous to the time when the difficulty occurred.

It therefore seems that there are a good many places where the head of the department can put in his services and benefit the organization, and if he can find the necessary time to walk out and through his system, even though he does not speak at all, no doubt he can see spots that will bear criticism, and it is for him to note them and apply the remedy.

For the head of a department to say to himself, "We are now organized and operating satisfactorily, there is nothing more in that line at present," is a rash statement even to himself, as he will soon find out if he does not watch what he has tried to put together so carefully. To watch the organization, and constantly, too, is what is in a large degree necessary to the attainment of a low cost per kilowatt-hour.

ASSISTANT HEAD OF DEPARTMENT

To the assistant to the head of the department we will assign the duty of placing with the heads of the several divisions the orders given by the head of the department. We will ask him to see that the electrical instruments, steam gauges and all other indicating apparatus, are kept at the proper standard, to know whether the engines have been indicated, to keep in touch with the load and the time of demand at its highest point and its lowest point as well, and thereby be enabled to suggest the advisability of changing the load from one station to another, with a view to obtaining the best economy possible with the fuel and water consumed and the expenditure for labor, to check the amounts of fuel consumed, to check and comment on the grade of fuel and kick on the quality if necessary.

The assistant to the head of the department must necessarily be a man of technical ability and be able to take up the items heretofore set forth on that basis; for among the many small items, which when taken as a whole tend to lower the economy of operation, there are usually many that require analysis, which calls for the services of a man who is well versed in technicalities, and who can get down to the bottom facts of such matters easily and quickly and open the way to apply the proper remedy.

He will also act for the head of the department in his absence, and follow closely and report any irregularities in operation or machinery or labor; and it is the duty of the head of the department to invest his assistant with such authority as will enable him to perform such duties in a clear and intelligent manner, with the only stipulation that his treatment of all the parties concerned shall be of a kind that will stimulate good feeling in the department and at the same time not interfere in any manner with good discipline.

In fact, the duties of the assistant to the head of the department are manifold, and of great value if properly performed. He is in his position the second in the amount of responsibility taken, and should most fully realize it and endeavor to protect that position with his ability to look into the future far enough to warrant that the service of the company will not suffer and that the expenditure made to manufacture the output will be as low as is consistent with good service and operation.

In the foregoing matter the writer has endeavored to give an outline of the generating department organization of the Boston Edison Company. Whatever success has been attained in this direction has been due to efforts to secure a close and constant co-operation throughout the department, and to the maintaining of a discipline which has been necessary and warrantable, but which has been established and maintained with justice and tempered by kindness. In other words, there has been the disposition on the part of the company and of the department to show every employee that his position had a value both to the company and to himself, to show that the value of the position to the employee was what the employee himself could make it, aided by the counsel and instruction of the superior who held his services in immediate charge, and to show that by paying a uniform rate of wages for a uniform quality and quantity of labor in every line, the company has adopted a treatment of its men conducive to contentment, and are reasonable in assuming and expecting it.

A Train-Lighting Turbo-Generator

AN interesting piece of machinery shown by the General Electric Company at the recent American Railway Appliance Exhibition at Washington was a direct-connected turbo-generator set for train lighting. The machine consisted of a 15 K. W., 2-pole, 80-volt generator driven by a Curtis steam turbine at a normal speed of 4000 revolutions per minute. It is designed to be placed in a baggage car and to receive its steam supply from the locomotive boiler. The floor space of the set, as measured, was only 22 inches by 66 inches, or about 10 square feet. This means but 0.67 square feet per kilowatt capacity,—an interesting figure for so small a unit.

In view of the exceedingly high speed, 66 2-3 revolutions per second, the commutator construction was unusually rigid, a binding ring being fastened to the commutator at its middle points, concentric with the shaft, to assist in holding the segments in place under the centrifugal strains. The steam turbine was designed to run non-condensing at 160 pounds boiler pressure.

The advantage of the baggage car set over the individual car equipment of a dynamo driven from the axle is claimed to lie in the greater simplicity of the former. A single storage battery in the baggage car will easily supplement the turbo-generator at times when the locomotive is disconnected from the train. The 15 K. W. set will supply current for the lighting of from 8 to 10 Pullmans without difficulty.

An insulated helmet for divers, says "The Marine Journal," is being made for the United States Navy Department. This helmet is to be used where electric eels are numerous, as the electric shock which these eels are able to give to a diver is strong enough to make him insensible when it is transmitted through any exposed metal part of his armor.

Artificial Illumination.—I

By DR. EDWIN JAMES HOUSTON

IT needs no argument to prove that the nearer any artificial light comes to sunlight, the better will it be able to compete with the sun as a source of illumination. The human eye has been developed during the extended existence of man entirely along the lines of solar illumination. Any marked departure in the properties of an artificial light from those of daylight must result in a greater or less injury to the delicate structure of the eye, and consequent impossibility of correct vision. It is, therefore, a matter of importance that the characteristics of daylight illumination be carefully examined. Some of the principal of these characteristics are:—

1. General Diffusion.—From the immense size of the sun, the illumination it produces is necessarily surface illumination, as distinguished from point illumination. There is, therefore, an absence of the sharply marked shadows that characterize point illumination. In the case of a room, for example, the light not only enters the windows, but is diffused from the walls, ceilings and all other objects on to all the objects in the room. Where the coverings of ceiling and walls, and curtains, draperies, furniture and carpets are not of such a nature as to absorb the greater percentage of the light, an ideal condition of illumination exists—the surfaces of all objects in the room become a series of luminous points that diffuse in all didirections light differing both in intensity and color, thus permitting the different objects to become distinctly visible to the eye, while, at the same time, acting themselves as luminous sources, throwing light on all other objects in their neighborhood.

2. Almost Absolute Steadiness.—Except where there are rapidly moving clouds in a clear sky, sunlight is characterized by absolute steadiness. The irregular flickering that is so characteristic of such sources of illumination as the gaslight and the electric arc light is entirely absent in sunlight. The eye is, consequently, capable of closely examining the minute details of color and shape of near objects, without being exposed to those rapid fluctuations in the intensity and amount of illumination that are so wearying even to a healthy eye.

3. The Position of the Source of Illumination.—The position of the sun in the heavens is such that its light is unable,—except near the hours of sunrise or sunset, when its intensity is comparatively low,—to directly enter the eye, unless the observer gazes directly at the sun or stands where the directly reflected light is thrown into his eyes. It is a matter of great importance, in order to obtain sharp pictures of objects, that none of the direct rays from the light source shall enter the eye of the observer. In the case of sunlight, this condition is readily met by the fact that the general diffused light from the lighted objects can readily enter the eye of the observer without his directing the eye towards the direct source of illumination.

4. A White and Uncolored Light.—Sunlight, as seen in the solar spectrum, consists of an assemblage of colored rays, extending from reds to violets. These produce a combined effect on the eye that is ordinarily called white light, which is, so to speak, the light with which the eye has been accustomed to view objects. The absence of distinct coloration may, therefore, be regarded as one of the most marked peculiarities of sunlight. Except for the presence of a slight yellowish tinge, sunlight is colorless. This is not true of any artificial light that has so far been produced, though perhaps the arc light comes nearest to sunlight in its color values.

5. The Absence of Contaminating Influence on the Air Surrounding the Luminous Source.—Many of the ordinary sources of illumination, such, for example, as oil light or gaslight, contaminate the surrounding air by the products of combustion. Such contamination is necessarily absent in the case of sunlight and in such enclosed lights as the incandescent electric lamp. Sunlight, moreover, possesses, as is well known, marked powers as a bactericide or germicide.

6. Actinic Powers, or Powers of Producing Chemical Decomposition.—Such powers are markedly present in the case of sunlight, not only in the violet and blue rays, on the action of which photography is based, but also in those rays towards the red end of the spectrum, which are so efficient in effecting the chemical decomposition of the carbon dioxide that enables plants to obtain their woody tissue directly from the atmosphere.

Recent investigations show that an actual bleaching occurs in the photochemical substance of a purplish-red color called visual purple or rhodopsin which is contained in the retina.

This bleaching requires the actual presence of light, and varies markedly with the different colors of light. It is by the bleaching of the rhodopsin that an optogram or visible picture of the images falling on the retina is produced; this makes the eye momentarily unsuited for further use, the retina requiring that a regeneration shall take place, *i. e.*, that the purple color shall be restored. The time required both for the bleaching and for the regeneration varies with the color of the light as well as with its intensity. It is generally believed that the existence of optograms, or visible pictures of retinal images, is necessary for vision. While it has not yet been ascertained just how the decomposition of the visual purple produces the perception of the image by the brain, yet this decomposition is believed to be necessary to such perception. The presence, therefore, in artificial light, of rays capable of producing this decomposition is necessary for the complete perception of the image.

As regards the influence of different colored lights on the bleaching of the rhodopsin, the red rays appear to possess the least. Yellow light exerts little influence. The most powerful action exists in the greenish blue portions of the spectrum. Good vision is practically impossible with monochromatic light—light of a single color.

But entirely apart from the production of optograms by the bleaching of the visual purple, in order properly to distinguish the particular colors of objects, all such colors must be present in the light with which they are illumined. The various bluish hues or tints, for example, cannot be properly recognized by the eye when the light is devoid of such blues, nor can the reds, yellows or other different colored rays be seen unless these rays be present. It is evident, therefore, that in order to obtain the true colors of natural objects, not only must any satisfactory artificial light possess all the different colored rays that exist in sunlight, but these rays should be present in the same relative proportions. This is practically impossible in the case of any artificial illuminant, although some closely approach sunlight.

The visual sensations produced on the eye by the action of light may be divided into three distinct groups:—

1. Sensations of Light, or the Differences that Exist in the Brightness of the Images as Perceived by the Brain.—These sensations vary in intensity from the deepest black, corresponding to the absence of all retinal stimulation, to the purest, brightest whites, corresponding to a stimulation by light possessing true daylight colors. Physically, differences in the sensations of light are due to the differences in the amplitude of the light waves, or, as it is called, to differences in the intensity of the waves.

2. Sensations of Color.—These differences include all the colors of the solar spectrum, from the reds to the violets. The sensations of color are capable of being differentiated under three heads:

a. Differences of hue or tone, due to differences in the wave lengths or the number of vibrations per second.

b. Differences of brightness or shade, due to differences in the amplitude or the intensity of the waves.

c. Differences of tint or saturation, due to differences in the complexity of the waves.

It has been roughly estimated that the human eye is capable of distinguishing at least 500,000 different light and color sensations.

Sensations of Form.—The form of the visual image is closely associated with the perception of space. Here the binocular vision, together with the movement of the two eyes, is the principal differentiating factor.

The character and nature of the sensations which follow the retinal stimulus depend on two factors,—the nature of the stimulus and the condition of the portion of the retina that has been stimulated.

"Each of these factors," says Schäfer,* "is complex, and consequently the character of the sensations may be influenced by many circumstances, including the nature of the previous stimulation of the retina, the size of the position of the area stimulated, the duration of the stimulus, and the rate at which individual stimuli succeed each other, the nature of the stimulant of other parts of the same retina, of the other retina, and even of other sense organs."

As a rule, too little attention has been paid in systems of artificial illumination to the physiological actions of that delicate organ which is to use such artificial light for the purposes of vision. It is not only necessary to obtain sources of light that are satisfactory as regards their intensity and color, but it is especially necessary to see that such sources shall be placed so that the distribution of the light shall be as nearly as possible that to which the eye is accustomed in daylight.

Nature appears to have especially provided means whereby the direct light of the sun shall not enter the eye of the observer except obliquely from above. The eye has so long been accustomed to the entrance of direct light in this manner only, that when sunlight finds its way into the eye obliquely from below, abnormal conditions of vision are apt to result. Snow blindness, for example, so common in the arctic regions when the sun shines in a clear sky, is probably not so much due to the unusual intensity of the light which is reflected from the snow directly into the eyes, as to the unusual direction in which such light enters.

Dr. Louis Bell† refers to the erroneous belief that the cause of the injury to the sight from the reflection of sunlight on snow is to be traced to the greater transparency of the lower eyelid than of the upper eyelid. He quotes the statement of a prominent oculist that the blacking of the lower eyelid so as to render it opaque to light will thoroughly protect the eyes from all danger arising from snow blindness. Dr. Geo. M. Gould,‡ however, points out what may perhaps be taken as the true statement as to the way in which nature protects the eye from the entrance of direct light; this he believes is to be traced to the eyelashes, while, in addition, the eye is protected from the entrance of light in the direction in which most of the light would enter it, i. e., obliquely from above, by the additional safeguard of the eyebrows.

Before proceeding to discuss sources of artificial illumination and the best means for the distribution of the light they produce, it will be advisable to inquire briefly as to some points concerning the action of the receiving organ of such light—the human eye. As is well known, in order for any object to become distinctly visible, it is necessary that a picture of such object shall be sharply focussed by the eye, so that an image shall be formed on the delicate network of nerve fibers called the retina. The ability of these retinal images to correctly represent external objects as regards color, form and detailed structure will depend, not only on the manner in which such images are formed on the retina, but also on the condition of the retina itself as regards past images. There are two facts that should be constantly kept in mind in connection with this:—

1. That the retina is capable of maintaining its high condition of sensibility for the reception and transmission of its images to the brain for a few seconds only.

2. That periods of rest must alternate with the periods of activity in order to permit the retina to regain its sensitiveness. For this reason the light stimulus must be changed in its intensity every few seconds. As Dr. Geo. M. Gould* has pointed out, there are no less than twelve distinct methods, consisting generally in shadings of the retina and variations in the stimulus, that are employed for the purpose of permitting the human eye to regain its sensitiveness. He enumerates these as follows:—

1. The constantly shifting and modified shadows that are cast by the retinal arteries, veins and capillaries by reason of the varying direction and intensity of the entering light, the most deeply shaded parts probably serving as centers from which the sensitizing process extends.

2. The reflections of light from the blood corpuscles of the capillaries of the retina acting as minute mirrors, and so throwing off numerous darting points of light to all portions of the retina, thus casting slight shadows of themselves on the retina, and permitting the restoration of sensitiveness.

3. The shadows of the black spots known as *muscæ volitantes*, which should be recognized as possessing physiological rather than pathological significance, and which are probably of marked value in permitting the retina to regain its sensitiveness.

4. The presence of a retinal pigment extending so far towards the periphery of the retina as to prevent the entrance of all light into the eye except that which passes through the pupil.

5. The opaque coloration of the iris, thus ensuring a shadowing of the retina.

6. The automatic contraction and dilatation of the pupil of the eye under variations in the light stimuli.

7. The pigmentation of the skin resulting in the partial opacity of the eyelids.

8. The shielding action of the eyelashes.

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* "Text Book of Physiology," Dr. E. A. Schäfer, Vol. 2, page 1052. MacMillan & Co., New York.

†"Art of Illumination," page 3. Dr. Louis Bell. New York, 1902.

‡"Biographic Clinics," P Blackistone, Son & Co., Philadelphia, 1903.

* "Biographic Clinics." Geo. M. Gould, M. D. P. Blackistone, Son & Co., Philadelphia.

9. The frequent winking of the eyes, which results in the complete shutting out of the retinal stimulus for a short time many thousands of times in a single day.

10. The existence of binocular vision, resulting in breaking up the continuance of the stimulus of the retina on any single spot.

11. The incessant movements of the eyes, as well as of the body and head, which cause the images to appear on different parts of the retina, and thus afford it an opportunity for recuperation.

12. The shadowing by the eyebrows. These afford especial protection from the direct entrance of the light from above obliquely downwards, as in the case of all ordinary sunlight.

But no matter how thoroughly artificial illumination supplies a light, the general properties of which are similar to those of ordinary daylight, unless the eyes themselves are in good condition, perfect vision for work is necessarily an impossibility. It is perhaps not going too far to say that a perfectly normal human eye is rare. An eminent oculist has expressed the opinion that a pair of perfectly normal eyes do not exist. If an eye that possesses even in a slight degree near-sightedness or astigmatism, or other numerous imperfections to which the eye is subject, attempts without the aid of glasses to perform work requiring close inspection, there must necessarily result, in a comparatively short time, a permanent injury to the eyes.

There exists, unfortunately, a false idea in many workshops and on many railroads that as soon as a workman begins to wear glasses his usefulness as a skilled worker is thereby greatly lessened. The falsity of this is self-evident. It is practically the same as stating that because such a workman insists on obtaining the best visual pictures of his work, such work, therefore, is necessarily less valuable than that of his fellow workman, who for fear his failing sight shall be discovered and lower his rating with his employers, persists in endeavoring to get along without the assistance which proper glasses would afford him. It would, I believe, prove to be a matter of greatest economy if all large shops would provide, without expense to their workmen, the services of competent oculists to systematically examine the eyes of the workmen and prepare for them, free of charge, the best glasses possible, since the increase in the quantity and quality of the work thus rendered possible would more than repay such firms for what might seem to be a comparatively lavish and needless expenditure of money.

It will be borne in mind in connection with this that the above recommendation refers to oculists,—the skilled practitioners, who are thoroughly capable of determining the condition of the eye and prescribing for its proper correction—and not to the optician, whose province should properly be limited to filling the prescriptions of the oculist.

From the standpoint of a layman, it has often occurred to the writer that too frequently considerable damage must be done to the eye from the use of improper glasses. The writer has in mind at the present time a statement made to him by an eminent oculist, who said that during one of the many world's fairs he examined a pair of glasses that had been prescribed for a near-sighted person by a firm of manufacturing opticians, in which one of the lenses was that necessary for the correction of near-sightedness, while the other was suitable only for a far-sighted patient. The use of such glasses would necessarily have ruined the eyes of the wearer had attention not been immediately called to the error.

Generally speaking, the object of all artificial illumination is to permit natural objects to be seen in the absence of sunlight, or, in other words, to turn the night into day. Necessarily, the character of the illumination required will depend on the nature of the place and the character of the work to be performed. In the theater and in public assembly halls generally the light is required mainly on the stage or on the platform. The actors must be strongly illumined so as to permit their features to be seen at a distance. The necessity for this direct illumination frequently results in considerable injury to their eyes. There is, indeed, comparatively little necessity for throwing much light on the main body of the audience. Indeed, in some cases, it is essential in order to ensure the best effects that the light shall be limited to the stage.

The ordinary illumination of a dwelling house is different. Here a general illumination is necessary, so as to permit all objects to be readily distinguished. Where steady work, such as reading or writing, is to be carried on, it is necessary that the light should be limited generally to the printed or written page. Here it is very essential that the only light which enters the eye is the diffused light which comes from the page.

The requirements for the illumination of a store are, in many respects, similar to those for the house. Here general illumination is necessary for the distant examination of the goods. In addition to this, however, some special arrangements should be made for the more thorough examination of goods by close inspection. Where such goods consist of dress materials, that are to be worn mainly at night

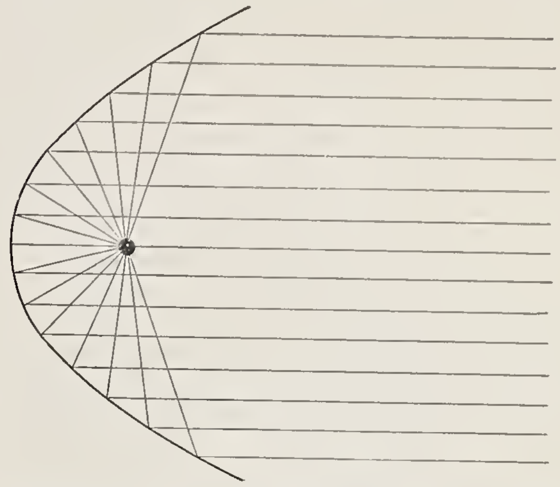


FIG. 1.—A PARABOLIC MIRROR, WITH THE SOURCE OF LIGHT PLACED AT THE FOCUS, THROWS OFF THE LIGHT IN PARALLEL RAYS

under artificial illumination, a separate room is generally provided so as to determine the true color values of such fabrics at night when the presence of all sunlight is excluded. In order that such examination shall be successful all daylight should be carefully excluded from the room in which the examination is made, the illumination being entirely either by the incandescent lamp, the arc light, the Welsbach gas mantle, or other lights that are in common use. In this manner the purchaser will be able to determine exactly the color values of the fabric under the light to which it is most apt to be exposed.

In stores where goods are placed

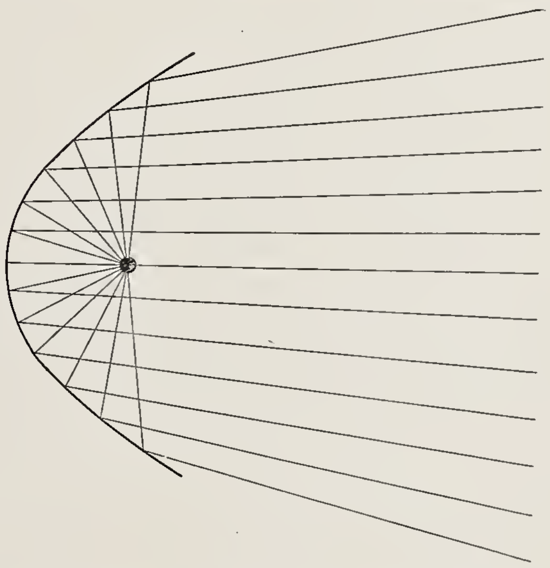


FIG. 2.—IN SEARCHLIGHTS IT IS NECESSARY TO ALTER THE PARABOLIC MIRROR SO AS TO GIVE THE RAYS A SLIGHT DIVERGENCE

in show cases, so that a fairly close examination can be made without subjecting the goods to damage consequent on careless handling, it is necessary that none of the direct light shall enter the eye of the observer. For this purpose the lights are generally placed in suitable reflectors that are supported on the upper side of the cases.

The principal requirements for the illumination of work are as follows:—

1. The work must receive the proper amount of illumination under such circumstances that no light whatever, except the diffused light from the work, shall enter the eye of the workman. This requirement includes two restrictions,—that all direct light from the luminous source be prevented from entering the eye of the workman, and also that no regularly reflected light shall enter his eyes from the object.

2. The amount of light entering the eye should be carefully regulated, so that it shall not exceed that required to produce distinct vision. Anything in excess of this amount will result in an unnecessary loss of sensibility to the retina, as well as in the necessity for too great intervals of time for restoring the sensitiveness of the retina. On the other hand, too feeble illumination will result in images too feeble to permit an examination of the details of the objects.

3. There should be uniformity in the illumination of the work.

If the intensity of illumination be much greater in certain parts of the work than in others, there will necessarily result the production of an imperfect image, since the unnecessary amount of light will not only rapidly render insensitive the portions of the retina on which the light actually falls, but a tendency will exist for the area of the insensitive regions to spread beyond the points that have actually received the excessive illumination. Any artificial illuminant, therefore, which produces marked alterations in the intensity of the illumination will make good work an impossibility.

4. The reproduction of the retinal images in the natural colors of the object,—which is possible only where the artificial light approximates true daylight in color values.

5. A cool light during summer weather is another requisite. In order to ensure the best work, it is necessary that the health of the workman be carefully preserved. If, as is the case with some artificial illuminants, a high temperature and a vitiated air result, good work will soon become an impossibility.

Let us suppose now that a satisfactory source of light has been provided for artificial illumination. The question will then arise as to the best manner in which the necessary scattering or diffusing of the artificial light shall be ensured so as to resemble ordinary daylight. This may be done in three different ways,—by regular reflection, by reflection and by diffusion.

By regular reflection is meant the throwing off of the light from the surfaces at angles that are equal and opposite to the angle at which the light strikes such surfaces. Generally speaking, the regular reflection should never be employed for scattering the light required for fine work. As is well known, light that is regularly reflected from a surface fails to render such a surface visible. In the case of a clean mirror the mirror itself remains invisible, the reflected light only serving to render visible the objects from which such light originates. It is only when the surface of the mirror becomes tarnished so as to permit it to diffuse or scatter the light in all directions that the mirror itself becomes visible.

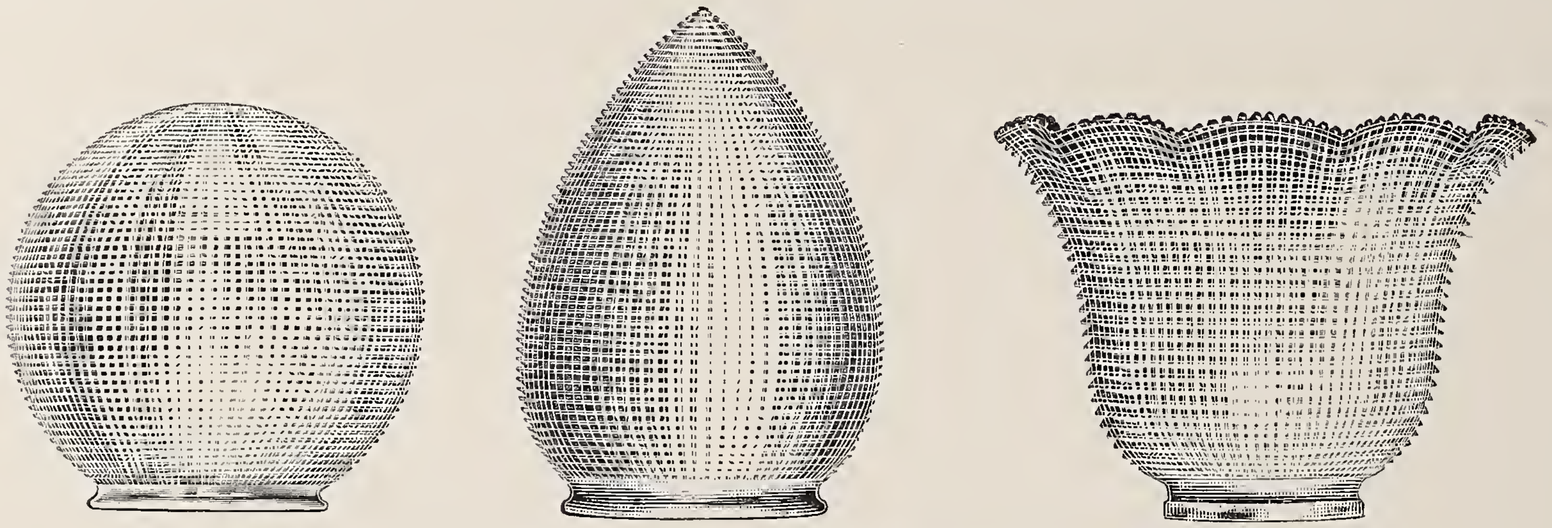


FIG. 3.—HOLOPHANE GLOBES, MADE BY THE HOLOPHANE GLASS COMPANY, NEW YORK

The evil effects produced by regularly reflected light from objects, the details of which are intended to be examined, are to be seen in the case of varnished maps hung up on the walls of school rooms or lecture halls, or blackboards the surfaces of which are formed of slate or other highly polished surfaces, on which various chalk marks are placed. As is well known, in certain positions none of the details of the map or the work on the blackboard are visible in certain parts of the room in which the regularly reflected light enters the eyes of the observer.

The same is true of the lighting of oil paintings which have been covered with a highly polished surface of varnish. The details of such pictures can be seen only in certain positions, while if the observer takes a position in which the light is regularly reflected from the surface, the details become practically invisible. An effort should be made to ensure the protective covering of varnish without a high polish, thus permitting the picture to be seen when viewed from any direction in front of it. Surrounding the picture by gilt frames that too frequently oppose a barrier of reflected light to its proper examination of the painting is also a serious mistake. As regards the illumination of objects that are at great distances from the source of light, it is necessary that reflectors be employed, since if the method of diffusion were employed there would be too great a decrease in the intensity

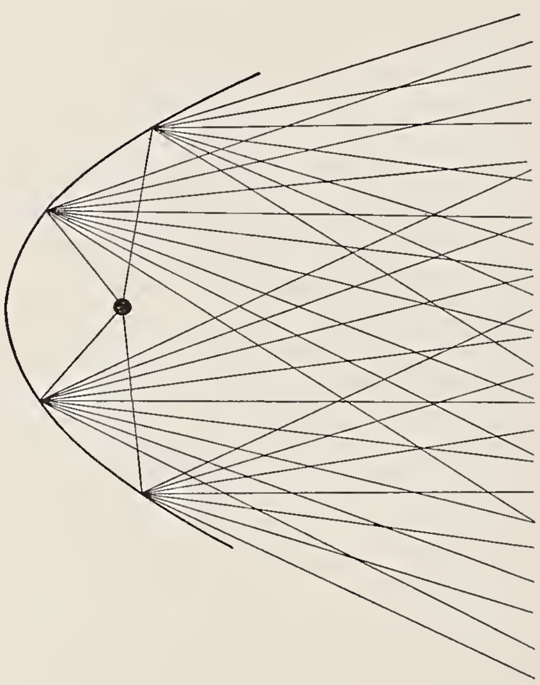


FIG. 4.—A PARABOLIC MIRROR COATED WITH FINELY DIVIDED ALUMINIUM SO AS TO SCATTER THE LIGHT IN ALL DIRECTIONS

from the light being scattered or thrown in all directions. In order to ensure as small a loss as possible, the source of light is placed at the principal focus of a parabolic reflector. Under these circumstances the light is thrown off from the surface in parallel rays as a beam of light, as shown in Fig. 1.

In order to decrease the loss of light by reflection, the surface of the reflector is made as smooth and highly polished as possible. With the best reflecting surface known, as in the case of highly polished silver, the coefficient of reflection, or the ratio between the intensities of the incident and the reflected light, is 0.92, while in the case of burnished copper it is as low as from 0.4 to 0.5.

In the case of searchlights, in order to increase the area of illumination beyond the area of aperture of the parabola, to which the illumination would be restricted were the rays maintained in an absolutely parallel direction, it is necessary in practice to give the rays a slight divergence, in this way covering a much larger area, as shown in Fig. 2. The amount of this divergence, however, must be kept within certain limits, since otherwise the decrease in the intensity of the rays would be so marked as to render them of comparatively small value.

In the case also of the parabolic reflector that is placed back of the headlight of a locomotive for the purpose of lighting the track, a slight divergence is given to the rays so as to ensure the illumination of an area wider than the track on which the car is moving. The same thing is also true of the tower system in the lighting of streets or grounds. Here, disregarding the great loss of light, a satisfactory general illumination is obtained, since absolute uniformity in the illumination is not a matter of importance.

For the illumination of public works, such, for example, as for excavations or for rough building at night, where a uniform illumination is not a matter of importance, large reflectors, for throwing the light downwards, are not objectionable.

The use of reflectors for throwing artificial light on near objects that require careful examination should, however, never be employed, since in such cases the necessity exists for ensuring a uniform illumination; for example, the use of a reflector hung over a work bench for the purpose of throwing light on the work is objectionable for this reason. Even in the case of the highly polished and true surfaces that are obtained in parabolic reflectors, the uniformity of the illumination is far from being marked. But when, as in the case of most of the reflectors in ordinary use,—ordinary silvered glass sheets or sheets of silvered mica—marked irregularities are produced that are known as caustics—variations in the intensity of the light produced by the irregularities in the reflecting surface acting as small mirrors, condensing the light in irregular patches. The presence of such irregularities can be readily seen by holding a sheet of white paper below any of the silvered glass or mica reflectors on the market. Under these circumstances the surface of the paper, instead of exhibiting a uniform illumination, will be seen to be marked by irregular, brightly illuminated curves that are separated by regions in which the illumination is more or less wanting. Such a method of scattering light must, therefore, be highly objectionable, since it fails to ensure that uniform illumination of the work which is a prime requisite for obtaining accurate vision.

The refraction of light is based on the fact that the rays of light are bent out of their course while passing from one medium to another of different density. Where the object requires powerful illumination, the increase in the intensity of the light may be obtained either by the use of suitable mirrors, or by refraction by the use of condensing lenses, as in the case of the microscope or of the projecting lantern. By the use of such lenses the light is focussed or collected on some limited region of the part that is to be examined. Such a method of illumination, however, is undesirable except in the case of microscopic or projection work.

The objections arising from this focussing or condensing of the light are removed by the use of the well-known "Holophane" globe. Here a source of light, say an incandescent electric lamp, is placed inside a hollow globe, as shown in Fig. 3, the surface of which is formed so as to take the shape of a central cylindrical lens, on each side of which segmental or prismatic rings or hoops are formed, the angles of which are so graded as to throw the principal portion of the light of the lamp downwards, thus preventing its dissipation and concentrating it on the work below. Apart from objections arising from the marked loss of light due to the difficulty of keeping the surfaces of the lenses clean from dirt, this method does not possess the advantage of preventing the direct light from entering the eye of the workman, and, therefore, is inconsistent with the best work.

In diffusion, or irregular reflection, the light falls on a surface that throws it off in all directions from each of its points. In other words, each point in the surface of the body becomes, to all intents and purposes, a luminous source, radiating light in all directions. By placing a source of light in front of a suitably shaped opaque body, the surfaces of which have been roughened by covering them with a finely divided material, such as aluminium paint, every one of those portions becomes a radiant point, throwing off light in all directions, while the passage of all light to the other side of the opaque body is absolutely prevented. Here there is mainly a condensing of the light on that side of the shade which is covered by the diffusing substance. If the material covering the shade consists of finely divided aluminium, surfaces illuminated by such a source of light will be characterized by marked uniformity in the intensity of the light. Under such circumstances the presence of shadows or points of unequal illumination would be impossible, since each point in such a surface of illumination scatters light in all directions. The impossibility of the presence of points of unequal illumination will be evident from an inspection of Fig. 4.

Here an ordinary incandescent electric lamp has been placed within a parabolic shade that has been covered with finely divided metallic aluminium. As will be seen from the drawing, each point in the surface throws off or diffuses light in all directions.

Municipal Electric Lighting in Chicago

CHICAGO, taken in the aggregate, says "The Western Electrician," of that city, has miserable street lighting. Mile after mile of streets are lighted by gas lamps, and these not even good of their kind. It is therefore ridiculous to talk of selling the surplus current of the municipal street lighting stations to commercial users. There is no surplus, but instead a great, yawning deficit. Let the streets be lighted properly before the city administration looks around for a market for the product of its arc lighting stations. All taxpayers share in the expense of the municipal plants, but only a minority have the benefit of electric street lights in their own neighborhoods. If from one modern plant current were sold for commercial use, this injustice would be still further accentuated.

A special Parliamentary committee is now at work in Canada investigating the telephone business with a view to deciding the question of municipal ownership.

Sign and Decorative Lighting

By LA RUE VREDENBURGH, of the Edison Electric Illuminating Co., of Boston

A Paper Read at the Convention of the National Electric Light Association, Held at Denver, June 6-11

A NIGHT VIEW OF AN EDISON CHIMNEY

IT is undoubtedly a safe assumption that the business world recognizes the increased drawing force of an illuminated sign over a plain one, not only on account of the additional hours of its usefulness, but also on account of the attractive efficacy of light. With this assumption granted, the central station desiring to increase the number of its sign customers has a good proportion of its work already accomplished, for there is no need of entering into an argument to establish the superiority of its commodity.

The only thing necessary for the salesman to do is to convince the prospective customer that an electric sign on his place of business will add sufficiently to its attractiveness to justify the necessary outlay, and by "attractiveness" is meant power to attract and hold customers. This power may consist of a variety of attributes: some business houses attract solely by the quality of the goods offered; others by the beauty of their decorations or the artistic nature of their display; still others by the convenience of their location; some by their courtesy and consideration of the wants and wishes of customers, and some by their prompt delivery of goods and the reasonableness of their prices.

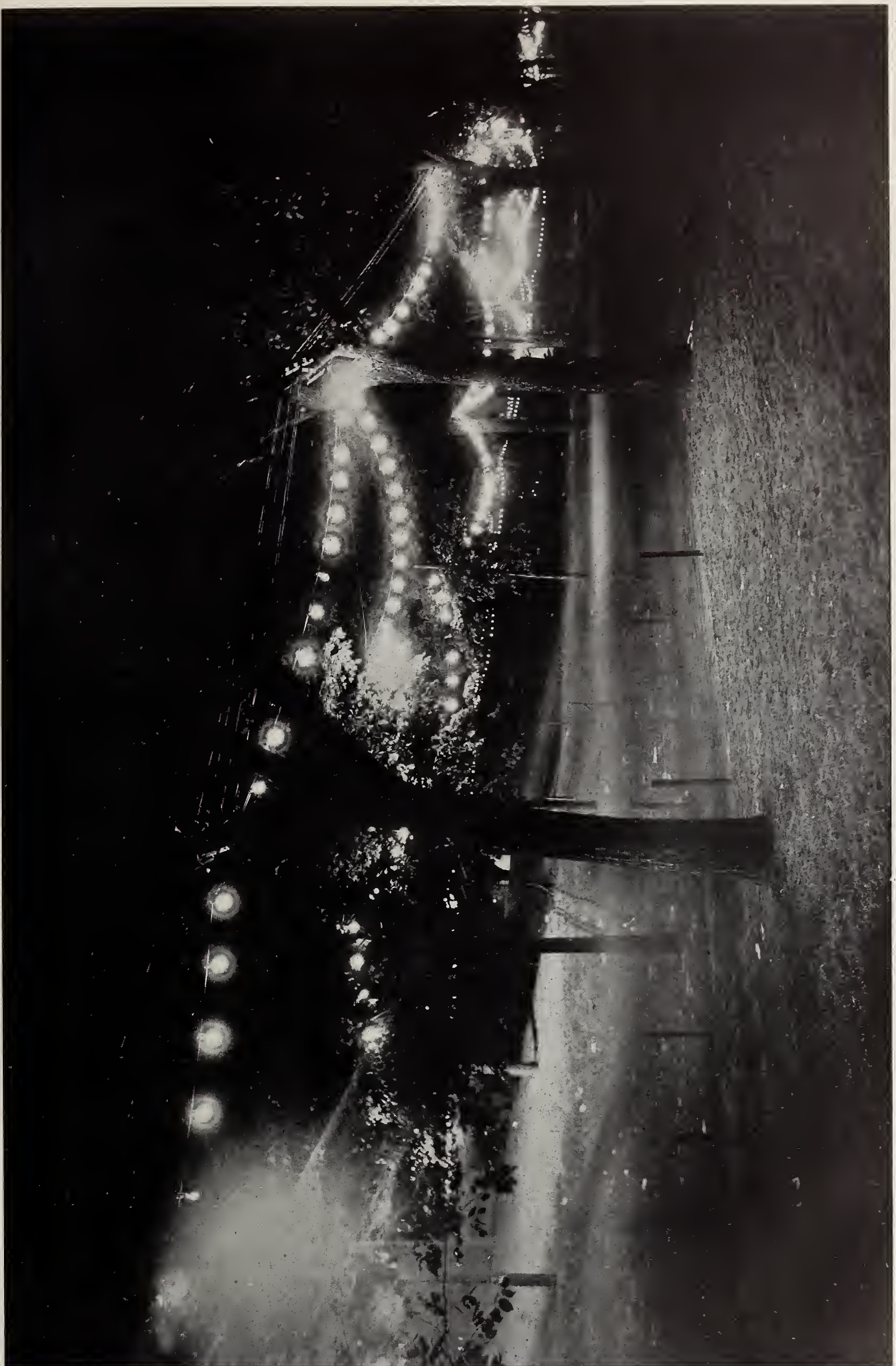
The chief power of such attributes is to hold customers after they have been secured. The enterprising merchant, however, is not satisfied with simply holding his own; he must be continually adding to his own or retrogression follows. Hence there is a constant and ever-increasing demand for methods, the use of which will bring new trade, and here opens the limitless field of advertising, with its numberless methods and inexhaustible means. It is desired here, however, to consider only the value of electric signs and decorations, and these not so much as advertising mediums as important features of central station demand.

AN EFFECTIVE NIGHT DISPLAY

There can be no question of the increasing demand for, and appreciation of, the electric sign. A comparison of the present appearance of the streets of any city with that of a few years ago emphatically attests the public appreciation of electric light, not only in signs but also in window decorations and in general illumination.

One of the large lighting companies has more than trebled the number of its sign customers during the last year and a half; another has increased its sign business 33 1-3 per cent. within a year, having added about 600 signs of all sizes. This company has adopted the policy of supplying and installing signs free of charge under contract, provided the customer will agree to keep the sign a certain length of time and burn it either fixed hours or a certain stipulated amount as governed by a minimum bill. In most of the signs so put out by the company referred to, 4-candle-power lamps are used, although, in some cases, 2-candle-power lamps are used and, in a few cases, lamps of a larger candle-power are installed; the consensus of opinion seems to be that 4-candle-power lamps are the best for general sign illumination. In most of the larger cities the majority of signs burn until

ONE OF MANY POPULAR TYPES OF BOSTON STREET SIGNS



ILLUMINATION OF BOSTON COMMON ON THE OCCASION OF THE REUNION LAST YEAR OF THE GRAND ARMY OF THE REPUBLIC

A BRILLIANT NIGHT EFFECT. THE PALACE OF ELECTRICITY AT THE ST. LOUIS EXPOSITION LAST YEAR. TWELVE THOUSAND INCANDESCENT LAMPS WERE USED IN ITS ILLUMINATION

ANOTHER NIGHT DISPLAY ON BOSTON COMMON ON THE OCCASION OF THE REUNION, LAST YEAR, OF THE GRAND ARMY OF THE REPUBLIC

midnight, but some of the companies have a 10 o'clock switching hour, and most of the signs which burn upon meter do not average as late as 10 o'clock.

One thing which has acted as a decided handicap to the introduction of electric signs in many cities and towns is the restriction placed by ordinance on the size and position of signs. In many cases they are prohibited from projecting more than 2 feet from the building line. In general, these ordinances were enacted before the value of electric signs to the municipality itself was fully realized. A little properly directed effort on the part of the lighting companies will undoubtedly tend to the correction of this condition, as the benefit accruing to any town from the added illumination of its streets by means of signs is so self-evident that but little argument is necessary. A revision of the antiquated ordinances regarding signs has been accomplished in Chicago. There is still a restriction of the size, and a license of a certain amount per square foot is levied annually, to provide for a rigid inspection of hangings, etc.

A certain minimum number of lamps is also required in order to prevent anyone's putting up an immense board sign with just enough lamps installed for it to be called an

NIGHT VIEW OF THE SOLDIERS' MONUMENT ON BOSTON COMMON DURING LAST YEAR'S GRAND ARMY REUNION

FROM ALL POINTS OF VIEW BOSTON COMMON PRESENTED A MAZE OF INCANDESCENT LAMPS, FESTOONED AND OTHERWISE FANTASTICALLY ARRANGED

electric sign. The ordinance also requires that the lamps shall burn until at least 9:30 o'clock every evening, so as to insure the municipality receiving the benefit of the illumination. There is no doubt that a large number of the cities and towns in the United States could be induced to enact similar ordinances. It would certainly be the means of making the cities much more attractive and give the lighting companies a greatly augmented revenue.

The method pursued by one of the large companies last year was a persistent and systematic advertising campaign by means of letters, folders, mailing cards, booklets, return postal cards and enclosed stamped envelopes sent to a selected mailing list secured by a thorough house-to-house canvass, including all retail merchants in all lines of business whose stores were sufficiently pretentious to possess a plate glass window. This campaign last year resulted in more than doubling the number of sign customers. The company referred to supplies 4-candle-power lamps for signs only. The result was obtained in a city where an ordinance restricts the projection of signs to 2 feet from the sidewalk line, consequently most of the signs installed are either vertical or flat against the face of the building.

Most of the large companies use electric signs for their own advertising, thus proving their faith in what they recommend to others; the effect of this is undoubtedly in the right direction. The rather large initial cost of electric signs has always militated against their use, but recently manufacturers have been directing their energies to the reduction of this first cost, with the result that some very effective signs are now on the market and can be purchased at a very reasonable cost. One of the recent improvements is the thermostat control, by means of which a sign is flashed without the use of a flashing switch. This is only practicable, of course, on comparatively small signs, mostly for interior use.

In some cases, as mentioned before, the lighting companies furnish and install signs free of charge, these, of course, of some standard make and type; in others, the customers are required to pay for them in small monthly instalments. This can undoubtedly be done at a profit to the company, as signs are usually burned for long hours, and, while part of this is on the peak of the load, a good proportion of it is at a desirable time, and companies should bear in mind that every sign installed is a distinct and emphatic advertisement of their business. Many commodities purchased by the public are taken away and used at home or in other places where no one but the possessor sees them, but the electric sign is meant for purposes of display and advertisement and advertises not only the owners but also the maker of the sign and the company that furnishes the electricity.

One of the larger companies—and possibly others—has placed the sign business in the hands of one man who is especially qualified by experience and study to handle this branch of the business. The great majority of merchants when considering the subject are completely at a loss as to what size and style of sign to adopt, and invariably consult the lighting company for advice in this matter. An expert should be able to advise the prospective sign customer in all matters of detail, and as the conditions are so varied and the possibilities so unlimited, judicious advice from such a source is of great value to both customer and company. No effort should be spared to insure the customer's installing the most efficient and most economical sign, and it can readily be seen that there is an opportunity for the exercise of a great deal of ingenuity and good judgment in planning or selecting a suitable one. The candle-power of the lamps installed should depend upon the location of the sign, whether it is intended for long-distance exposure or for interior use, or in narrow streets low down on buildings, where from the nature of the surroundings the sign may not be seen but at a comparatively short distance. There are so many matters of detail which must be considered that the adoption of any standard type and style of signs is practically impossible.

The lighting companies are naturally inclined to encourage the use of exposed lamp signs, as these consume the greatest amount of current, but there are a number of other types of signs which are much less expensive to construct and also to operate, such as illuminated boards, transparencies, and the like. The value of a satisfied customer as a medium of advertising is universally recognized, and it is much better to equip a small customer with an inexpensive sign which he can operate at a moderate cost and for an extended period, than to persuade him to install an expensive one, the maintenance of which is more costly than the size and nature of his business justifies, for such an experience would naturally tend to prejudice him against the use of signs in general.

The subject of window lighting might justly be considered here, as the conspicuous illumination of a show window has a distinct value apart from simply displaying goods, for the well-lighted window attracts almost as much attention as a brilliant sign and is the primary inducement to further investigation by stimulating curiosity. One notable case exists in which a large store window is most strikingly illuminated with no goods displayed, nothing but cards and placards intimating what beautiful and attractive goods may be seen within. This might not prove altogether satisfactory as a permanent arrangement, but as a temporary change should prove effective and might induce persons to enter in order to satisfy a curiosity which, were the goods in the window, would be satisfied without entering the store. Of course, the main thing is to persuade people to come in—after that the salesman must do the rest. The Boston Edison Company has installed in its exhibition rooms a sample show window with five different schemes of lighting, illustrating the effect of concealed lamps, reflector lamps, overhead lighting, side lighting, meridian lamps and various combinations of these. This has undoubtedly been of service to customers in determining what method to adopt, and to the company's salesmen in advising customers along this line.

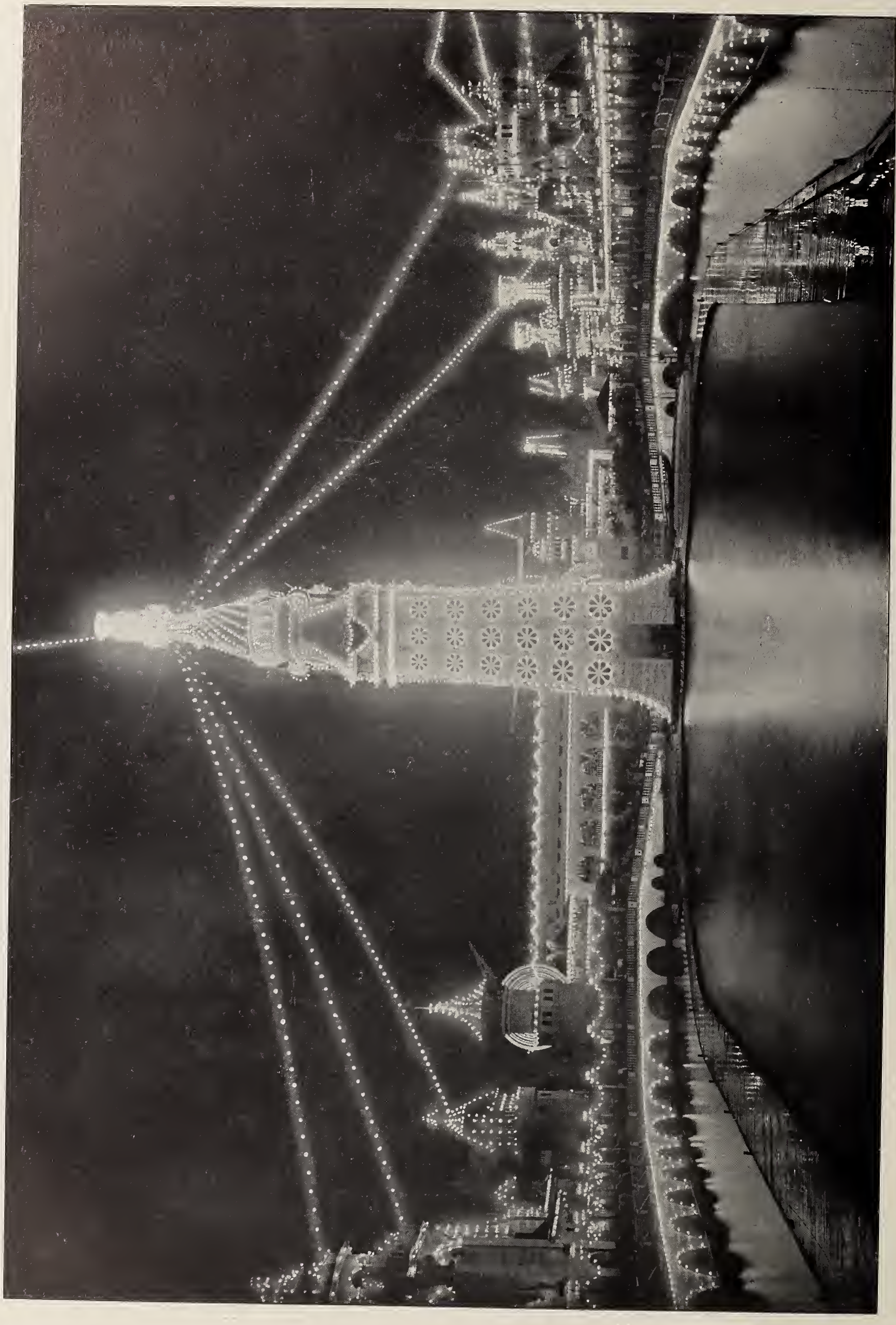
As to decorative lighting, while all artificial light is inherently decorative, there is no illuminant which lends itself so readily to ornamental and decorative effects as electricity. In fact, this is limited only by human ingenuity, and the improvements during the last few years along the line of handsome and artistic electric fixtures have been most marked. The possibilities along the line of extensive outdoor decorative effects by means of electric lights have been most satisfactorily demonstrated at the various expositions held in this country during recent years. Probably the most effective and interesting display of this sort was made at the Pan-American Exposition at Buffalo. Conditions were particularly favorable there, and were taken advantage of to the fullest extent.

Local outdoor decorations in various cities do not appeal very strongly to the lighting companies, on account of their excessive demand for but a brief period, occurring usually at the time of the heavy normal load. They are, however, of value to the companies in opening the eyes of the public to the possibilities along this line. There is probably no system that lends itself so readily to this kind of work as what is known as the "Elblight System,"* but its rather excessive first cost militates against its general use. This system is adapted equally well to interior decorations, and as this sort of work is something for which there is more or less of a constant demand, the lighting companies may well afford to give the subject careful attention. The miniature decorative lamp sets gotten up by the General Electric Company are admirably adapted to a great variety of interior decoration, especially to Christmas trees.

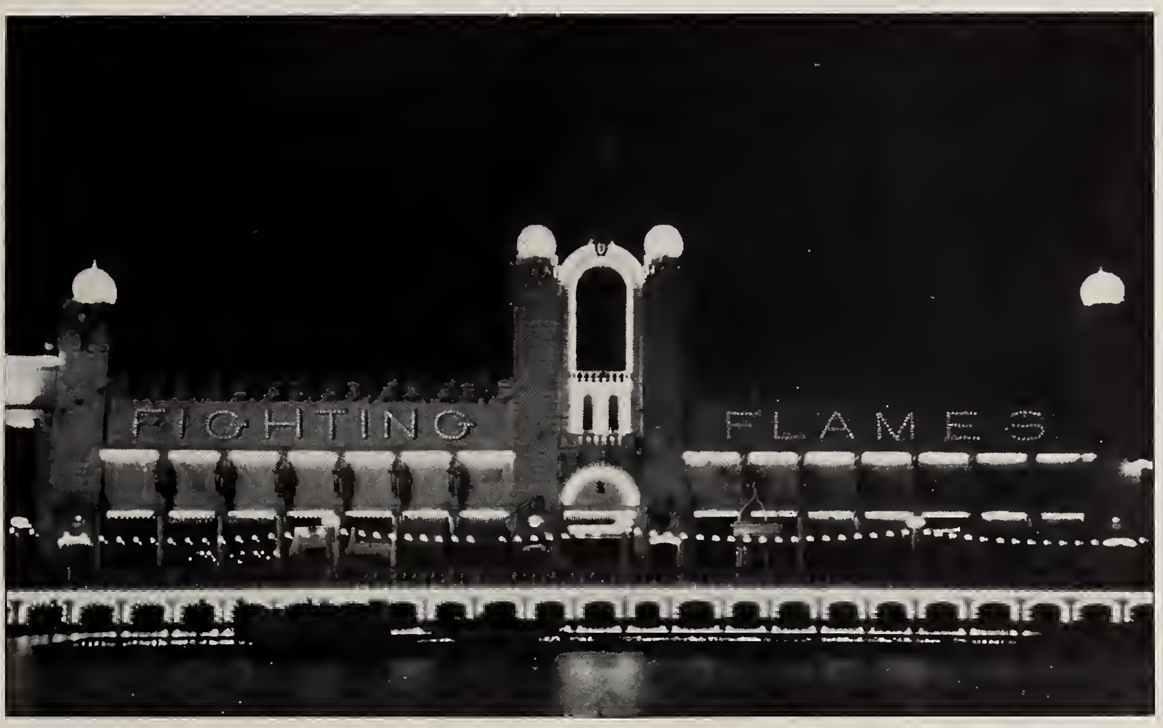
Another field which shows quite a promising crop for lighting companies is the illumination of billboards. These are generally controlled by advertising concerns who are beginning to appreciate the increased value of their space when properly illuminated. This is also appreciated by the advertisers, for they realize that the illumination of a signboard adds about five hours each day to its usefulness, and they are willing to pay for these five hours. Some of the lighting companies whose lines extend through country districts in reaching suburban towns are beginning to light the large billboards displayed along the railroads and highways. This should be profitable lighting wherever the boards are

* The lamps in this system have so-called pin-prong terminals protruding from the base, which is cemented to the lamp, thus doing away with sockets. These terminal pins may be forced into the supply cables anywhere, establishing contact without the need of the usual methods of connection. Ease and rapidity in fitting up signs and decorative displays are thus secured. The system is put on the market by the Elblight Company of America, of New York City.—The Editor.

THE INCANDESCENT LAMPS HERE ARE EXTRANEOUS TO THE SIGN, SERVING A SIMPLE ILLUMINATING PURPOSE



A NIGHT VIEW IN LUNA PARK, CONEY ISLAND, NEW YORK. A SPLENDID EXAMPLE OF THE VALUE OF THE INCANDESCENT LAMP FOR STRIKING AND EFFECTIVE DECORATION



INCANDESCENT LAMP EFFECTS AT DREAMLAND, CONEY ISLAND, N. Y.

within a reasonable distance of the company's lines.

Another type of sign which appeals strongly to the general advertiser is the so-called "talking sign." This sign, although quite expensive to install and only adapted to use in larger cities, is of such versatility and attractiveness, enabling the user to present such various and extended arguments that it should prove a profitable investment. The lighting companies cannot afford to overlook or neglect that branch of the business covered by sign and decorative lighting, for it has already assumed decided prominence and its future is almost unlimited. This is an advertising age, and the newer and more progressive methods are eagerly sought and adopted.

The Roentgen Ray Congress at Berlin

At the recent congress held at Berlin to commemorate the tenth anniversary of the discovery of Roentgen rays, a large number of scientists, statesmen and medical men met to do honor to Prof. Roentgen. Numerous papers were read, of medical rather than of electrical interest. A monument has been erected in Berlin to Prof. Roentgen.

In Uganda, in Central Africa, where telegraph wires are strung on poles made from a species of fig tree, it is said that for over a thousand miles these poles are in full bloom.

Three-Phase Cooper Hewitt Vapor Converters

In view of the general interest manifested of late in the single-phase vapor converter for changing storage batteries, it is but natural to wonder why the three-phase vapor converter which figured so largely in the early experiments conducted along these lines about two years ago, has not been more in prominence.

The reasons for this are as follows:—The vapor converter for changing alternating current into direct current was an entirely new departure, and in putting this product upon a commercial basis the simple construction of the single-phase converter was much in its favor. It was also found that the field most anxiously awaiting a device of this nature was that for charging storage batteries from a single-phase alternating-current circuit. On account of the considerations just mentioned, and also the fact that it is perfectly feasible to use three single-phase converters, one in each leg of a three-phase system if necessary to obtain direct current therefrom, it is not at all strange that the development of the converter has been principally along single-phase lines.

Inasmuch as the maximum capacity of the converters thus far developed is about 30 amperes, it is evident they are not yet adapted to very heavily loaded lighting or power circuits, although their capacity may be increased at will by connecting a sufficient number of them in parallel. In order to reduce their first cost in installations which now require the grouping of the converters in parallel, a larger sized converter of the single-phase type is soon to be placed on the market which will have a capacity of about 50 amperes.

It is not at all improbable that from time to time the capacity of the single-phase converter will thus be increased until it is able to care for the loads common in the largest direct-current lighting and power installations, and then, with three-phase conditions warranting it, the perfected three-phase converters may be ready to meet the demands.

In discussing the paper on "The Oscillograph," read by L. T. Robinson at a recent meeting of the American Institute of Electrical Engineers, Caryl D. Haskins suggested that a romancer might conceive of the oscillograph being used to record word vibrations, so that letters might be dictated into it and the records sent away in place of typewritten letters.

The Science of Steam Generation

By F. J. ROWAN, Assoc. M. Inst. C. E.

THE most familiar phenomena often contain for us, and may convey, the most profound instruction in the facts of science; but too frequently that is passed by in favor of the utilitarian aspect. For example, the ordinary domestic fire-grate is rich in lessons on combustion and the formation of flame; but who that wants to make use of the warmth, or to enjoy the cheerful glow of the fire, ever thinks of stopping to analyze the processes which are going on before his eyes.

So with the boiling of water. The homely kettle is the exponent of several facts or principles which are of very great interest and importance. The conduction of heat from the fire through the metal to the water, the distribution of heat throughout the liquid, involving its expansion and circulation, with the ultimate change of physical state in the formation of steam, as well as some idea of the elastic force of steam, are all exemplified and almost unheeded day by day. The kettle, however, introduces us to only one method of steam formation, namely, that which takes place in open vessels, at a slow rate, or in comparatively small volume, and at atmospheric pressure.

When we come to consider the rapid formation of steam in considerable volume under high pressure we are introduced to a far more complex physical process which demands suitable conditions and produces a considerable variation in the phenomena observed. In the one case we have a natural action, producing in a leisurely, normal way; in the other, an artificial process, which must be conducted on an enlarging scale, and, in these days, with greatly increased acceleration of speed. Naturally, with such a process there are additional elements, all of which must find a place in the final result produced, and these are the question of, the weight of, and space occupied by, the boilers, the weight and cost of fuel and water consumed, and facility of management and preservation; and all these bring into view the subject termed "efficiency," which furnishes a strict rule by means of which the performance of every boiler must in the end be tested and judged.

Steam generation is the result of several processes which are carried out with a boiler or generator of suitable design. These processes are,—

1.—Combustion, which means the combination of the oxygen of the air with the carbon, hydrocarbons, and hydrogen of coal or other fuel, at a suitable temperature.

2.—Transmission of heat.

3.—Change of the physical state of the water in the boiler, in which is involved the phenomenon of latent heat.

The science of steam generation embraces, or is the sum of, those physical laws which govern all the actions involved in the form and functions of the boiler. It is the practical application of this knowledge to the purpose mentioned which alone can guide us to the best form of boiler, so that the highest result may be obtained; and in order that we may appreciate the proper relation of the various processes concerned in steam generation to one another, and to the result finally arrived at, we must adopt a comprehensive view of the subject. To have this we must begin with a correct fundamental idea which is secured by considering the steam boiler as a heat engine to which we apply the reasoning applicable in the case of every other form of heat engine.

It is curious that in the past as a general rule boilers seem to have been considered from every other possible point of view rather than this one. There were undoubtedly exceptions; but as far as the general practice is a guide, it has been customary to regard the boiler in the light of a structure or machine. In early days difficulties in manufacture and from imperfect materials, no doubt, seriously hindered the production of any but the most elementary forms; yet, at the same time, comparatively little effort seems to have been directed to the production of any others. The main idea of design was founded on the kettle as a pattern, and modifications of form were introduced from considerations of strength or of convenience of manufacture.

The requirements of a boiler were reckoned to be the providing of sufficient space to hold a mass of water, and sufficient space to receive and hold the steam, with a margin of strength to carry the working pressure. As regards the application of heat, the direct radiant heat of the glowing fuel or the contact of the flame was considered the great thing, the hot gases from the point of the extinction of the flame not being considered of much account. From imperfect knowledge of the facts of combustion, flame also was often incompletely formed either because of insufficiency of air supply or too speedy contact of the gases with the metal surface of the boiler, and thus followed additional loss of heat.

Although quaint inventors proposed stirring the water, in order to "open its pores," as they said, to the passage of the heat, or to inject small quantities of water successively into heated chambers, or to subdivide the water into small quantities by means of tubes or partitions, or to convey the heat through the masses of water by means of highly heated oil or by fusible alloys, and so on, proving that they to some extent appreciated the problem which was before them, yet no doubt these were considered, as inventors are still to a great extent considered, as visionaries and impracticable dreamers. At any rate, the "kettle" ideas survive in a considerable measure even to this day.

General practice, even with the kettles, has, however, immensely improved, and, thanks to the labors of enthusiasts like the late Charles Wye Williams, such knowledge as that of the main facts of combustion has become widely spread, so that very much better results are obtained and a high percentage of the potential heat of the fuel is often usefully applied in raising steam.

The writer would here, nevertheless, raise a protest against the prevalent habit of making that one result the measure of the efficiency of a steam boiler. It gives information as to the use of the fuel, but conveys no hint of the proportions of the boiler or of the efficiency of its surfaces. The boiler may be, from another point of view, five times too large or ten times too heavy; but the present statements of "efficiency" give no enlightenment on such points. The elements of the boiler, which are essential to the problem of really efficient steam generation, are carefully excluded from all present estimates of efficiency. This may be due to the fundamental idea of the boiler and its functions which has been adopted, but it is very evident that in the future this must be altered or added to.

In his lecture on "Gas and Caloric Engines," at the Institution of Civil Engineers, in London, probably the last lecture he delivered, the late Professor Fleming Jenkin showed that, in dealing with heat engines, the term "efficiency" can be used in several ways, of which he gave the following four examples:—

First, we may have what may be termed the "absolute efficiency,"—that is to say, the ratio between the indicated horse-power and the total quantity of heat which is generated by the fuel per minute. Denoting this efficiency by the letter E, we have

$$E = \frac{I.\,H.\,P.}{H}$$

Second, there is what may be termed the "ideal efficiency" E_i. This is the ratio of the difference of the absolute temperatures $(T_1 - T_2)$, between which a heat engine works, to the higher of these temperatures, and represents the utmost proportion of the total heat which can be converted into work in an ideal engine,—thus

$$E_i = \frac{T_1 - T_2}{T_1}$$

Third, E, compared with E_i, gives the "relative efficiency," E_r, thus

$$E_r = \frac{E}{E_i}$$

Fourth, we may compare the work which a given engine might perform theoretically, according to an indicator diagram calculated on certain hypotheses, with the heat generated by the fuel per minute. This would be the "theoretical efficiency" of that engine, E_t. If $H\,P_t$ denotes the work calculated as described, then $E_t = \frac{H\,P_t}{H}$

Now the expression of boiler efficiency which is in use to-day bears a relation only to the first of these, and so represents the ratio between the quantity of water evaporated (reckoned as heat) and the total quantity of heat generated by the fuel in a given time. What is wanted is an expression of the heat transmitted (in thermal units or in pounds of water evaporated) per unit of heating surface per unit of time compared with the total yielded by the combustion of the fuel in that time; and in order to properly classify such a result we need a standard or theoretical efficiency on the lines of Professor Jenkin's fourth, in which $H\,P_t$ should become $H\,T_t$ or some other symbol expressing the maximum heat transmission possible per unit of surface.

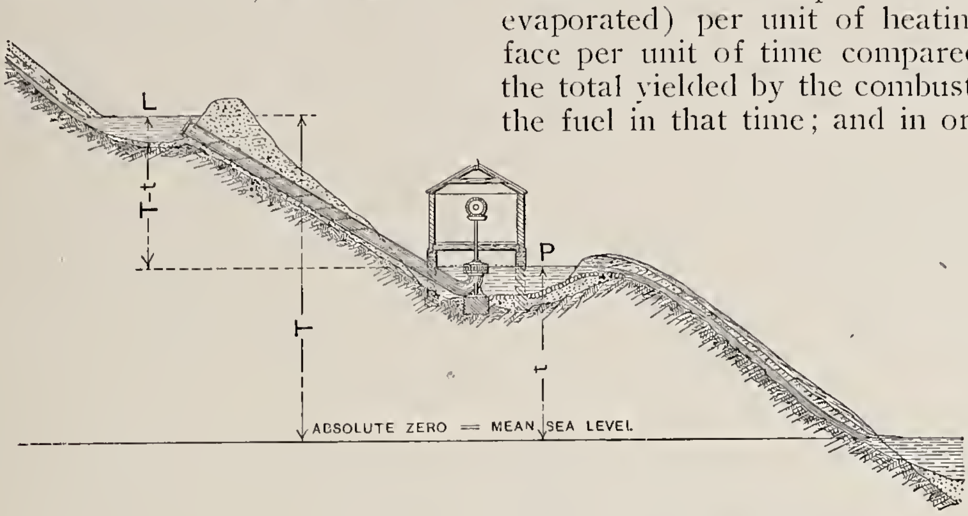


FIG. 1.—AN ILLUSTRATION OF CARNOT'S DOCTRINE, 1824

Attention is here directed to Fig. 1, which is an illustration used by the late Sir William Anderson to give a graphic representation of the theory of principle of the heat engine.

It represents a hillside rising from the sea. Some distance up there is a lake L, fed by streams coming down from a still higher level. Lower down the slope is a millpond P, the tail-race from which falls into the sea. At the millpond is established a factory, the turbine driving which is supplied with water by a pipe descending from the lake. The datum line is the mean sea level, the level of the lake is T, and that of the millpond is t; Q is the weight of water falling through the turbine per minute. The mean sea level is the lowest level to which the water can possibly fall, and hence its greatest potential energy, that of its position in the lake, is $QT = H$. The water is working between the absolute levels T and t; hence, according to Carnot, the maximum effect W to be expected is $W = H\left(\frac{T-t}{T}\right)$; but $H = QT$; therefore, $W = QT\left(\frac{T-t}{T}\right)$ or $W = Q\,(T-t)$, that is to say, the greatest amount of work which can be expected is found by multiplying the weight of water into the clear fall, which is, of course, self-evident. It will be clear that if we want to increase the effect produced by a given weight of water, without in any way improving the turbine, we can do so either by collecting the water higher up on the hill and thus increasing T, or by placing the turbine lower down nearer the sea and thus reducing t.

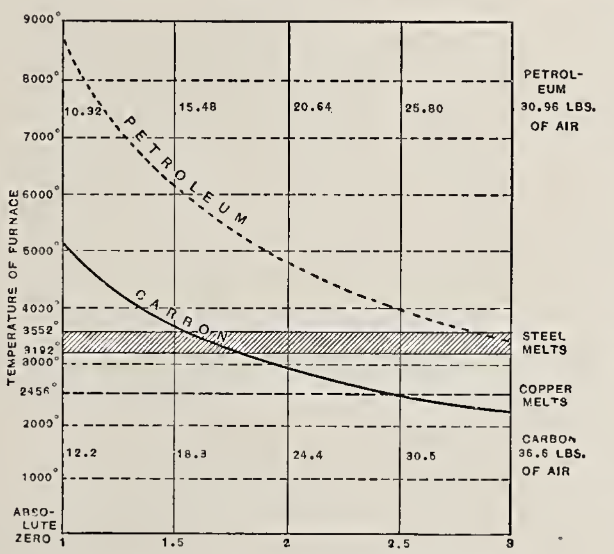


FIG. 2.—EFFECT OF QUANTITY OF AIR ADMITTED TO A FURNACE ON ITS TEMPERATURE

Applying this to a heat engine, such as a boiler, the sea level represents the absolute zero of temperature, and, similarly, T and t represent the maximum and minimum temperatures between which work is being done. Therefore, the "ideal efficiency" of such a heat engine will depend upon the production of the highest possible temperature in the furnace and the lowest possible temperature in the escaping waste gases.. The problem before us is to produce the results with the most efficient and economical apparatus.

The first step brings us face to face with the interesting phenomena of combustion. The writer shall take it for granted that these, involving the main facts of the chemistry of combustion, are generally understood, and shall direct attention only to one or two important points connected with the subject. In Table I are given the number of British thermal units due to the combustion of the substances mentioned in the first column, the weight of the products of combustion, their mean specific heat, and the temperature theoretically produced when only the exact quantity of oxygen or air necessary for chemical combination is used. These temperatures are hardly ever produced in practice on account of the employment of an excess of air, as well as because of its complete combustion, and the last three lines of the table show the result when carbon is burned with air only to the monoxide (CO), and when 20 per cent. and 50 per cent. excess of air are used in burning to carbonic acid (CO_2). Such results are represented graphically in Fig. 2, which the writer has borrowed from a lecture by the late Sir William Anderson, in which curves are given to show the theoretical temperatures on the absolute scale for carbon and for petroleum (composed of 0.84 carbon and 0.16 hydrogen) when one and one-half, two, two and one-half and three times the theoretical quantity or air are employed.

Thus, for solid carbon, taking as a starting point 5150 degrees F. absolute* as the theoretical temperature of combustion with 12.2 pounds of air per pound carbon, the lower curve shows the calculated temperatures with successive additions of air, making the total amounts 18.3, 24.4, 30.5, and 36.6 pounds per pound of carbon, these quantities being set up as vertical ordinates to the base line which represents absolute zero. The horizontal lines represent various degrees of temperature on the absolute scale, the shaded portion showing the limits within which steel was supposed by the late Sir William Siemens to melt.

TABLE I

Conditions of Combustion	Number of B. Th. Units Produced	Weight of Products of Combustion	Mean Specific Heat of Products of Combustion	Temperature Produced
1. 1 lb. Carbon burnt to CO_2. Pure oxygen supplied...........................	14,000	3⅔	0.216	$\frac{14,000}{3\frac{2}{3}}$ = 17676° F
2. 1 lb. Carbon burnt to CO. Pure oxygen supplied...........................	4,000	2⅓	0.243	$\frac{4,000}{2\frac{1}{3} \times 0.248}$ = 6912°
3. 1 lb. Carbon burnt to CO_2. Oxygen supplied in air...........................	14,000	13	0.237	$\frac{14,000}{13 \times 0.237}$ = 4545°
4. 1 lb. Carbon burnt to CO. Oxygen supplied in air...........................	4,000	7	0.254	$\frac{4,000}{7 \times 0.254}$ = 2249°
5. 1 lb. Carbon burnt to CO_2. Oxygen supplied in air 20 per cent in excess	14,000	15 2-5	0.237	$\frac{14,000}{15.4 \times 0.237}$ = 3836°
6. 1 lb. Carbon burnt to CO_2. Oxygen in air 50 per cent in excess	14,000	19	0.237	$\frac{14,000}{19 \times 0.237}$ = 3109°

The upper curve represents the same process in the case of the petroleum mentioned, only in this case the theoretical minimum of air required is 10.32 pounds per pound of oil, and the successive additions are in mutiples of that quantity. These higher temperatures produced by the combustion of oil are in favor of its economy as a fuel for steam raising, although this point has not been used by the advocates of liquid fuel.

By transferring heat from the waste escaping gases to the incoming air to be used for combustion, higher temperatures of combustion are obtained than those due to the use of air at the atmospheric temperature. We can obtain a rough idea of this effect by taking the case mentioned on Line 5 of Table 1, and supposing the air to be thus heated to 400 degrees above the normal atmospheric temperature. The results would be that 14.4 × 400 × 0.238 = about 1371 units of heat would be added to the furnace per pound of carbon burnt, and the temperature of combustion would then be

$$\frac{14,000 + 1371 \text{ degrees}}{15.4 \times 0.238} = 4211 \text{ degrees F., or}$$

an increase of 375 degrees over the temperature 3836 degrees produced without the preliminary heating of the air.

Where, however, heat is required in the waste gases in order to give them "ascensional force" (so-called) for the production of chimney draught, a limit is very quickly placed on the amount of the heat which may be transferred for the purpose just mentioned; but with mechanically-produced draught, or what is called "forced combustion," that restriction is removed, and, given suitable apparatus, we may bring the temperature of the waste gases down to that of the atmosphere if we please. Forced combustion also enables us to produce a much larger volume of heat in a furnace of given size per minute or per hour than would be possible with the chimney draught ordinarily available, and rates of combustion up to 100 pounds of coal per square foot of grate area per hour are known with various degrees of pressure of air supply up to 9 inches of water column.

There is still one method by which the combustion temperature (the level of the lake, *T*, in Fig. 1) may be elevated, and that is by increasing the pressure under which the operation is carried on. Although the correctness of this method has its foundations in the dynamical theory of heat and the laws which govern the specific heat of gases, it has not yet found favor amongst engineers. But it is certain to be made use of sooner or later. If we look up a table of the specific heat of gases, we find that whilst under "constant pressure" the specific heat of air is 0.2374, nitrogen 0.2438, and carbon dioxide 0.2163, under "constant volume" these become,—air 0.168, nitrogen 0.173, and carbon dioxide 0.171. This means that if gases are allowed to expand while being heated, they will require more heat to raise their temperature than would be necessary were they confined to a limited space during the operation, when, of course, their pressure would increase.

This is consistent with dynamical laws, for a certain quantity of heat disappears or becomes latent in the work of expanding the gases, this quantity being available as sensible heat when the gases are not expanded or compressed. It is, of course, well known that when air is compressed in an air compressor its temperature is raised, although no heat has been applied during the operation, and that is the converse action which shows the reappearance of the latent heat as sensible heat.

Now as applied to combustion, it

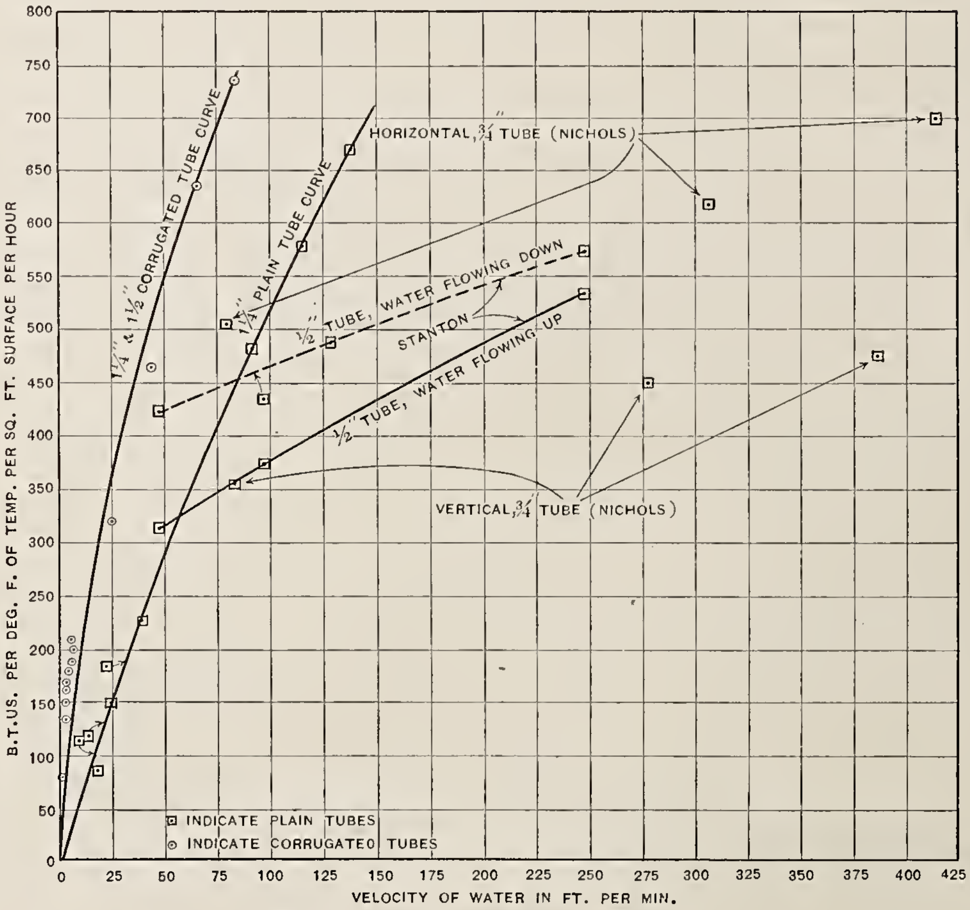


FIG. 3.—HEAT ABSORBTION CURVES

* Sir Wm. Anderson's calculation of temperature.

$$T = 520° + \frac{14544 \text{ units}}{13.2 \text{ lbs.} \times 0.23^8} = 5150° \text{ absolute.}$$

has been shown that by conducting the process under a pressure of two atmospheres a temperature will be produced 715 degrees higher than that obtained at atmospheric pressure, and a further rise of 493 degrees would be realized by increasing the pressure to three atmospheres. It has also been shown that this method increases the proportion of carbonic acid in the gases. This method would certainly demand some alteration of the existing combustion arrangements, but the time is not far distant when the ordinary inside grate will be abolished for ordinary forced combustion, and in unit of time, when heating by convection occurred, the results were from 4700 to 16,050 heat units per unit of time.

I believe the best results will be obtained by confining the radiant heat to the combustion chamber, arranged so that the minimum of the heat rays will be directed in a useless direction, and thus making use of them to increase the temperature of combustion and the completeness of flame formation.

We come now to the second division of the subject, which deals with the utilization of the heat produced and the lowering of the lower temperature of water from that of the atmosphere to 212 degrees F.; but then 966 B. T. P., or degrees Fahrenheit per pound (the heat which becomes latent), must be added to the water before its physical state is changed, its volume as steam relatively to its former volume of water becoming about as 1600 is to 1. This steam has still the temperature of 212 degrees, and although it might be supposed that much more heat, and, therefore, fuel, would be required to produce steam of, say, 300 pounds, per square inch pressure, or about 415 degrees F., yet that is not the case.

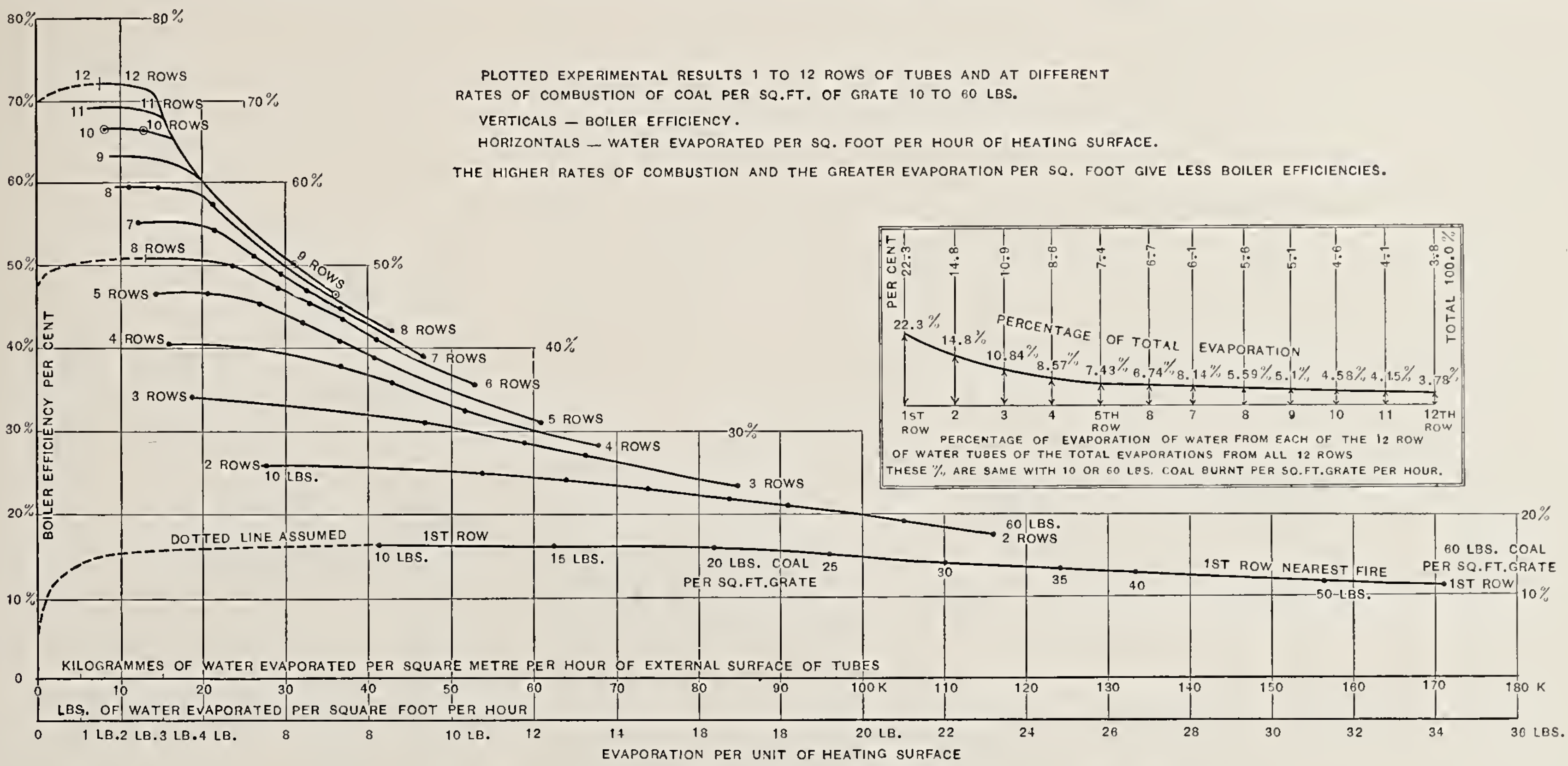


FIG. 4.—RESULTS OF EVAPORATION TESTS WITH A NICLAUSSE WATER-TUBE BOILER

any case no merely mechanical difficulty can be allowed for any length of time to stand in the way of improvement.

Another point should be noticed here, and that is the question of the use of radiant heat from the incandescent or glowing carbon, as against the heating by convection which takes place by means of contact of the flame and hot gases with the boiler surfaces. Some people attach much importance to the radiation from the fire; but except in furnaces like those of Lancashire and Cornish and locomotive boilers, that importance is, to a great extent, a matter of imagination. Not only do the heat rays proceed in straight lines in all directions equally, but they may even be reflected from the very surfaces which we hope will absorb the heat. Moreover, certain experiments have shown that whereas in heating by radiation the rate of heat transmission in the apparatus employed ranged from 3820 to 8540 C. G. S. heat units per unit of surface per ature level in the heat equation. Here we are concerned with the kernel of the subject of steam generation; for, important as combustion undoubtedly is, yet the determining factor of the problem before us has proved in some cases, and will prove generally, to be that of heat transmission. It is, however, a fact that although boilers are, and have been, designed with a view to convenience of stowage, to strength of the structure, to largely increased heating surface, to lightness, and to other points connected with their use, the best conditions for the transmission of heat have not as yet exerted any marked influence upon boiler design. This is remarkable because an observer, looking at the subject from the outside, must at once perceive that steam generation is primarily and mainly a question of heat transmission.

The difference between water in the liquid state and in the gaseous state (or in the form of steam) is merely a matter of heat. A comparatively small amount of heat suffices to raise the

In Table II are given the temperatures of saturated steam at various pressures, these temperatures being stated in Centigrade degrees in Column 1, and the corresponding pressures in atmospheres in Column 2; in Column 3 is given the total amount of heat in Centigrade heat units necessary to raise unit weight of water from 0

TABLE II

I Temperature in Centigrade Deg.	II Pressure in Atmospheres	III Total Heat in Centigrade Units	IV Pounds of Water Converted into Steam per Lb. of Carbon
100	1	637	12.57
121	2.025	642	12.53
134	3.008	646	12.46
144	4.000	649	12.40
152	4.971	651	12.36
159	5.966	654	12.30
171	8.036	656	12.27
180	9.929	659	12.21
189	12.125	662	12.16
199	15.062	664	12.13
213	19.997	667	12.06
225	25.125	670	12.01
239	27.534	675	11.92

degrees C. to the state of vapor at each temperature. From this table we can find the weight of water which the heat of 1 pound of carbon can raise from 0 degrees C. to the state of vapor at any of these temperatures. We take 8050, which is the thermal value in Centigrade units of 1 pound of carbon, and divide it by the total heat for the temperature wanted. The writer has, therefore, added a fourth column to this table, in which the result is calculated out for all the pressures and temperatures given.

Thus $\frac{8050}{667} = 12.06$ pounds water raised from 0 degrees C. and converted into steam of 19.997 atmospheres, or about 300 pounds per square inch, by the same amount of carbon. That is one of the secrets of the economy of high-pressure steam, because practically the same expenditure of heat produces such a vast difference in the amount of obtainable energy when that heat is intelligently applied.

Now, as the combustion of the fuel which furishes us with this heat cannot take place in contact with the water,—in which it is unike the combustion of the metals potassium and sodium,—we are at once confronted with the fact that the heat so yielded must be passed from the outside of some chamber to water on the inside, —that is, across some solid medium. That medium is either wrought iron, steel, or copper,—most frequently mild steel in ordinary practice; and if we inquire what is its capacity per square foot of surface for transmitting heat, we find that this is practically unlimited, unless interfered with by great thickness or some artificial resistance, such as a coating of scale or oil.

When we turn from this to inquire what is realized in practice with boilers, we find that in the year 1747 an inventor named John Payne, in describing his boiler to the Royal Society of London, announced that he had "rarefied" or turned into steam 90 gallons of water with 112 pounds of coal. This gave an evaporative rate of 8.03 pounds of water per pound of coal; but, unfortunately, we do not know the rate of evaporation per unit of surface.

Present practice with modern boilers rarely exceeds John Payne's result, and, measured per unit of surface, it reveals the astonishing fact that the average evaporation amounts only to from 2½ to 7 pounds, rarely more, and say exceptionally to 10 pounds of water per square foot of heating surface per hour, whereas the writer believes we have solid ground for maintaining that an evaporation of 50 to 80 pounds, and possibly of 100 pounds, per square foot of surface per hour can be obtained in regular practice with suitably designed boilers. Here, then, is a great opening for improvement, and in order to take advantage of it we must make ourselves acquainted with all that can be learned from investigations of the phenomena of heat transmission.

Many such investigations have been carried out, but the writer can refer to only a few which may be considered as more directly bearing on the subject here. The men who are interested in evaporators and feed-heaters have done a good deal of this work, and, in fact, most of the early experiments on heat transformation were carried out with steam or hot water as the source of the heat.

Of the pioneers the most distinguished was Péclet, whose "Treatise on Heat" proved a storehouse of information for many years. Most of his experiments, made with a view to determining the heat-transmission coefficient (or coefficient of conductivity) of various metals, were carried out by means of a simple apparatus in which the metal plate under experiment separated two compartments containing water. The water on one side of the plate was hot and on the other cold, and the experiment consisted in measuring the amount of heat transmitted in given time through the metal from the hot to the cold water. In each of the compartments apparatus was provided to give rapid motion to the water, Péclet having discovered that motion is a vital necessity to heat transmission. He also laid it down as an axiom that, especially where gases are employed, the motion of the currents should be in opposite directions over the two surfaces.

The effect of movement was also shown in experiments on cooling (which is, of course, heat transmission reversed) by Colding and B. C. Nichol, whilst the influence of increased velocity on heat transmission has been investigated by G. A. Hageman, Professor Louis Ser, Professor Osborne Reynolds, T. E. Stanton, H. G. Hudson, and perhaps some others, and has been shown to be profound. Some of the most notable results from experiments on heat transmission, where steam is the heating medium, were obtained by G. R. Lang, who communicated them to the Institution of Engineers and Shipbuilders in Scotland in 1889. These experiments were carried out in an apparatus which was a working size of one of the Weir evaporators, and the principal results obtained showed an evaporation of 101.14, 109.32, 118.75, 135.33 and 140.23 pounds of water per square foot of surface per hour, with temperature differences (between the steam and water) of 69.1, 75.7, 81.3, 99.7 and 106.7 degrees F. The thermal units transmitted per square foot of surface per hour per 1 degree difference of temperature were 1324, 1329, 1334, 1286 and 1224.

Fig. 3 represents graphically some results obtained by Nichols and Stanton, in England, and by H. L. Hepburn and W. O. Hildreth, in America, in experiments with tubes, plain and corrugated, and in vertical and horizontal positions, with steam on one side and water on the other. Such investigations have been carried out so thoroughly that formulæ have been developed by means of which the principal dimensions of feed-water heaters are calculated for a given duty.

Investigations of the phenomena of heat transmission where the heat is derived from flame or hot combustion products applied directly have been made by Hirsch, Blechynden, Bryant and Witz with special apparatus; and many measurements of evaporation have been made with steam boilers.

In the special apparatus used by Hirsch the plate experimented with formed the bottom of a small boiler or cylindrical dish for the evaporation of water. A series of holes were drilled some distance into, but not through the plate, in two concentric circles on the fire side of the plate, and into these holes plugs of alloys were inserted, having a range of melting temperatures from 230 degrees to 842 degrees F. From their behavior in his experiments Hirsch concluded that sound and clean plates in a boiler could not be overheated as long as water was being evaporated from them at rates up to 75 pounds per square foot of surface per hour. He also investigated the effects of increased viscosity of the water, of incrustations, of flaws and joints in the plates exposed to the heat, and of coatings of oil and grease upon the rise of temperature in the plates at different rates of evaporation.

The form of apparatus employed by Hirsch was, with some improvements, adopted by Miss E. M. Bryant, B. Sc., in her investigations on "The Thermal Condition of Iron, Steel and Copper when Acting as Boiler Plates." This apparatus avoided the loss by conduction and radiation and the errors due to the fusible plugs in Hirsch's arrangement; but it had its own defects, the most prominent of which perhaps was the manner in which heat was applied to the plate. Naturally, Miss Bryant's endeavor was rather to attain permanent conditions of action than to reach maximum rates of transmission; nevertheless, she has plotted for us results giving rates of evaporation of from 30 to 70 pounds per square foot per hour, with the corresponding temperatures of the fire side of the plates obtained by means of thermo-electric junctions connected to a galvanometer. At 50 pounds per square foot evaporation a half-inch plate has a temperature of 150 degrees C., and at 70 pounds a temperature of 170 degrees C.

It may suffice for us to take Mr. Stromeyer's estimate that in trans-

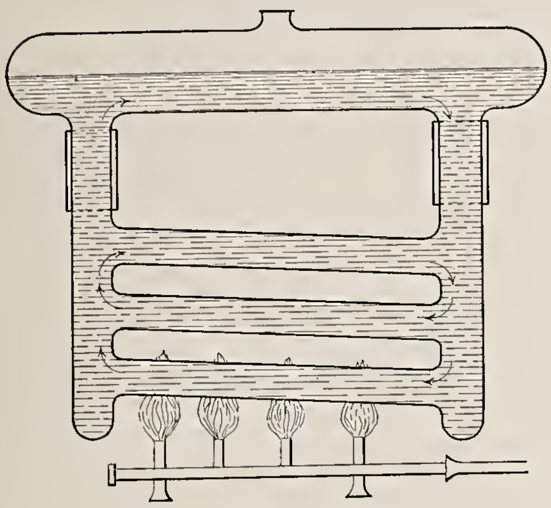


FIG. 5

mitting enough heat through boiler plates to evaporate 20 pounds of water per square foot of surface per hour, Miss Bryant shows that the temperature gradient in the plate will be 40 degrees F. per inch of the thickness, and that if 140 evaporative units of heat per hour be transmitted, the mean temperature of a clean furnace plate one inch thick will be 70 degrees F. higher than that of the water. These figures are most eloquent, and show that even with such thickness of plate the rise in temperature of the metal is quite a negligible quantity even at such rates of evaporation. When we deal with the much smaller thickness used in water-tube boiler construction it is apparent that the power of the metal to transmit heat is practically unlimited.

Of experiments conducted with actual boilers there were several quali-

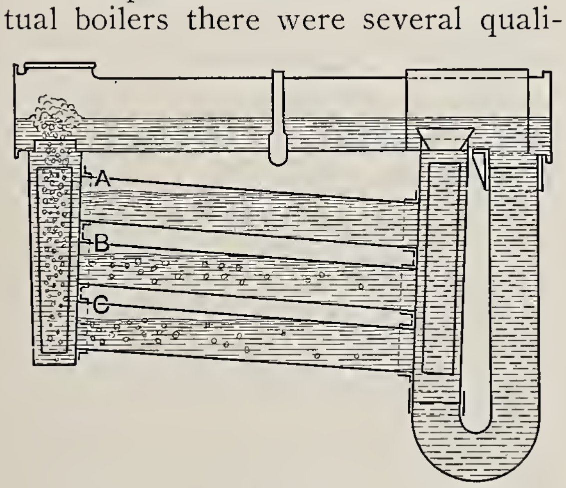


FIG. 6

tative trials, made in the early part of the last century, which had a certain interest; but the two prominent quantitative experiments which the writer wishes to call to notice are those made with a locomotive boiler on the Great Northern Railway of France, and with a water-tube boiler of Messrs. Niclausse, of Paris.

In the former a goods engine boiler was separated into five sections by the insertion of tube plates, the fire-box and a few inches of the tubes forming the first section, whilst the other four were composed of equal lengths of the remainder of the barrel of the boiler. Although the sections were made steam-tight, they were not insulated as to conduction of heat from one to the other, and under these conditions the evaporation from each section was measured first with all the tubes open, and second with half of them plugged up.

The quantity of water evaporated per square foot of heating surface per hour varied according to the force of draught (produced by a steam jet in the chimney supplied with steam from another boiler), in the first section from 20 to 42.9 pounds, with tubes all open and from 26.5 to 44.7 with half the tubes closed; the second section showed 5.6 to 14 and 9 to 21 pounds under the same conditions; the third, 2.9 to 6.8 and 4 to 10.6; the fourth, 1.28 to 4.32 and 2 to 6.34; and the fifth, 0.72 to 2.81 and 1.31 to 4.76 pounds. These results convey several lessons, but the writer here merely makes use of the fact that they show an evaporation of from 20 to nearly 50 pounds per square foot of surface, obtained without danger or difficulty in a portion of a by no means particularly strong form of boiler.

In the other case a water-tube boiler of Messrs. Niclausse's design was used, and each horizontal row of ten tubes was provided with upcast and downcast passages for steam and water distinct from the other rows. There were twelve rows in all, and evaporation was tested at nine different rates of combustion of coal from 10 to 60 pounds per square foot of grate area per hour. The results are graphically represented in Fig. 4, the smaller diagram showing the evaporation from each row in percentage of the total evaporation from the twelve rows, which percentage was constant for all rates of combustion tried. The larger diagram gives the plotted results on a base line of pounds of water evaporated per square foot of heating surface per hour, whilst the heat efficiencies of the boiler are shown on a vertical scale. An evaporation of from 8¼ to 34⅛ pounds per square foot per hour was obtained with the first row commencing next the fire, whilst the twelfth or topmost row evaporated only from 1½ pounds to 6 pounds per square foot per hour. The first three rows nearest the fire, with 161 square feet of heating surface, gave 47.94 per cent. of the total evaporation from 645 square feet, the remaining 52.06 per cent. requiring three times the amount of surface to complete it. Here, again, we have rates of evaporation up to 34 pounds per square foot per hour without injury to the boiler.

Both of these investigations show that it is possible to have the surface used for generating steam too much extended in a boiler, and that a large proportion of that surface in boilers as now arranged would do better duty if used for heating the water up to the point at which the formation of steam takes place in the efficient part of the generating surface. The analogy of the amount of heat required by water in heating up to the point of steam formation compared with what is required afterwards points to a larger proportion of heating surface and to a smaller proportion of generating surface.

TABLE III.

Nature of Heating	Barometric Pressure Inches of Mercury	Temp. of Feed Water, Fahrenheit Degrees	Lbs. Water Evaporated per Sq. Ft. of Heat'g Surf. per Hr.
Seven Bunsen burners	29.33	59	13.0
Seven Bunsen burners and one air blast	29.84	61	38.8
One oxy-hydrogen blow pipe	29.84	65	41.2
Seven bunsen burners and three blow pipes.	29.65	67	54.0
Coke with air blast	29.92	67	88.9
Seven Bunsen burners, one air blast and one oxy-hydrogen blow pipe	29.70	57	136
Coke with air blast	29.92	194	204

There is one more set of experiments on evaporation to which the writer wishes to refer. These experiments were carried out by Professor Aimé Witz, of Paris, in a small vertical cylindrical boiler, about 12 inches in diameter, with a flat bottom plate half an inch thick. The water level was maintained at a constant height of 3.15 inches, the quantity evaporated being measured (of course, by the amount of feed), but the temperature of the plate was not observed.

Table III gives the results with various sources of heating. In the last two experiments the plate was made red-hot and then the water was admitted and maintained at the same level as before. In none of the first five experiments did the plate become red-hot, but the surface of the plate on the water side was kept quite clean.

Professor Witz's investigation was specially directed to the question of whether the spheroidal state of water was likely to be produced in boilers, and although his conclusion was that it was not likely, still the conditions under which the evaporation in the last two experiments was obtained were impracticable in a boiler worked under pressure.

This introduces us to the consideration of some phenomena which constitute limiting conditions under which boilers can be worked. It has been known for some years that the tenacity

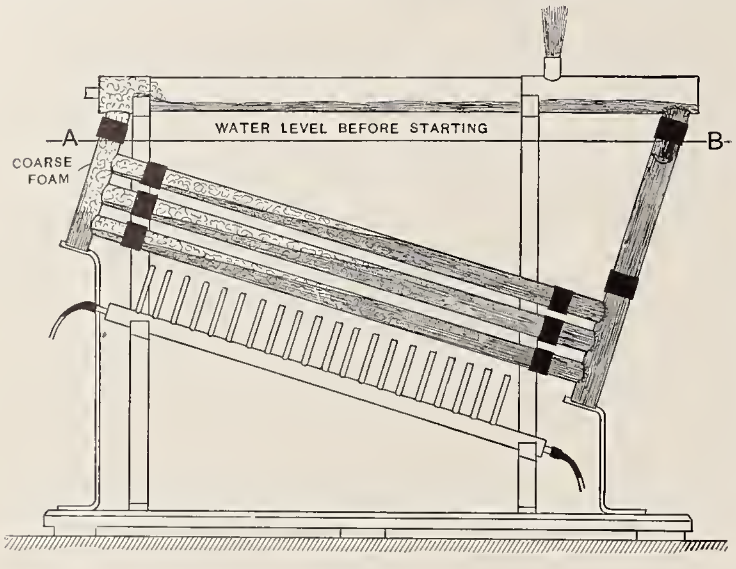


FIG. 7

and ductility of iron and steel are liable to variation with increase of temperature. This action has been made the subject of careful investigation by several workers, from Sir William Fairbairn onwards, the latest results for wrought iron and steel being due to Dr. Kollmann, Professor Martens, and Professor Carpenter. All of these show rapid loss of strength at high temperatures.

In connection with this point Mr. Stromeyer's estimate of the time required to overheat a boiler plate is of interest. Assuming that water is prevented from coming in contact with the plate, and that only steam is present on one side and fire on the other, Mr. Stromeyer says:—

"The rate at which the plate temperature rises, at least at first, can be roughly estimated on the assumption that it receives heat from the fire, but loses hardly any to the steam. The specific heat of iron being 0.11, an evaporative unit of heat (= 966 B. T. U.) entering an iron plate one foot square one inch thick (weight 40 pounds) would raise its temperature by 220 degrees F. We know that at a temperature of about 600 degrees F. the elastic limit of mild steel is reduced to about one-half of what it is when cold, while at about 1200 degrees F. the elastic limit is reduced to about one-eighth.

"If we consider a furnace plate half an inch thick exposed to a moderate heat, such as will evaporate 20 pounds of water per square foot per hour, then if the water level be lowered so as to expose the plate, its strength will be reduced one-half in the same time that one and three-eighths evaporative units would have been transmitted. The time required to do this would be eight and one-half minutes. Therefore, after exposing a plate to such heat conditions for eight and one-quarter minutes, bulging might be expected at any time, and in seventeen minutes such a furnace plate would retain only one-eighth of its original strength, and would most certainly have given way unless the original factor of safety for compression were greater than 8. If, as in water-tubes, the metal is only $\frac{1}{8}$-inch thick, such temperatures as 600 degrees F. and 1200 degrees F. will be attained, respectively, in one-quarter of the periods just mentioned, or, say, in two to four minutes; but as such tubes have a factor of safety of from 30 to 40, one need not expect bulging before two minutes have elapsed, and, even after four minutes, rupture need not necessarily take place. The fact that bulges are not infrequent shows that such tubes have to stand much more than is generally believed."

Dealing with the part played by incrustation or lime "scale" in producing bulging, Mr. Stromeyer referred to the theory here as being that the lime scale prevents access of water to the plate surface, but allows a film of steam between plate and scale which permits almost any amount of overheating to take place. The conductivity of ordinary lime deposits is, however, much greater than that of a layer of grease.

"Roughly speaking," Mr. Stromeyer remarks, "scale of 1-10-inch thickness offers as much resistance to the passage of heat as does a film of grease 1-100-inch thick, or a plate of steel 10 inches thick," so that it is of great importance to exclude oily matter from the interior of boilers.

There are several other interesting subjects intimately connected with the science of steam generation, the consideration of which space restrictions here forbid. Such subjects are the effects of high pressure on the temperature of boiling and on the various chemical actions concerned in boiler incrustation and corrosion; the action of air in boilers and the means of its entrance; methods of cooling the waste combustion gases, and the comparative efficiency of feed-heaters and air-heaters.

The writer passes over these to notice a practical point connected with the action taking place in boilers as at present arranged. In almost every case the heat is applied to boilers at a low point in the structure, whether the form embrace horizontal or vertical water-tubes. The effect of this is illustrated in Figs. 5 to 8. Fig. 5 illustrates an experiment by Charles Bellens to show that with very slight inclination from the horizontal, and freedom to move in either direction, the currents of water produced were somewhat mixed. When their direction was controlled as in Fig. 6, and as it is in most horizontal-tube boilers, the steam is rapidly collected at the top surfaces of the tubes, as shown at *A*, *B* and *C*, and also in Fig. 7, steam or a mixture of steam and froth filling a good space at the top of the tubes and in the upcast passages. This leads to unequal heating and to consequent stresses on tubes and joints. It will be noticed also that a considerable quantity of water is forced up above the normal water level and has to return by downcomer passages.

This result is also plainly witnessed in vertical-tube boilers, in which the greatest heat is applied at the lower ends of the tubes, as in Fig. 8, and from the point of view of heat transmission the writer believes we should look upon this action as a defective one. A good deal of the water so thrown up cannot have the temperature of the steam, but can borrow heat from the steam, and, moreover, must lose heat probably by radiation in the operation of returning by downcomer passages which must not be exposed to the full heat of the fire. We have very little appreciation, until the

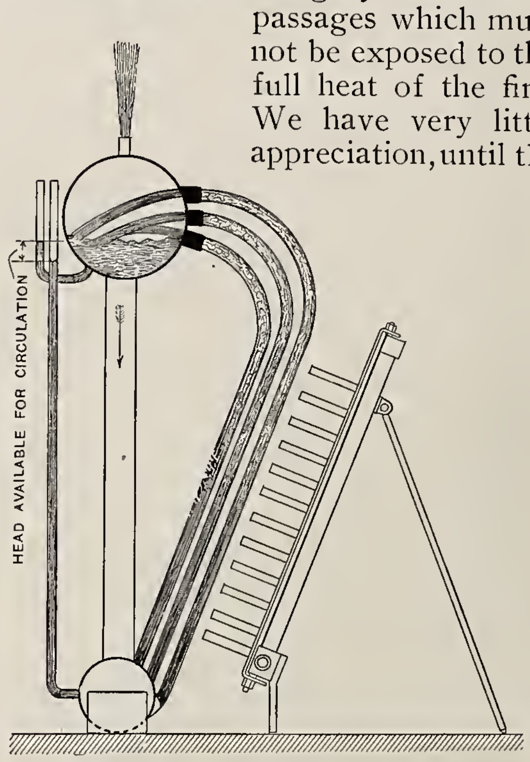


FIG. 8

question is raised, of the magnitude of the action which this involves.

W. H. Booth has made a calculation founded upon a given rate of evaporation, and, therefore, of cubic space occupied by steam as found at a given pressure in water tubes and of its necessary speed of movement. For boilers of the small-tube variety, with tubes about 1½ inches in diameter, 5 feet long, with 20 square feet of grate surface and a ratio of tube to grate surface of 45 to 1, there might be 600 times the amount of the boiler feed circulating in the useless way de-

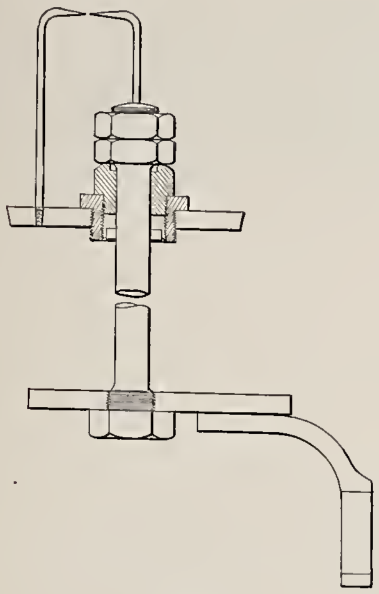


FIG. 9

scribed. Mr. Thornycroft claimed to have measured 100 times the feed in one of his boiler models, and Professor Watkinson claimed 240 times the feed from his calculations based on the action of glass models, and any of these figures represents a very large quantity of water in a boiler even of moderate dimensions.

For instance, in Mr. Booth's example, with 450 tubes evaporating 1170 gallons per hour, if 600 times the feed were the quantity passing by the downcomers per hour, that would mean 700,000 gallons in that time. This is probably an extreme case, but the writer refers to it in order to direct attention to what strikes him as a defect in the present system of applying heat to water tubes. Means for eliminating it will most certainly be devised as time goes on.

Before concluding this rapid survey there are some considerations affecting the form of a boiler which claim notice. The action of pressure in altering the forms of some boilers has

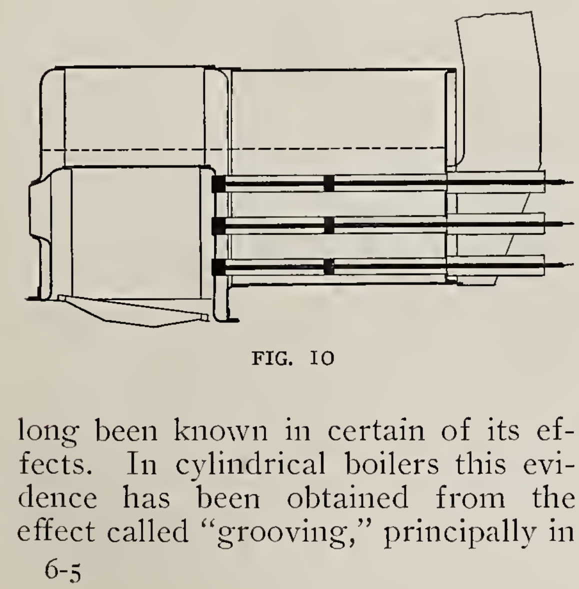


FIG. 10

long been known in certain of its effects. In cylindrical boilers this evidence has been obtained from the effect called "grooving," principally in the neighborhood of lap and butt joints; but, of course, the necessity for having stays to support flat surfaces is a distinct testimony to the same action,—that is to say, it is an attempt to prevent it. The reason of it is found in the law of fluid pressures which is known as Pascal's law. Apart from the action of gravity, this law states the fact that pressure exerted upon a mass of liquid is transmitted undiminished in all directions, and acts with the same force on all equal surfaces and in a direction at right angles to these surfaces. The tending of such an action is, therefore, to cause any vessel which is subjected to internal pressure to assume the form of a sphere, and where there are irregularities of form, or greater departures from the spherical in some portions than in others, greater strain will be thrown upon such portions or their immediate connections.

Some interesting measurements of such deformations under the influence of pressure in cylindrical or Scotch marine boilers were given by J. T. Milton in a paper before the Institution of Naval Architects in 1893. The fact, too, that the load borne by any vessels, or portion of a vessel, is proportional to the area, gives the reason why with boilers of the cylindrical or drum type the weight of material has to be very greatly increased with increase of pressure, and shows us that we can have lighter scantlings of material and yet far greater strength in boilers properly designed with small areas, such as some of the water-tube class.

There are, in addition to these pressure stresses, strains set up by the action of the heat, which must be provided for. These temperature stresses amount, in the case of good wrought iron or steel, to from 186 to 190 pounds per square inch of section per degree Fahrenheit increase of temperature, and in the case of cast iron to about 100 pounds per square inch. Expressed in another way, we may reckon what the stress is by taking a bar of wrought iron one inch square in section and finding that the elongation or stretching of that bar, when cold, by the dead pull of one ton weight, will be exactly reproduced by heating the bar 16.8 degrees F. The effects of a force of 12 tons would, therefore, be produced by heating the metal 200 degrees, and of nearly 24 tons if it were heated through 400 degrees. We cannot wonder that under the action of such a force, when due provision has not been made for it, cylindrical boilers have been torn through the solid shell plating, or that tube plates have become deformed and tubes have been crushed out of proper contact with them at their joints, or that the tubes of some water-tube boilers have become bent and leaky.

A. F. Yarrow made use of the apparatus shown in Fig. 9 to demonstrate the expansion of the vertical stays nearest the tube-plate in a locomotive type marine boiler, and stated that the movement was often sufficient to enable a penny to be inserted between the nut on the stay and the gland of the stuffing-box. Mr. Yarrow also used bars fitted through tubes at different levels in the boiler, as is shown diagrammatically in Fig. 10, to register the bending of the tubes through unequal expansion. As both ends of the tubes were held rigidly in tube-plates, any expansion in individual tubes must produce either bending of the tube or distortion of the tube-plates. Probably both happened, but the rods in Fig 10 very plainly indicated the course of the heating. The top tubes commenced to bend first, then, after an interval, the second bar, and, later, the lowest bar moved. When steam pressure was got up, the pressure, forcing the tube plates asunder, straightened the tubes.

Although these experiments were carried out with fire-tubes, they convey lessons which are applicable also to water tubes, and show that a properly designed boiler must possess ample provision for the action of natural forces which come into play during its working. That provision is not made in many boilers, and its absence leads to frequent repairs.

The intermittent character of many of these strains, whether produced by direct pressure or due to the action of heat, rather intensifies their bad effects.

It will thus be seen that we have a many-sided problem before us in designing or even in considering a steam generator, and although the writer cannot but feel that he has given a very inadequate account of the subject, he hopes that he has at least indicated the vast field of possible improvement which awaits all the skill and energy which can be brought to bear on it.

Along the line of the Aurora, Elgin & Chicago Electric road in Illinois there are twenty farms using current of about 25,000 kilowatt-hours a month.

It is announced, says "The Electrician," that the steamships "Caledonia" and "Columbia," of the Anchor Line, are to be fitted with Marconi wireless telegraph apparatus, and that these are the first steamers trading from Glasgow to adopt wireless telegraphy.

From the World's Technical Press

Electromagnetic Surgery

SOME remarkable instances of the use of powerful electromagnets in surgery are given in the "Scientific American," among which may be mentioned a case in which a piece of a hammer head had been driven into the muscles of the upper arm, and another in which a piece of a chisel had become embedded in the forearm. The surgeons advised no operation, trusting that the pieces would work out of themselves; but, instead of this, the wounds festered, so an electromagnet was tried. The result was completely successful, the pieces immediately appearing on the magnet.

Similar success attended the extraction of a chip of steel that had been embedded in the palm of a man's hand for one and a half years, another piece of steel that had been in the back of the hand for seven years, and a broken sewing needle that had caused much pain. In all these cases the particles appear to have made their exit through the channel by which they entered, and without any surgical operation.

The most suitable form of electromagnet for this purpose had a core 4 feet long and 6 inches in diameter, and was insulated with special cartridge paper. With this was used a current of 30 amperes at 110 volts pressure.

Free Lamp Renewals and Advertising Signs

FREE lamp renewals, says the "Western Electrician," are now supplemented in some of the larger cities by free electric signs. The central-station company supplies the sign, lettered attractively to advertise the customer's business, and furnishes it to the user free of charge under a contract by which the subscriber agrees to take the current to illuminate the sign for a specified length of time and at an agreed price. Title to the sign naturally rests with the electric light company. By this arrangement the merchant gets the use of the most modern and striking of all signs simply by paying for the electricity needed to operate it after dark, although the sign is a good one in day light as well. The central-station company, by the arrangement, creates absolutely new business.

Incandescent Lamp Abuses

IT is safe to say, remarks "Cassier's Magazine," that the incandescent lamp is the most familiar piece of electrical apparatus in existence, and, from the operating standpoint, the simplest contrivance known to the art. Its reliability is now so well assured, through improved processes of manufacture, that it may fairly be considered as standardized. The absence of papers and discussions upon the subject at gatherings of electric light engineers, and in the technical press, bears witness to this. At the same time, the incandescent lamp is often abused in practice, and charged with faults which it has never committed.

There is the question of its life, for instance. Central station managers generally appreciate the need of knowing what the lamps on their circuits will produce in candle power and what they will stand in voltage variations. Consequently, many an electric lighting company maintains a testing laboratory at considerable expense in order that its equipment may be scientifically studied at regular intervals. The isolated plant, however, seldom tests its lamps. If it were necessary for each isolated plant in a city to fit up and operate its own testing laboratory there would be better reason for failing to study equipment.

An organization of isolated plants for the common good in a given city would be a step in the right direction. What is wanted is a certain community of interest. There are a good many engineering schools whose laboratories might just as well be testing commercial lamps as the time-honored samples which have done duty in the educational institutions themselves for several successive classes. The advantages of testing remain to be appreciated in many quarters. Even in installations buying current from central stations, it is a good thing to put a voltmeter plug into a lamp socket now and then. Presumably everyone realizes the fact that a slight increase in voltage above normal tremendously shortens the life of the incandescent lamp, and yet plant after plant goes on, year in and year out, without making the simple periodic measurements which will show how matters stand. It is safe to say that a consumer located two or three miles from the central station who puts a voltmeter across his meter circuit, supposedly 500 volts constant potential, and obtains readings varying from 570 to 260 volts, does not regret having made the test.

A great deal remains to be done in the proper use of incandescent lamps, however, besides keeping an eye upon their life. The illumination of rooms under different conditions is a subject little understood by the general run of isolated plant owners and operators. It is unfair to the incandescent lamp to charge it with injuring the eyesight if the lamp is so installed that its direct rays enter the eyes without the intervention of a shade. There would be no need of calling attention to such a simple matter as this, were it not for the constantly recurring examples of bad practice.

It is strange that in so many plants there should be so much complaint about the dimness of incandescent lamps which have been in use for some time, when the simple process of wiping the bulbs with a damp cloth would increase the illuminating efficiency wonderfully. There is little use in discussing the expediency of raising the voltage, rewiring the leads, or worse yet, cutting out the installation in favor of gas, as long as the incandescent bulbs are allowed to accumulate weeks' deposits of dust and grime. Perhaps this form of neglect is the greatest abuse which the incandescent lamp is obliged to suffer. It is a rare sight to find anyone dusting lamp bulbs in factory or office or even in a dwelling.

Pertinacious Currents

IN his experiments in fog-dispersion, Sir Oliver Lodge has used what he termed "pertinacious" currents. At the Royal Institution recently, says "The Electrical Engineer," of London, he told the nature of the currents to which he had given this name. By it he simply meant a high-potential continuous current, which was obtainable from a voltaic battery with a quantity of cells in series, though that was an inconvenient and expensive method. An alternating-current dynamo could be reversed by means of the commutator, so that an approximately steady current was obtained, but with commutating devices it was not easy to employ high voltages.

One way of obtaining high-potential continuous currents was by the use of a one-way rectifier. If a current were taken through the primary of a Ruhmkorff coil and a Caldwell break, and the secondary was connected to a number of Leyden jars, the provision of a rectifier which would allow the supply current to pass one way, but prevent all exit the other way, would enable the jars to be charged to bursting pressure, so that they could maintain a pertinacious current through a leak or other high resistance with which they might be provided. An arrangement of this type was of service for fog dissipation.

He suggested that the action of the rectifier was due to the rapid clearing away from the anode of all the carriers of positive electricity, by means of the bombardment from the cathode, and to the fact that the current could only be conveyed by the agency of these positive carriers when they were allowed to come into actual contact with the positive terminal. The bombardment was found in time to create so high a vacuum in the vessel that no current at all could pass. It was therefore necessary to employ in the rectifier a vapor, such as that of mercury, the supply of which could easily be maintained from inside the vessel.

Measurements of High Temperatures

THE melting points of the metals, their alloys and their salts, have long supplied a familiar means of measuring temperature; but the difficulty of procuring a sufficient number of substances of ascertained melting-point has, until recently, prevented the general application of the method. This difficulty no longer exists, says "The Engineering and Mining Journal," for Seger cones having melting-points ranging from 590 degs. to 1850 degs. C., with intervals of about 20 degrees C., are now procurable from any dealer in chemical apparatus.

In describing these cones, Thomas Gray, in a paper read before the Scottish section of the Society of Chemical Industry, says that they consist of triangular pyramids composed of kaolin, mixed with silica, boric acid, and various metallic oxides in the necessary proportions to form a graduated series. The melting-point of the various compositions have been determined by Hecht with the help of a standard thermo-couple. In applying the method, a number of cones, having a range of melting-points which includes the temperature to be measured, are placed on a fire-clay plate and introduced into the furnace. If the cones have been properly chosen, the first members of the series will be observed to melt, while the last will remain unaffected. The melting-point of the cone which just softens sufficiently to cause the apex of the pyramid to bend down to the base-plate is taken to be the temperature of the furnace.

By the calorimetric method, a cylinder or ball of metal is heated in the furnace and dropped into a measured quantity of water; from the rise of temperature of the water, the temperature of the furnace is calculated. The metal used may be platinum, nickel, copper, or wrought iron. Platinum is to be preferred, as it does not oxidize when heated, and has no chemical action on water. The total heat of platinum up to 1600 degs. C., namely, the amount of heat which 1 grm. of the metal gives out when cooled from the various temperatures down to 0 deg. C., has been carefully determined. From a chemical point of view, nickel is more suitable than iron; but the determinations of the total heat of nickel by different observers do not show a very satisfactory agreement. Iron is the least suitable metal chemically, as it oxidizes, scales, and decomposes water at high temperatures, but it possesses the advantage of being always available, and the cylinder is thus easily replaced.

In the thermoelectric method, the electromotive force, which is generated when the junction of two dissimilar metals is heated, is measured; and from the value of this, the temperature of the heated junction is deduced. The metals which are suitable for this purpose must have a high melting-point, and should not alter in structure and composition when heated; they must also be perfectly homogeneous. Platinum and the metals of the platinum group most nearly fulfill the conditions referred to above. The thermocouples used practically are composed of wires of platinum opposed to an alloy of platinum either with 10 per cent. of rhodium, or with 10 per cent. of iridium. The wires of the couples are joined by fusion in the oxy-hydrogen flame, insulated by threading through perforations in a porcelain rod about one-quarter inch in diameter, and the free ends of the wires are connected to terminals in a wooden handle. As the composition of the wires is rapidly altered by exposure to heated furnace gases, the couple is enclosed in a porcelain tube, glazed within and without, which is some times encased in a wider iron tube to minimize the risk of fracture.

For occasional observations of temperatures up to 1000 degs. C., the calorimetric method, using an iron cylinder, will be found serviceable. The comparatively trifling cost of the apparatus is its chief recommendation. For higher temperatures, a platinum cylinder may be used; but care must be taken to avoid loss of heat in transferring the cylinder from the furnace to the calorimeter.

The Cultivation of Rubber

IT has been asked, says "The India-Rubber Journal," of London, that, considering the high profits attached to the planting of rubber, why it is that more people are not engaged in it. The answer is that for years a great deal of experimental work was required and many failures occurred owing to lack of knowledge. Now, however, the conditions essential to the success of rubber planting are better known, and consequently good results are being obtained. The reason why more people are not interesting themselves in the industry is on account of the long wait of seven years which is essential in the cultivation of rubber, and the memory of terrible fiascos is also too fresh in their minds.

In cultivating rubber, the land selected must, of course, be suitable. There need be no difficulty about this, as large areas in Ceylon, the Straits Settlements in the Malay Peninsular, etc., are available. It is also essential that the climate should not be unhealthy for Europeans. Many previous ventures in rubber planting have failed on this account. Planters have, of course, various methods of proceeding with the cultivation, but the following may be taken as the usual one:—

The seeds are planted in a nursery and allowed to grow until they are about 6 feet in height. The trunk is then lopped off to about 3 feet, and the young tree transferred to the plantation. The ground has by this time been cleared of forest growth, and these young plants are then planted at the proper distance apart, the average number to the acre being about 200. The plantation for the first year or two must be kept fairly well weeded, but when the trees have grown to some height very little further attention is required.

The total expense of buying, clearing and planting 200 acres, including the cost of white superintendence and labor, as well as the expense of erecting the necessary buildings, etc., and maintaining the plantation up to the end of the sixth year, can be taken as not more than £4200. This figure has been arrived at after careful calculation of all expenses, and it may be said that in several cases, at least, plantations have been brought up to the sixth year at a lower rate than this.

At the end of the sixth year the rubber trees can be tapped, and it can be safely reckoned that half a pound of rubber per tree can be depended on. Two hundred trees were planted to the acre, but it is well to allow for a mortality of 5 per cent. among them; this brings the total number of trees in 200 acres to 38,000, and these yield during the seventh year 19,000 pounds of rubber. Taking the average net profit on this rubber at 4s. per pound (cultivated rubber fetched on an average 6s. 4d. per pound for the last few months, but taking the possible price at only 5s. per pound and leaving 1s. per pound for the cost of collection, preparation, freight, brokerage, etc.), this gives a return during the seventh year of £3800. Allowing £800 for the cost of white superintendence and maintenance of the plantation for the year, this leaves a profit on a year's working of £3000. During the eighth year 1 pound of rubber can safely be reckoned on from each tree, bringing the return on the plantation up to £7600.

These figures, it will be admitted, are somewhat too generous looking to be believed; yet there is ample evidence to show that they are genuine enough. Put into brief statement, it can be said that a rubber plantation of 200 acres will cost £4200 to bring it on to the end of the sixth year, and, guaranteeing its suitability, proper soil, and in a proper climate and under efficient superintendence, it will in the seventh and eighth year return the total capital invested, and every year thereafter yield an income of between £4000 and £5000.

Small Size Carbons in Enclosed Arc Lamps

In a paper read before the Chicago branch of the American Institute of Electrical Engineers, George N. Eastman gave the results obtained in determining the variation of candle-power by varying the size of the carbons in a direct-current enclosed arc lamp.

The different sizes of carbons tested were obtained by turning down the standard ½-inch carbon to the desired size, care being taken that no shoulder was left on the lower carbon which would shadow the arc. The length of the carbon turned down varied from 1½ to 2 inches.

The mean lower hemispherical candle-power for the various sizes of carbons tested and their corresponding efficiencies are given as follows:—

Variation of Candlepower with Size of Carbon. 80 Volts—3-5 Amperes.

Size of Carbon.	Arc Volts.	Arc Amps.	Arc Watts.	M. L. H. C. P.	Watts Per M. L. H. C. P.
⅛ inch........	80	3-5	280	417-6	.672
3-16 inch......	80	3-5	280	353-6	.787
¼ inch........	80	3-5	280	255-4	1.095
5-16 inch.....	80	3-5	280	255-4	1.095
⅜ inch........	80	3-5	280	228.8	1.223
7-16 inch......	80	3-5	280	211-4	1.325
½ inch........	80	3-5	280	182-6	1.533

The principal objection to the smaller-sized carbon is the shorter life and the resultant increased cost of trimming. The increased cost of carbons is such a small part of the total cost of maintenance that it need not be considered. Another point in favor of the use of small carbons is the decrease in light due to the carbon deposit on the inner globe. Where ½-inch carbons 12 inches long are used and allowed to burn throughout their entire life without cleaning the inner globe, the light is decreased from 40 to 50 per cent., due to the deposit of carbon. This deposit varies in proportion to the size of carbon, and is therefore an important factor in the selection of the size of carbon to be used.

Taping

The most obvious use of tape, says C. Stephens in the April number of "The Electric Club Journal," is to provide a permanent mechanical separation of conducting materials and to maintain a gap between two conducting wires, or a wire and the ground, which might be done by any non-conducting material, even wooden blocks. A good quality of tape, however, not only prevents the lodging of small conducting particles and dirt, but actually increases the dielectric strength of the gap. In other words, a good insulating tape will considerably increase the effective length of an air gap. For instance, 10,000 volts will puncture an air gap of approximately ¼ inch between spherical terminals. If the same air gap be filled with impregnated linen tape more than 40,000 volts will be required to puncture. A sheet of treated cloth 0.01 inch thick will stand a puncture test of from 4000 to 10,000 volts, while 10,000 volts will puncture almost ½ inch of air between needle points.

KINDS OF TAPE

Generally speaking, there are three classes of tape—(1) untreated cloth, (2) rubber, (3) treated cloth.

Untreated cloth tape may be of any fabric, such as linen, cotton or silk. When this tape is kept perfectly free from moisture it forms a good insulation. Its chief advantage, however, is its mechanical strength, which admits of rough handling during the taping process. After it is in place it is usually treated by brushing with or dipping in varnish or some other insulating compound. This increases the dielectric strength and prevents the absorption of moisture.

Rubber tape may be divided into two general classes—(1) those tapes without any cloth or other supporting body, (2) those with some supporting body. The first class of rubber tape is made up from a rubber compound. It is relatively thick, but being quite elastic the operator is enabled to obtain varying thicknesses by stretching. It is best adapted where the voltage is high and where there is plenty of room for insulation. In splicing rubber-covered cables this tape secures for the splice practically the same insulation as is on the body of the wire. The second class of rubber tape may be obtained in a variety of forms, the most common of which are viscous tapes. These tapes are sticky at ordinary temperatures. They adhere readily and, after drying for some time, become quite hard and offer considerable mechanical support. Viscous tapes vary considerably in thickness and cost, depending on the materials used in their manufacture.

Treated or varnished cloth tape may be sticky, or it may have a smooth, hard surface; it usually requires some binding material to hold it in place. Its insulating property is very high and, being very thin, it is well adapted where space is valuable, especially in insulating wires in slots of machines. However, it is not very strong mechanically and should not be used on rough or uneven surfaces, or where it is likely to be subjected to mechanical strains.

MOISTURE PROTECTION

A taped joint or conductor should be moisture proof. To insure this the tape should be wound very firmly. A good joint should be made between the tape and the insulation of the wire. In taping a splice the metal surface should be smoothed, using a file if there are sharp points or corners left from soldering. The surface should then be sand-papered slightly and wiped with a dry cloth to remove all dirt, dust and soldering fluid. The kind of tape used in any case will be determined largely by the space in which the conductor is confined. As a rule, a thin viscous tape is used on all ordinary work which is subjected to moderately low voltage. When the voltage is high and the insulating space is very limited, and especially where the conductor comes in contact with the iron parts of a machine, the conductor should be taped with treated cloth and finished with a taping of untreated cloth, and then the whole thoroughly shellaced or varnished.

United States Naval Wireless Telegraph Experiments

IN the winter maneuvers of the United States naval vessels in the Caribbean Sea thorough experiments were made with a number of systems of wireless telegraphy.

It was found, says "The Army and Navy Journal," that although there was from 20 to 25 per cent. difference in the efficiency of the upper and lower stations on the "Kearsarge" for extreme distance of transmission or reception in favor of the former, there was no observable difference in the reliability of the two stations within practical working range of the lower station.

By the use of an interference preventer it was found that any wave varying in length by as much as 3 per cent. could be excluded from the wave to which the preventer is adjusted, provided the intensity of such interfering wave is not greater than that of the wave to be received. Although the adjustment of the interference preventer is difficult, when once made it is practically constant.

As to the necessity for a "call," it was found that this varied with the operator and the work of the station. If the station is working nearly all the time, the operator on watch would keep on a head telephone and needed no other call. If there are enough operators it is said the telephone can be worn constantly even if there is little work for a station to do, but it will take as many operators to stand such a watch as if the station was working constantly. Where the operators are few and the station is liable to be called up any time, some sort of call is needed, and with the normal working of a ship, the call is said to be "highly desirable."

It was found that the influence of weather, both on sending and receiving, was very marked. The energy sent out by a transmitting station was diminished by hot, sultry weather and bright sunshine, twice the usual energy being required on such days. Transmission is easier by night than by day and is most difficult between the hours of 10 A. M. and 4 P. M. Atmospheric discharges frequently interfere with reception.

So far as it was possible to find out, there was no material difference in the transmission with, against or across the earth's magnetic field. Generally speaking, the greater the actual surface of the effective or upper part of the aerial wire, the more powerful the station is for transmitting.

In the test of the wireless chain between ships, a speed of 250 miles per hour for a message of twenty-five words was obtained at relaying intervals of 40 miles, and over 400 miles for ten-word messages at the same intervals.

The wireless experiments this winter confirm the Navy officials in the opinion that wireless telegraphy is still in an experimental stage, and show the utter absurdity of the claim that any one system has been perfected.

Interesting experiments in wireless telegraphy are to be made on the "Lebanon," which is to be fitted out as a wreck destroyer in accordance with the recent law passed by Congress providing for the destruction of derelicts. The "Lebanon" is to be fitted with wireless instruments provided with an improved apparatus invented by the Stone Telegraph & Telephone Company, of Boston, which it is claimed will prevent interference by other systems. The instruments of Mr. Stone, it is also claimed, are practically "fool proof," that is, they can be manipulated by men with little training in wireless telegraphy. It is possible the Stone instruments will also be placed at several shore stations for experimental purposes.

Hydro-Electric Mining Plants

ONE of the important developments of the past year in mining has been the extended application and adaptation of electric power to mining uses. It is a fact to be recognized, says "The Mining World," that the European mines have set the pace in the matter of utilizing electrical appliances, but the year just passed has witnessed a number of installations in America that would indicate that the full necessity and importance of this modernization is recognized by the American operators.

The California mines have installed numerous hydro-electric plants recently, mostly on a comparatively small scale. A considerable project is under way to develop power in the mountains for use in some of the Arizona mining camps. The electrization of the Joplin mines is already an accomplished fact, and it is claimed that the operating expenses will be materially reduced by the change. The projected water power development at the head of Lake Superior, which has been planned for some time and is now definitely under way, includes supplying power to the iron mines of the Mesabi and Vermilion districts. It has often been commented on that the Vermilion iron mines, which are located in a district where there is abundant water power, have so far failed to make any attempt to utilize the power for mining purposes. These recent developments, with the electrical installations already in, are certain to be followed by extensive utilizations of electricity in mining wherever current can be obtained from water power within the widely extended range of economical transmission.

In Mexico the installation of hydro-electric plants is going on at a rapid rate. A most important example is the case of the famous El Oro camp, which will utilize power from the Necaxa plant, just built. The supply of coal in Mexico is confined to a remote part of the country as transportation is at present provided, and the necessity of utilizing the water power is also the greater for this reason. This water power is called "carbon blanca" (white coal), and it is certain to play an important part in the future development of the mining industry in Mexico. In South America likewise there have been numerous hydro-electric installations, and the future development of mining in those countries is likely to be greatly affected by this new agency.

The utilization of the hydro-electric power for all mining purposes is bound to increase in every mining district where the conditions will permit its utilization, and the result will certainly be a general cheapening of the production and an increase of production in many cases.

Phase-Indicator for Electric Currents

WHEN two circularly polarized fields of equal amplitude, but of opposite directions, are superposed the resulting field will be linearly polarized, and its azimuth will depend only upon the phase difference of the two original fields. This principle, says "Engineering," of London, has been applied by H. Th. Simon, of Gottingen, to the construction of a phase-indicator for electric currents which permits of interesting applications. When two rotating magnetic fields are superposed an alternating magnetic field will result, whose azimuth will indicate half the phase difference of the two original fields.

Any phase difference between 0 and 2π can thus be measured, independent of the frequency—which influences other phase-indicators—and the phenomenon can well be demonstrated with the aid of two small tri-phase generators and a Braun tube, which shows the deflection of cathode rays by magnetic fields. The shafts of the two generators are coupled, and the currents of the generators are taken through two pairs of three coils, wound about a ring of iron. Each generator produces a revolving magnetic field, and this field acts upon the cathode rays, which undisturbed would mark a fluorescent spot. Each field tends to move the spot around in a circle, and when both fields are excited a fluorescent line becomes visible, whose azimuth will change when the phase difference between the two current systems is altered. Such a change can be brought about, for instance, by an alteration in the coupling; if the coupling is formed by an elastic shaft, the torsions of this shaft will become apparent.

As the cathode tube is not convenient, Simon described another arrangement in the communication which he made last September to the Naturforscher-Versammlung—which corresponds to the British Association—during its meeting at Breslau. The iron ring is placed horizontally and a length of a magnetized steel wire is fixed in the axis of the ring in such a way that a little mirror, attached to the top of the wire, lies in the plane of the ring. The wire is made to oscillate like a chord. A ray of light falling normally upon the mirror will then indicate the azimuth of the oscillations, which is observed on a graduated circle above the ring. The device can be tuned, and thus be rendered fairly sensitive, though it does not possess the high sensitiveness of a galvanometer.

Another arrangement is suitable for examining the uniformity of the working of an electric motor. If we imagine each of the two generators to drive a synchronous motor—the two would revolve in opposite directions—and fix a disc with one slot to the shaft of each motor, then rays of light passing parallel to the shafts will mark on a screen a line of light corresponding to the phase azimuth; and if the two discs revolve in front of a graduated dial, only the division indicating the phase difference will be visible. In practice one slotted disc is fitted to the flywheel of the motor in question, the other to the engine shaft. With similar arrangements the torsional vibrations of propeller shafts can be studied at a distance. Simon particularly recommends his device, however, as a substitute for the compass on iron ships. If we use the horizontal component of the terrestrial magnetic field as field for the one generator, couple the generators and place their axes vertically, then the one field will be stationary in space and the other will change its direction with the position of the ship. The phase difference read off will hence mark the deviation of the ship's axis from the magnetic meridian, and the whole device would replace a compass. Similar proposals have been made by L. Weber and others, but have not been adopted on board and we are afraid, adds "Engineering," that Simon's instrument will not be more successful. But reliable phase-indicators are useful.

The Action of Radium on Electrical Resistance

ACCORDING to "The Scientific American," M. Bronislas Sabat recently made a series of experiments in M. Curie's laboratory as to the action of radium rays on the electric resistance of different metals. The rays were obtained with the strongest preparation of radium in the laboratory, namely, a bulb containing 0.2 gramme—0.00705 ounce—of pure radium bromide. Thin wires of the different metals were rolled around paper tubes in order to form a resistance coil, and the radium bulb was placed in the center of the tube. The rays of the radium thus act upon the wire.

As an example, an iron wire which started with a resistance of 4.64 ohms, at once rose to 4.66 under the first action of the rays, and after five minutes' action rose to 4.68, which is the maximum effect. After removing the radium, the wire comes back to the original resistance in a few minutes. For iron, this gives a difference of 0.776 per cent. In the case of a platinum wire of the same diameter (0.1 millimeter, or 0.0039 inch), he finds 0.257 per cent. For German silver, it is but 0.092 per cent. Bismuth shows 0.284 per cent.

The variations depend upon the size of the wire and the absorbing power for the rays, etc. A certain increase of resistance is thus found at once, and before the heat is communicated from the radium. The greatest variation of the resistance sometimes goes beyond the point which would be reached by the heat sent from the radium alone, and it is probable that the metals absorb the rays and these are transformed to heat; raising the temperature of the metals absorbs the rays and these are transformed to heat, raising the temperature of the metals and then changing their electric resistance.

Electric Cranes for Extra Heavy Lifts

SOME time ago, writes E. K. Scott in "The Electrical Review of London, the representative of a large firm of hydraulic crane builders cast doubts on the ability of electrical cranes to handle heavy guns for warships, or complete trucks of coal. He was, of course, thinking of the hydraulic accumulator, which is such an important adjunct to the hydraulic crane, and so hard to beat for simplicity, cheapness and efficiency. It is clear that, on account of the extremely varying load, if large electric cranes are to be employed at all for such purposes, they must be used in conjunction with electric accumulators.

The conditions to be met are somewhat similar to those on an electric tramway having only a very few large cars running, and for such work the reversible booster has been successfully employed for some years. This has the advantage of enabling the main dynamo to work at a steady load, sending current into the battery or into the outside circuit, just as may be required, the action being entirely automatic.

In a particular case with which Mr. Scott had to deal, and which was the first example of the kind in England, the dynamo normally gave 100 amperes at 315 volts, whilst the cranes on occasion might take as much as 350 amperes. When the cranes were making a heavy lift, the balance of the current of 250 amperes was supplied momentarily by a storage battery.

When charging, the booster adds about 15 volts to the dynamo pressure, and when discharging, the total ampere-turns due to the series coils completely overcome the ampere-turns of the shunt coils. The magnetism of the field magnets is thus reversed, and about 20 volts added to the battery discharge, so that the pressure at the cranes is kept about constant.

In the reversible booster and the storage battery the electrical engineer has two helpmates which will enable him to successfully undertake the very heaviest work he may be called upon to tackle—in fact, anything which is to-day done by steam or hydraulic power.

The Production of Mica

MICA, in its indifference to high temperatures and non-conductivity to electricity, says "The Mining Journal," of London, possesses physical characteristics which give it a unique position as an article of commerce, particularly in relation to electrical work for insulation purposes, and in minor degrees for lantern slides, negatives, and as a base for paints and explosives. Among other things, the mineral is distinguished by a particularly wide range of geographical occurrence, as also by a large series of mineralogical forms.

The three most valuable occurrences of mica are muscovite, phlogopite and biotite. The first mentioned, which is found in a variety of colors, is mined in India, and in lesser degree in German East Africa and Brazil. Phlogopite is worked in India, Ceylon, Canada and Brazil. In order of importance the three chief producing countries are British India, Canada and the United States. The exports of the Indian mines in recent years are: 1902-3, 20,412 cwts., valued at $426,595; 1903-4, 21,548 cwts., valued at $420,275.

From the technical point of view, Canada affords the most interesting field for inquiry, since it is here that efforts are being made to work the mineral on a substantial and organized scale, and not merely from hand to mouth. The existence of an unlimited supply of cheap labor has occasioned a singular crudity of method in the Indian mines. Although the finest quality, as well as the largest quantity, comes from the peninsular, the production is carried on absolutely without the use of machinery, the mineral and the waste material being passed to surface in small baskets by long lines of women, and unwatering operations being carried on by means of jugs.

Throughout the American continent, practice, although more modern, is still, owing to a variety of causes, of an archæan type. Miners in this branch seem peculiarly prone to the vice of dividing their profits up to the hilt, no proper development work being carried on excepting in certain well-known cases. In Canada the open quarry method is still largely followed, notwithstanding the dangers occasioned by the heavy frosts.

In the Lacey mine, Ontario, however, modern machinery is used and the example of adopting the power-drill has been furnished. A high proportion of waste occurs, the finished product averaging only some ten to twenty per cent. of the output. It is hoped, however, that with improved methods of treatment the proportion may be made less disadvantageous.

The Canadian output at present shows an inclination to decline, being valued at $166,810 in 1903 and $159,175 in 1904, though estimated as high as $410,960 in 1902. The American output, which is chiefly small mica—the quality most affected by tariff conditions—shows a steady decline in value since 1900. The decline in values at the end of the century was due to a sudden demand for small mica for the micanite industry, which, of course, lowered the average quality of the mineral exported. The industry in India employs about 9000 persons, and is worked on a $1.25 gross royalty basis.

Osmium Electric Incandescent Lamps

THE osmium incandescent lamp is about as old as the Nernst lamp, but is as yet little known. The first experiments in electric incandescent lamps were made with metallic filaments, and these experiments have been continued, though the carbon filaments soon became a pronounced success.

Theoretically, says "Engineering," of London, bright metallic filaments are preferable as light radiators to carbon filaments. But platinum wires melt too easily. The success obtained with osmium is largely due to the perseverance of Auer von Welsbach. Distinguished by a very high melting-point, osmium has several properties which appear anything but promising for application as incandescent material. Like the rare earths, it was considered very scarce until a proper demand arose for it. Osmium and iridium accompany platinum and remain behind when the platinum is dissolved in aqua regia. The residue is alloyed with tin, and the finely divided osmium, which forms a poisonous volatile oxide, isolated by oxidation. The oxide can easily be reduced again, but the metal can neither be rolled nor drawn. In order to obtain wires, platinum wire was coated with osmium and the platinum volatilized; this expensive way afforded a very moderate amount of success, because a fusible alloy with 4 per cent. of platinum is formed.

A paste of osmium and organic compounds was finally prepared and pressed through diamond dies; the thread is received on cardboard, carbonized, and then baked in an atmosphere containing much water vapor and some reducing compounds. Under these conditions a filament of porous osmium, free of carbon, results, which is fixed into the electrically-fused ends of the terminals. The wire is brittle in the cold, and softens when glowing, so that the bulbs, fitted with closely-wound spiral filaments used in some lamps should always be held in the same position. All the early lamps were of low voltage.

The Deutsche Gasglühlicht A.-G., according to a lecture delivered by F. Blau before the Elektrotechnische Verein, first brought out 37-volt lamps, and the lamps with which most of the practical experience has been gained are of 37 or 44 volts. Their filament has a length of 280 millimeters, a diameter of 0.087 millimeter, and consuming 1.5 watts per candle, yields 25 candles, one candle per 3 square millimeters of surface. A carbon filament would, with 1.5 watts per candle-power, yield one candle per 1.6 square millimeters.

The resistance of the hot osmium filament is more than eight times as great as that of the cold metal. When the voltage rises by 10 per cent., the current therefore rises only by 6.5 per cent., and the light emission by 40 per cent.; with carbon filaments the figures would be: Current increase, 12 per cent.; light increase, 80 per cent. Small fluctuations in the potential, therefore, affect the osmium lamp very little.

The life of the osmium lamp is very long. The light emission rises during the first 200 hours from 100 to 110, and sinks then very slowly to 80 per cent. after 2000 hours. The new 110-volt lamps also show after 800 hours their original brilliancy. Many lamps have lasted 5000 hours. Cases of blackening by volatilization are rare, and of the lamps installed two years ago, less than 10 per cent. have been returned; the company makes an allowance for returned old lamps. These features demonstrate that the filaments could easily bear higher strains; but so far experiments in this direction have not been very successful. Three of the recently introduced 73-volt lamps are coupled in series on 220-volt circuits.

As a rule, the lamps are joined in parallel and coupled, after Ehrentrant's plan, with small transformers, consisting of one coil primaries, in such a way that the primary is itself cut out when the last of the group of lamps—no matter which one—fails. Though sensitive to blows the osmium lamps can be transported like ordinary glow-lamps, and used for train lighting.

Some Aspects of Electrical Engineering

By JAMES SWINBURNE, M. Inst. C. E., Past President Inst. E. E.

JAMES SWINBURNE

ELECTRICAL engineers, as recently told by the author in an address delivered to the students of the British Institution of Civil Engineers, have carried accuracy into commercial work; it is not confined to their laboratories.

If a mechanical engineer transmits power by belts, ropes, shafts, or what not, he has only the vaguest idea of how much he will lose on the way. The electrician knows within 1 per cent. how much he will lose in his conductors. It is the same throughout his work; he is always able to calculate beforehand exactly what his machinery will do. It is largely to the accuracy of the electrical engineer that we owe the modern scientific methods of testing steam engines. A large engine could not be run on a Prony brake; and in no case is a brake an easy or convenient method of absorbing and measuring power. Transmission-dynamometers are also anything but satisfactory. The indicator has all sorts of errors, and it gives only the power transmitted by the piston-rods; it does not give the real output of the engine. But as soon as the engine is coupled directly to a dynamo the output can be measured electrically with great accuracy.

The electrical losses in the dynamo are known, and the only uncertainty is the mechanical loss due to the dynamo-bearing, and the churning of the air. These are comparatively small, and can be calculated so that the error in them is too small to be important in comparison with the whole power. The indicator is thus used only as a tell-tale, to show if the steam is being used properly in the engine. The real measurement is made by measuring the water taken by the engine, and its temperature, pressure, and dryness, and the electrical output of the dynamo. I believe it is not too much to say that the accurate testing of steam-engines has been brought into use by the electrical engineer.

The motor again is a beautiful mechanism for supplying power at a constant speed just as wanted. For example, if you want to test the friction of a bearing, nothing is simpler than to drive it by an electric motor, with instruments showing the power taken. The motor gives a pure torsion, without any of the side-pulls due to any transmission-dynamometers, and the power is accurately measured. The bearing can have any weight put on accurately. It was not until electric driving came into use in machine shops that engineers got to know how much, or rather how little power, machine tools really took to drive them.

Electrical engineering has not been developed by engineers with some knowledge of electricity, but by electricians and other people who have often had very little knowledge of engineering. The early dynamos were made by opticians. The early Gramme rings were driven on to wooden hubs; and for a long time the field windings were painted red, because it looked like sealing-wax varnish. Opticians used sealing-wax varnish first as an insulator, until it came to give the correct scientific look to all electrical instruments, just as badly-designed hand-finished brass work with hand-chased screws is necessary in other scientific instruments. As dynamo machines got larger they came more into the hands of engineers. In fact, engineers owe a great deal to the dynamo. It was the dynamo that produced the steam turbine. The Parsons turbine for marine propulsion would probably never have existed if he had not begun on the dynamo. The modern high-speed engine also owes its existence largely to the dynamo. Willans was making launch engines before the dynamo came into use; but the modern Willans engine was developed in conjunction with the modern dynamo. The other high-speed engines of to-day have, probably without exception, been developed for dynamo driving in the first instance. In America, as far as I remember, the Armington & Sims and the Porter-Allen engines owed their development to the Edison dynamo.

The modern central station engineer ought to be both a highly competent engineer and a highly competent electrician. He is generally called upon also to deal with large financial questions. The advantage of a knowledge of electricity in this connection is too obvious to require further notice.

From the point of view of civil engineers who are not especially electrical, it may be interesting to see what electricity can do to help them in their own work. In the first place electricity may be used for signaling, as may be typified by the electric bell. Its object is merely to give notice or indicate at a distant point. The ordinary telegraph and the submarine cable are examples of this, and wireless telegraphy and telephony are developments. Most of the work in telegraphy and telephony is exceedingly simple, requiring very little scientific knowledge; but every now and again some problem crops up requiring the highest mathematical ability. But for the present purpose it is enough to realize in this connection that the electrical signal is available, and it is useful in a variety of ways; for instance, in telling the water-level at a distance.

In a slubbing machine the silver passing between two rollers insulates them. If the silver stops for any reason the rollers touch and an electromagnet stops the machine. In many weaving machines the breaking of a thread releases an electric trigger and stops the machine. The electric organ is a good example. In this case it is easier to control the electric circuits than a collection of mechanism in a tracker or tubular pneumatic action. It is very difficult to play modern large tubular pneumatic organs in time, because the time-lag between what you play and what you hear is considerable. You must therefore keep time with the music you think, not with what you hear, which is very troublesome. The electric action halves the time-lag at least. Again, in testing clothed flats for carding machines, the flat is passed under a bar, and if any of the wires touch it electrical contact is made and the flat is not passed. It is a disgrace to our railway engineers that they have not applied electrical fog signals yet. Railway telegraphy has made little advance for many years because no advance was called for; and the result appears to be that railway telegraph men are not ready to tackle the more difficult problem of communicating with a train.

The most interesting aspect of electrical engineering is that it supplies a means of transmitting power. Electrical transmission of power differs so much from other methods that it demands some consideration. In the first place it will transmit over long distances. It is obviously impossible to transmit power commercially by means of ropes, shafts, or compressed air, over distances running into hundreds of miles. Such distances are beyond anything wanted just at present, but even over distances of a few miles there is nothing to compete with electricity. It is needless to dilate on this point, it is so well known already.

When we come down to short distances it is simply a question of economy, and before embarking on a scheme an estimate is made. For instance, a cable tramway may compete with an electrical system if the traffic is extremely heavy and there is a bad hill at one place. Apart from questions of economy, it is interesting to consider the characteristics of electrical transmission and to compare it with others. For example, belt-driving transmits at one speed only, unless there are cone pulleys or their equivalent. It is only possible for short distances. Rope-driving can be carried round corners better, but cannot be used with cone pulleys. Hydraulic transmission has the general characteristic that a movement of the distant ram or piston involves the same consumption of energy whether the work done is large or small. The speed, however, can be varied.

Electrical transmission has some very curious characteristics. In the first place it is not positive in starting. In starting a hydraulic lift, for instance, there is no consumption of pressure water unless the lift moves, but if the electric motor gives its full torque with its field in the normal condition it takes full power even if it does not turn at all. All the power has to be wasted in resistances somewhere in the circuit. A motor, therefore, works something like a Pelton wheel under full head of water. A Pelton wheel has its normal speed and at any other speed there is waste; but an electric motor has the advantage that the normal speed can be varied within very wide limits by altering the field excitation. I am of course speaking here of transmission at constant or approximately constant electrical pressure because this is the only system in use.

In many mechanical systems of transmission of power, for example by ropes, there is nearly as much waste going on at light loads as at full loads. In electrical transmission this is not so. There is a constant waste in the dynamo, but it is small, of the order of 5 per cent. But the waste in the line varies as the square of the current, so that at light loads it becomes inappreciable. Electrical transmission involves no moving connections—an advantage shared by water, compressed air and gas distribution. In the last mentioned case there is a substance moving along inside the pipes, but that gives no trouble. In old days people would have said there is the electric fluid running along inside the conductors. Then people gave up that idea except as a useful analogy. Later the idea came in that the energy is all conveyed everywhere but in the copper, and Poynting showed exactly how it goes. Now we must consider electrons as traveling along in the copper, although the energy connected with each electron is outside the electron, and the energy concerned in the movement of a very large number in copper is nearly all outside even the copper. These ways of regarding the question are by no means useless; quite the reverse; they are all good, but for different purposes. The engineer will generally find the old single electric fluid the best working hypothesis. The idea of pressure, current, quantity, capacity and resistance are all based on the "hydraulic analogy."

Another characteristic of electrical transmission is that there is no difficulty in getting the power to a moving object, such as a train. A tramway car can be moved by a cable, but the cable merely pulls it; it does not carry power to it so that it turns its own wheels. Power can be conveyed to a torpedo by pulling wire out, but it is generally difficult to transmit power mechanically to a moving machine. The overhead crane in an erecting shop is a good example. One method that was commonly used was to have a square shaft running along the side of the shop, sliding through a square hole in a pinion on the crane. The bearings gave trouble and the friction was very great. Rope gearing was also used, but had great disadvantages. The electric crane is now becoming universal on account of the facility with which the power can be got to the crab.

Of late years a great need has sprung up for a variable-speed transmission gear. The steam engine gives a large torque at starting and works fairly economically at all speeds provided the torque is right. The petroleum engine, however, will not work well at a low speed, and has to be started light. Numerous variable-speed gears have been designed for auto-motors, but the problem of the mechanical variable-speed gear cannot be said to be solved. Electrical transmission, however, supplies an economical variable-speed gear within very wide limits. This is a peculiarity which has led to its adoption in some special cases. Although a steam engine will give full torque at very low speed it cannot develop a large power unless it is running fast, and there is a limit to its speed. If it can be arranged, a steam engine works best if kept running at its normal speed. This was one reason why electrical transmission was adopted in the celebrated Heilman locomotive. The engine ran at its best speed and drove a dynamo whose field excitation could be varied. This drove motors on the axles. Their fields were also variable. A similar arrangement is also applicable to large petroleum-driven cars. It is not used on automobiles as it is not well adapted to such small work.

There is a curious but difficult problem in connection with deep-level mining. If a shaft is 6000 feet deep it cannot be worked with a single winding engine at the top, as the ropes are too long and heavy. A winding station has to be arranged half way up, and one problem is to transmit the power to the winding engine economically. Compressed air, ropes, or shafting are out of the question. The electrical transmission is simple. The engine for the lower half is at the top. It drives a separately excited continuous-current dynamo and this drives a similar separately excited motor on a winding drum. This has almost the effect of a mechanical coupling between the engine and the distant motor.

It is strange that electricity does not take the place of hydraulics in working guns. Wires are easier to lead about than pipes, and can be easily duplicated, so that there is no stoppage if a main is struck. There is no chance of freezing, and the motors are very easily controlled. Quick-firing guns up to large sizes are now trained and elevated by shoulder pieces. For larger guns there would be no difficulty in making the shoulder-piece control the switches, so that when it is moved relatively to the cradle the gun follows automatically. The gun would then feel exactly as if aimed by the shoulder-piece directly, although there would really be the intervention of electrical power.

Another characteristic of electrical transmission is that it will give constant speed with varying load, if wanted. A shunt-wound machine can be wound not only to give constant speed with varying load, but to give constant speed even with varying pressure on its terminals. For such a purpose, for example, as pulling models through a shipbuilder's tank, the shunt-wound motor is admirable. The constant-current system, which is not used in this country, gives constant torque at various speeds, which may be important for some purposes.

Electro-magnets are not directly employed to any great extent in industry. An electro-magnet is sometimes used to take the place of chains and hooks in lifting iron and steel. It is also used to attach portable drilling machines to ships' sides. The electro-magnet has received wide application in the concentration of ores.

The electrical separation of ores has been proposed. The idea is to start Foucault currents in the conducting particles by subjecting them to a magnetic field which moves and varies locally. The pull of a varying field varies as the fourth power of the linear dimensions, and the weight as the cube, so that particles soon become too small to be acted upon in this way. Electrostatic ore concentration has been tried or is in use. The dry ore impinges on a charged plate. The non-conducting gangue tends to cling, while the conducting sulphides are shot off after contact. This is the only industrial application of static electricity I know.

Electrical heating is of interest to engineers. Electrical welding, for instance, is now an important process. There was for a long time difficulty in making the steel wire for carding machines. It had to be very uniformly tempered. In hardening and tempering the thin coat of oxide gave great trouble as it wore out the machines which bent the wire and inserted it in the foundations. Ashworth then invented a machine which heated, quenched, re-heated and cooled the wire without exposure to the air. This has since been done electrically; and now an immense quantity of bright tempered steel is turned out by this means.

Perhaps the most important electrical development from an engineering point of view is the electric furnace for the reduction of iron ores. The electric furnace is already playing a very important part in producing metals which are used in making special steels.

Electric and magnetic testing have been used for discovering flaws or faults in such things as shafts and axles. When axles are made alike, on the interchangeable principle, the note they give when struck will show if they are correct, not only as to absence of flaws, but as to actual measurements.

Electricity is likely to aid research in the very difficult subject of alloys. The electrical conductivity, the electromotive force in contact with electrolytes, and the thermo-electric forces are all likely to help to throw light on the constitution of alloys, and its variation with time.

It is proposed to use wireless telegraphy in connection with Lieut. Peary's next voyage in search of the North Pole. Stations will be erected at proper distances which will keep his vessel in touch with the nearest cable station on the Labrador Coast, and from there with New York.

A Typewriter for Transmitting Morse Signals

IN a recent paper read before the New York Railroad Club, Charles E. Yetman described a typewriter for transmitting Morse telegraph signals. This machine, in size and appearance, is not unlike the ordinary typewriter. It is fitted with a single or universal keyboard. It is two machines in one: a complete typewriter and a telegraph transmitter. When the machine is not in use it may really be said to consist of three parts, the typewriter, the transmitter and the keyboard. If the typewriter part of the machine is to be used, the depression of a lever at the right of the frame connects it with the keyboard, and when the work is complete the raising of this lever again disconnects it. If the transmitter is to be used the depression of a lever at the left of the frame connects it with the keyboard, and opens the telegraph circuit; the raising of this lever at the completion of the work of transmitting again disconnects the transmitter and closes the telegraph circuit. The typewriter and the transmitter may be connected with the keyboard at the same time by the depression of both the levers above referred to, so that a mechanically correct copy of the matter transmitted may be secured, a feature invaluable for train dispatching. The machine may be permanently connected into a telegraph circuit by simply cutting the wire and inserting the two cut ends into binding posts fixed in the frame at the rear. Temporary connection into any circuit may be made by the use of a cord and jack placed under the spring of the Morse key circuit closer, so that the machine can be moved quickly from one wire to another like any ordinary typewriter.

The carriage is returned by one direct downward movement of a lever at the right of the keyboard; the line spacing is accomplished automatically at the same time by the same motion. The paper feed has been constructed with special reference to the rapid handling of telegraph blanks. The carriage moves upon ball bearings, and the type bars, which are the real life of a typewriter, are connected into their hangers by ball-bearings. The touch is exceedingly light and is absolutely uniform in every part of the keyboard.

A congress on radiology and ionization will be held in connection with the exposition at Liege, Belgium, from September 12 to 14.

Time Limit Relays and Duplication of Electrical Apparatus in Power Houses

RECENT PAPERS READ BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

TWO papers were presented at the meeting, on May 16, of the American Institute of Electrical Engineers—one on "Time Limit Relays," by George F. Chellis, and the other on "Duplication of Electrical Apparatus to Secure Reliability of Service."

TIME LIMIT RELAYS

In power stations and sub-stations feeding large alternating and direct-current distribution systems, as explained by Mr. Chellis, relays form a necessary part of the station equipment for the protection of apparatus and feeders, and for the purpose of rendering the operation of a system automatic. In connection with the operation of oil switches on high-pressure, alternating-current systems, the function of the relay is to close the control circuit to the switch, thereby opening the main circuit when the current exceeds the value at which the relay is adjusted to operate. Not taking into consideration the time element of the switch, its operation would be practically instantaneous if controlled by a simple relay. Therefore, since heavy currents, due to swings of the load, may often flow for such short periods that it would not be desirable to open the circuit, relays are provided with some form of time-limiting device by means of which the length of time a given current may flow without operating the switch can be adjusted to meet existing conditions.

Relays may be divided into three classes:—

1. Differential relays, operating at a lower current value when the direction of the flow of energy is reversed than when flowing in its initial direction.

2. Straight overload relays, operating when the current reaches a certain predetermined limit, irrespective of the direction of flow of energy.

3. Reverse-current relays, operating when the current reaches a certain predetermined limit upon reversal of the direction of flow of energy.

ALTERNATOR RELAYS

The type and design of the ideal relay for the protection of alternators will depend upon the conditions under which it is to operate. A relay should operate on overload at normal pressure, on short circuit at zero pressure, or reduced pressure, or when the direction of the flow of energy is reversed. It can be designed to operate in the event of any of these conditions prevailing, and each at a different value, in which case a differential relay would be required. The principal advantages of the differential relay are that it can be so designed as to permit the alternator to be loaded to its maximum current capacity at normal pressure without danger of being cut out, and also operate on short circuit, when the pressure is zero, at a point sufficiently under the short-circuit current of the alternator to allow a suitable factor of safety. Compared with the straight overload relay, set to operate on short circuit with an equal factor of safety, at power-factor values usually attained (50 per cent. and higher), it will permit a greater load being carried at any operative pressure.

Assuming that the relay is to operate on short circuit and reversal, but not on overload at normal pressure, the ideal relay should have the following characteristics:—

1. It should permit the alternator to be loaded to its maximum current capacity at normal pressure.

2. It should limit the current on short circuit to not more than 75 per cent. of the short-circuit current of the alternator.

3 It should limit the current on reversal to the lowest value at which no difficulty is experienced when synchronizing.

4. It should be provided with a positive time-limiting device, the time adjustment of which is independent of the current value at which the relay is operated.

FEEDER RELAYS

The method of protecting feeders depends upon the operating conditions. This subject may be most consistently discussed by considering the conditions from the power-house alternating-current bus-bar to the sub-station direct-current bus-bar.

To guard against overload, and to open the circuit in the event of a short circuit, a relay is required at the power house end of each feeder. A relay is also required at the sub-station end, where the feeders are operated in parallel, being connected to a common sub-station bus-bar, or where the sub-station bus-bar is divided, leaving groups of two or more feeders in parallel.

To fulfil requirements properly, an ideal combination would be an overload time-limit relay at the power house end and an instantaneous reverse-current relay at the sub-station end of each feeder. Mr. Chellis did not know of an alternating-current reverse-current relay, the operation of which did not depend upon the pressure of the system, nor a relay that depended upon the pressure operating on a reversal only, that would not become completely inoperative at zero pressures or at comparatively low pressures. If differential relays were used, with a "differential factor" sufficiently high to render the relays of any appreciable value at low pressures, it is probable that they would be so sensitive that any disturbance causing a momentary reversal, without a serious decrease in pressure, would cut the station out unnecessarily.

This theory is borne out by the experience of the Interborough Rapid Transit Company in the sub-stations of the Manhattan division, where instantaneous differential relays were installed at the sub-station end of the feeders. When feeders were operated in parallel, it was found in most all cases where a feeder became short circuited that all the differential relays at the sub-station end would operate, and also those of one or more of the other sub-stations; this caused the remaining relays in the other stations to operate because of overload, thus resulting in a total shutdown. After straight overload time-limit relays were substituted for the differential relays, on the occasion of several very severe short circuits the affected sub-station cleared itself in a perfectly satisfactory manner and without disturbing the rest of the system. It would appear, then, that the straight overload time-limit relay is the most satisfactory device obtainable for the protection of feeders at the sub-station end.

With synchronous converters a straight overload time-limit relay on the high-pressure side of the transformers will give satisfactory protection for the alternating-current side; while for the direct-current side a reverse-current relay, operating the direct-current breaker, will be required to open the circuit, and thereby prevent the synchronous converter from attaining destructive speeds, in the event of the field circuit being opened.

Satisfactory direct-current reverse-current relays are obtainable; they are commonly of the motor type, having an armature separately excited from a source of constant pressure, such as a storage battery. They are provided with a stop to prevent continuous rotation; the field depending for its intensity and direction upon the line current. This type of relay, as installed on the 1500-K.W. synchronous converters of the Interborough Rapid Transit Company, will operate at about 15 per cent. rated current on reversal.

The relative value of the time adjustments for the various relays depends on the order in which it is desired to open the switches. If feeders are operated in parallel, when a short circuit takes place on any given feeder, there will be a rush of current to the point of short circuit from the power house and also from the sub-station bus-bars, the comparative value of these currents depending upon the location of the point of short circuit, the number of feeders in parallel, and the ratio of the kilowatt capacity of generators to the synchronous converters in service at the time. While the overload current limit may be exceeded in all feeders, both at the power house and sub-station ends, the current in the short-circuited feeder at the sub-station end with n feeders in parallel will be $n-1$ times as great as that in the other feeders, plus the current supplied by the synchronous converters, or the current may be supplied entirely by the synchronous converters and the direction of the flow of energy in the unaffected feeders reversed; in any case the current in the latter will be the same at both ends. The current at both ends of the affected feeder will, therefore, reach a higher value than in the other feeders, and to clear it necessitates opening the switches at both ends.

To break the circuit at the lowest possible current value it is necessary first to open the switch at that end of the feeder which has the highest current value. Since the circuit will still be closed from the other side, there will not be a high pressure across the terminals of the switch at the point of breaking. This permits making the final break with the resistance of the other feeders, plus the resistance of the affected feeder in series therewith to the point of short circuit, in which case the current at the time of the final breaking of the circuit will be much lower than in the event of the operation being made in reverse order.

Since the current in the affected feeder will always be heavier than in the others, a relay having an inverse time-limiting device may be used to advantage. A series of tests carried out with the bellows-type time-limit overload relay, showed that with equal current adjustment, by adjusting the time of two relays in the ratio of 0.5 to 1, when operated in series, they would discriminate properly at all loads—the one with the shorter time adjustment operating a sufficient time in advance to leave ample contact clearance on the one with the longer time adjustment.

Therefore, with equal time adjustments at a given current value, the relay having the heavier current will operate in a correspondingly shorter time, and thereby disconnect only the affected feeder. The time-limit for these relays should be adjusted at the current value at which they are intended to operate, and so as to make the final break at the lower current value; the time and current adjustment at both ends should be the same, the time being that at which it is desired to limit the overload on the feeders. In all cases the time-limit of the alternator relays should be greater than that of the feeders to permit the operation of the latter without operating the former.

Assuming the safe time-limit of the alternators to be twice that of the feeders, and that of the synchronous converters equal to that of the feeders, but at a lower current value, the numerical value of the time adjustments may be three seconds for the alternators and 1.5 seconds for the feeders and synchronous converters, which values are within the range of most relays.

Special operative conditions may demand adjustments varying greatly from these values, but in all cases they should be so made as to give the desired protection for emergency conditions, as far as these can be predetermined.

DUPLICATION OF ELECTRICAL APPARATUS TO SECURE RELIABILITY OF SERVICE

Mr. Buck's paper bearing the above title was next presented and is here reprinted in full:—

The question of the proper reserve in an electrical installation, said the author, is a problem that, like many engineering problems, must be settled largely upon a basis of cost. It is nearly always a question involving a balance between a power company's obligation to its customers and the obligation to its stockholders. From the standpoint of the consumer the more reserve the surer will be his supply of power. On the other hand, to the power company's stockholders the less the investment in reserve the larger the dividends, unless the reserve has been cut down to a point where the power company's reputation is endangered by interruptions to service. The question is purely a practical one and no definite laws can be enunciated, nor can any curves be plotted which will indicate the proper amount of reserve to be installed under various conditions. The decision in each case must be based on intimate knowledge of the local conditions and requirements of the particular installation in question. All that will be attempted in this paper will be a discussion of the general principles involved.

Before a decision can be made upon the degree of duplication advisable for any given piece of apparatus, an analysis must be made of the defects which may develop therein, the length of time required for repairs in case of a breakdown, and the number and importance of the power customers dependent upon that particular appliance.

For purposes of discussion electrical reserves may be divided into several classes of apparatus, each governed by different conditions. These classes are:—

1. Generating units.
2. Generating plant switchboard.
3. Generating plant transformers.
4. Underground distribution system.
5. Overhead lines.
6. Sub-station apparatus.
7. Apparatus on premises of individual customers.

Reserve apparatus applicable to the above can again be divided into two classes:—

a. Actual apparatus installed complete ready for service.

b. Reserve parts held in storeroom.

GENERATING UNITS

There is no place in a power system where reserve apparatus is so important as in the generating station. In the writer's opinion the following conditions should be observed in every large generating plant where continuous service is demanded:—

The maximum overload capacity of the generators normally operating on the bus-bars should be such that at any time and under any conditions of load any one of the generators can be instantly disconnected from the bus-bars without necessitating a reduction of station load or causing a serious momentary drop of pressure. If any trouble, either incipient or actual, should then develop in one of the generating units, the unit can be immediately put out of service without waiting to start up another machine to take its place. Furthermore, there should, if possible, be one unit held as absolute reserve which need not be operated except as a substitute. This enables any one generator to be out of service for repairs, even during load-peaks. The size of generating unit selected for an installation has an important bearing on the question of reserve. The larger the unit the lower the cost of the plant per kilowatt, but, by necessity, the larger will be the investment in the idle reserve machinery. The proper relation can only be determined by a study of the local conditions under which the plant is to operate.

A station operated by steam turbines or by water power has certain advantages in reserve conditions. With steam turbo-generators, on account of the comparatively high part-load efficiency of the steam turbine, all the units installed in the plant, including the reserves, can be kept in operation on the bus-bars at all times without serious sacrifice in steam economy, due to the part load on each unit. This enables a generator to be quickly disconnected from the bus-bars at any time without overloading the remainder or causing a serious drop in pressure. This condition also obtains in a water-power plant, since the additional use of water caused by the continuous operation of the reserve units has only little effect on the cost of producing the power. With a reciprocating engine, however, each unit must be operated as far as possible at exactly the full-load point, on account of the economy required in steam consumption. This prevents obtaining the full utility of the reserve machines.

The exciters in an alternating-current generating station are, of course, the heart of the entire system, and the most careful provision should be made to insure continuity of service therefrom. Since the cost of the exciters is in every case only a small proportion of the cost of the plant there is little excuse for not installing ample reserves in connection with the exciter equipment.

Of equal importance with the complete reserve machinery installed is the stock of reserve parts held in the storeroom. There should be kept on hand at all times ready for immediate use a complete outfit of the parts of the prime-movers and generators which are most likely to wear out or break down. In the selection of such spare parts the most careful judgment should be exercised. In many instances a carefully selected reserve stock will enable breakdowns to be repaired in a few hours, weeks being required if the new parts, many of which might be special, had to be obtained from the manufacturer. From the standpoint of reserve, then, there is no part of the power plant of more importance than the storeroom.

GENERATING PLANT SWITCHBOARD

Under this heading might be included all of the electrical equipment of the station from the terminals of the generators to the point where the outgoing feeders leave the power house. This will necessarily involve a large amount of cable as well as all of the switch equipment and controlling appliances. Here the question of reserve is almost wholly a storeroom proposition. In the writer's opinion, the actual installation of duplicate cables in the station wiring and duplicate switches, controlling devices, etc., should be avoided as far as possible, as tending to occupy too much valuable space and to complicate the organization of this vital part of the plant. There should, however, be kept on hand, preferably in the power house itself, the fullest inventory of switch parts which are liable to injury, and full lengths of all sizes of cables used in the installation. The duplication of bus-bars is, of course, quite necessary in a generating plant, but more for reasons of flexibility of operation than for reserve. Bus-bar installations, as now constructed, are less liable to breakdown than almost any part of an electrical system. A great deal can be accomplished toward reserve in the case of switchboard equipment by keeping on hand a suitable outfit of jumpers with proper terminals soldered on to use for emergency connections to temporarily transfer feeder or generator leads from one switch to another.

GENERATING PLANT TRANSFORMERS

Many of the considerations involved in the generating units enter into the question of duplication for reserve in a transformer equipment. Here also in regard to the size of unit selected a proper balance must be established between the saving in cost per kilowatt by the adoption of large units and the saving in investment in reserve transformers by the installation of smaller ones. Another important question has recently been brought up in connection with transformer plants by the introduction of one polyphase transformer as a substitute for two or three single-phase transformers for a bank. A polyphase transformer occupies less space and costs less than a bank of single-phase transformers, but when reserve is considered it is not so good. If a bank of separate single-phase transformers breaks down the trouble is not likely to involve more than one of the component transformers, and this can be replaced by a small kilowatt reserve. If, however, a polyphase transformer breaks down, capacity equal to its full polyphase rating is put out of service.

In the writer's opinion all important transformer stations should have a complete spare bank, which can be shut down at any time without overloading the remaining transformers, and in addition one single-phase transformer should be held in stock to make good any bank in case one of the component transformers should break down.

A transformer station usually involves more or less of an equipment of high-pressure cables, switches, lightning arresters, etc.; and in the present state of the high-pressure art there is nothing more liable to frequent destruction than the devices involved in this part of an electrical system. Consequently, here the storeroom reserves should be most carefully provided for.

OVERHEAD DISTRIBUTION

If there is a single element in an electrical system where trouble is sure to develop sooner or later it is on the overhead lines, and the higher the pressure the more likely is the trouble to occur. This is so because the overhead lines are subjected to influences over which the power company has no control. These influences are principally lightning, general abnormal weather conditions, malicious interference, and accidental interference caused by the contact of other companies' wires during construction work. For these reasons it is practically out of the question to attempt to maintain a continuous power service over a single-circuit overhead line. There should always be enough circuits installed so that at least one can always be shut down without necessitating a reduction in load. This is especially true in the case of high-pressure lines. In low-pressure systems of 2300 volts or less it is nearly always possible to replace insulators and do other work on the line while it is "alive," but at higher pressures this should not be allowed if there is any regard for human life. In many plants where important interests are dependent upon the power transmitted the matter of duplication should be carried beyond the circuits and reserve pole-lines installed. Carried to its limit without regard to cost, the ideal condition would be a number of single circuits each installed on a single pole line and each line following a different route. With this arrangement lightning would not be likely to disturb more than one line at a given time, and a complete shutdown from malicious interference involving all the lines would be very improbable. The cost, however, in such a separation of lines would in most cases be prohibitive on account of purchase of right of way, patrolling, etc.

UNDERGROUND DISTRIBUTION

When trouble develops on an overhead line the location of the breakdown can usually be quickly found by patrol, and repairs made without delay. In an underground feeder, however, the conditions are radically different. Breakdowns are difficult to locate, and when found repairs frequently occupy many hours on account of the necessity for pulling out the defective cable from the ducts, putting in new cable and resplicing. Duplicate or triplicate cables should always be installed where important service is involved. This obligation is conceded by most engineers, and spare underground cables are usually installed. The installation, however, is apt to be carried out in such a way that the security of the reserve cables is impaired. Underground conduits as now generally constructed consist of a congested mass of ducts grouped in such a way that in the manholes the cables are crowded closely together and are in constant danger of destruction in case of a violent short circuit in the manhole. There is little value in installing spare cables when they are liable to be damaged at just the time when they are most urgently required. Such risk can only be obviated by constructing electrical conduits in such a way that the cables can be separated in the manholes by short-circuit proof barriers. Preferably, whenever possible, duplicate conduits should be constructed on opposite sides of the street, or, still better, laid through different streets. Only by such precautions can the full benefit of the reserve cables be insured.

Investment in duplication of generating units and transformers for reserve purposes does not result in any saving in operating expenses. On the contrary, if the reserves are kept in continuous service, in general the losses will be increased and consequently the efficiency of the plant lowered by just so much. Investment, on the other hand, in reserve cables and overhead circuits can be made to pay directly; for if such reserve circuits are kept in operation the efficiency of the transmission is raised and the cost of producing the power lowered by that amount.

SUB-STATION APPARATUS

The general considerations which apply to generating-plant reserves also apply to outlying sub-stations, but in a less degree, for the complete shutdown of a sub-station involves only a portion of the power system. Farther out on the power network to the plants of individual customers, where the transformer or other apparatus is supplied by the power company, no reserve seems necessary under the ordinary obligations of such cases. If a breakdown occurs, only the individual is inconvenienced, and therefore the risk is usually justified.

GENERAL

The above stated conditions of reserve apply particularly where certain public utilities are involved. Among which may be mentioned:

1. Electrified steam railroads.
2. Traction system in large cities.
3. Street lighting and the lighting of large public buildings.

Where such interests are at stake, storage-battery reserves are probably justified, aside from all considerations of economy resulting from improvement in load-factor.

When the present steam railroads adopt electricity as a motive power for all traffic, both passenger and freight, more rigid requirements in reserve are likely to be found than have ever been considered necessary as yet in central-station practice. Under present steam road conditions, if a locomotive breaks down, as frequently happens, probably only one train is stopped. The simultaneous breakdown of every locomotive on the road is of course improbable, consequently there is no likelihood of a complete tie-up of the system. Under a complete electrification, however, one whole division of the railroad might be operated from a single power house and a breakdown in that plant would involve every train on the division. No important railroad system would venture to operate with such a risk hanging over it. This condition, in the writer's opinion, will lead beyond the mere duplication of apparatus in a power house to the installation of duplicate or possibly triplicate generating plants, having such capacities that any one of the plants can be shut down in cases of catastrophe and the whole load of the system carried by the others. Such an arrangement with suitable reserves in transmission conductors would practically insure continuous train service at all times.

Where water power is used for the operation of important power systems, duplication of generating stations is especially important. In steam plants as now constructed with multiple stacks there is no single element of the plant which is common to and necessary for the operation of all the power units. Consequently, any part of the equipment can be inspected and repaired without a total station shutdown. In an hydraulic plant, however, there are a number of elements in the development which are essential to the operation of the whole plant, among which may be mentioned the dam, flume, fore-bay, tail-race, tunnel, etc. In cases of emergency it may become necessary to shut off the main water supply in order to get access to these parts. Furthermore, hydraulic plants are subject to ice troubles and floods in winter and low water in summer. It therefore seems essential if steam roads or other public utilities are to be operated electrically by hydraulic power, that the system should be operated by more than one generating station.

Such are some of the considerations entering into this problem of duplication for reserve. The details are subject to the local conditions of each particular installation. The matter of reserve grows more important each year with the development of electrical applications. Ten years ago or more shutdowns on electrical power systems were taken as a matter of course, and no one used electrical power unless interruptions to service could be taken without serious inconvenience. At the present time, though the obligations of the power generating companies are much more serious, an absolutely continuous supply of electric power is demanded by all users. To avoid loss of revenue and possibility of damage suits from shutdowns every power company is justified now in making a large investment in reserve to assure continuity of service.

DISCUSSION

The papers were discussed jointly. H. G. Stott said in part that the ordinary overload relay attempts to perform an opposite function to that of the telegraph relay, that is to say, the telegraph relay is introduced to enable us to utilize a strong current to operate the receiving apparatus, whilst the overload relay is introduced to allow us to utilize a weaker current to operate a switch apparatus because the main current has attained such voltages and strength that it has become impossible to design relays to work with main line current. He thought the principal point brought out in Mr. Chellis' paper was, in the handling of a large amount of power, the recommendation to open first the switch at that end of the feeder having the highest current, and then, by means of that, availing ourselves of the resistance of the transmission lines, to reduce the current on the short circuit when the second and final relay opens on that circuit.

Referring to Mr. Buck's paper, the speaker thought there was a tendency nowadays to assume that the limit as to size of central stations has been reached. Power houses of 50,000 K. W. are now common, but he did not see why power houses should not go to 100,000 K. W. It is simply a question as to how safe we can make each individual unit, and he did not think the impression should be conveyed that we have reached the final size of power plants, unless there is some special point, especially as indicated in the hydraulic plant, where there are certain unreliable items, such as the dam, flume, fore-bay, tail-race, etc., which control the entire amount of power.

In the steam plant no one item controls the whole amount of power. The nearest approach to this condition is in the water supply. That, however, in nearly all stations is in duplicate and is also further protected by the use of large storage tanks.

Referring to the safety of underground cables, Mr. Stott said experiments had shown that the safety of a cable so far as damage from its neighbours is concerned varies inversely as the voltage. In other words, the larger the current in the cables, the greater the danger to adjoining cables—the damage being proportional to the square of the current. Mr. Stott questioned the importance of having duplicate power houses to avoid the failure of power supply to trains. Statistics which he had examined show that in a period of three years the interruption of train service due to a stoppage of electric power is less than one per cent. of the total interruptions.

Philip Torchio said the importance of protection of high-tension systems against shut-downs is of great importance and has reached the careful attention of the engineers who have been connected with the operation of central stations. He doubted that a standard solution could be applied to every case. The speaker enumerated the instances in which overload relays are satisfactorily employed to safeguard the continuity of the service of the company (the New York Edison Company) with which he is connected. The success of such a system of protection obviously depends upon the care that is given to the maintenance of the several relays, but it is a fact that his company is now in possession of an instrument that is reliable and sturdier than most of the instruments on the switchboard. Probably, as further experience is gained, it will be found that some of these pieces of auxiliary apparatus may be omitted to advantage, but experience has already proved that a system based on the use of inverse time element relays gives a solution of the problem that is free of serious drawbacks.

C. W. Ricker thought that Mr. Chellis' paper did not pay sufficient attention to the steam and mechanical equipment of the station. It is frequently the case that the electrical apparatus is able to endure adverse conditions better than much of the apparatus behind it.

C. O. Mailloux had been astonished at the impatience with which the relay question is discussed by most operating engineers, especially in the Far West, where if the electrical engineer puts in a relay the operating relay is likely to put it out of business. The latter prefers to take his chances with the machinery without the relays, rather than with them, in the state in which they were up to two or three years ago. Where there are rotary converters it is indispensable to have some device that will prevent their running away, unless the load is principally or wholly for lighting, in which case there is scarcely any use for such devices.

The speaker complimented Mr. Buck on the manner in which the various questions involved in the design of central stations and the provisions which are to be made for operation are discussed. Mr. Mailloux said there was more original sin in the design of central stations than people are apt to imagine. Of course in extenuation of the sin it must be said that at the time the station was designed it was absolutely impossible to foresee and anticipate what was going to happen, either in the development of machinery or in the development and expansion of the business itself.

Where it is at all possible to anticipate the growth of a plant, the question of the number and size of the units should be carefully considered. The speaker had frequently observed that in Europe nearly all polyphase stations are equipped with polyphase transformers, while in this country nearly all are equipped with single-phase transformers. So far as he had been able to ascertain, this is due to the fact that by the American methods of manufacture single-phase transformers can be made more cheaply than they can be in Europe; or that polyphase transformers can be made more cheaply in Europe than here.

S. D. Sprong characterized Mr. Chellis' paper as a very timely one. Referring to the broad question of relays in the generator circuit he inquired whether it is essential for good operation to have automatic opening of switches in that circuit under any conditions. The practice of some large companies of having a relay which would signal the operator only at times of extreme load has been found very satisfactory.

Referring generally to the statement made by Mr. Chellis in his paper that a direct-current reverse relay operating a circuit breaker on the direct current side may be used to open the circuit of an inverted rotary to prevent the rotary from attaining destructive speed in case of open field circuit, the speaker thought that relays of the type described and without time-limit, either fixed or inverse, would be liable to disconnect the rotary during a momentary depression in the system voltage, resulting from short circuit on a feeder. He believed it to be the general opinion that when a speed limiting device is necessary, it should be one designed for that specific purpose, and that its operation should be based entirely on the mechanical feature of the rotary speed.

In closing the discussion Mr. Buck said he fully agreed in general with Mr. Stott's contention with regard to the relative damage in underground cables between those operating at high voltage and those operating at low voltage, but he had noted a number of instances where 11,000-volt, three-conductor cables had caused considerable damage in the manhole, due to the fact that the circuit breaker did not open, allowing the short circuit to hang on for some time—a condition which may happen in any plant.

With regard to Mr. Stott's contention about one power house versus two or more power houses, the speaker still felt that where hydraulic power is the prime mover, more than one plant should be required for important systems.

In steam plants this arrangement is not so necessary, but the bursting of boilers or steam pipes filling the station with steam might cause a shutdown, and a flywheel or parts of the dynamo might burst and temporarily wreck the station; hence he thought it indisputable that two or more power stations are more reliable than one. Whether one power station is sufficiently reliable is another matter.

The discussion being then concluded the meeting adjourned.

The Induction Motor in the Spice Mill

In a letter recently received, John B. Fallon, Jr., superintendent of the Stickney & Poor Spice Company, of Boston, Mass., writes:—

"I was very much interested in reading an article in your May number by George L. Clark, called "The Induction Motor in the Spice Mill." The experience I have had causes me to disagree with his statements as to the difficulty of operating direct-current motors in spice mills and also with the arrangement he suggests for motor drives.

"We have been running our factory by direct-connected motors for about four years, when I installed the present power plant. We have a 125-K. W. Crocker-Wheeler direct-connected generator direct-connected to an 18-inch by 36-inch horizontal Brown engine running at 100 revolutions per minute. We also have a 40-K. W. generator direct-connected to a high-speed engine, the entire unit being built by the B. F. Sturtevant Company, of Boston. With this equipment we run one 40-H. P. motor, one of 35 H. P., four of 30 H. P., three of 20 H. P., one of 15 H. P., one of 10 H. P. and one of 5 H. P.; also 15 arc and about 400 incandescent lamps. You will note we have not enough generator capacity to drive all our motors at full loads. The reason for this is rather peculiar and need not be explained here.

"Mr. Clark refers in his article to the trouble experienced in caring for the commutators of direct-current motors in the somewhat dusty atmosphere which necessarily exists in a spice mill. In reply to this I can only say that our commutator troubles have been very few, many of the motors being run with the original brushes still in them. They are blown out when the rooms are closed down on Saturday afternoons, except during the busy season, when the men are very apt to slight them. We use compressed air for all cleaning purposes, having a system throughout the plant for running pneumatic machinery.

"My experience has shown me that it does not pay to run individual motors for machines requiring less than 12 to 15 H. P. on our work, except where the machines are isolated. Our usual method is to group the machines requiring small power and belt them to a line shaft which is run by a motor either with a belt or a chain drive. I should gather from Mr. Clark's remarks that he prefers to use separate motors for the small machines, but we found upon experimenting that we could obtain no better results by using this method, while the primary cost is largely increased. On the heavy mills, we use a motor for each mill direct connected wherever possible. In two cases we have a 30-H. P. motor direct connected to two mills, one mill being on each end of the armature shaft.

"I have had very little experience with alternating-current machines, but have always understood that they did not operate satisfactorily above their rated loads. In our work at times, we have to operate under overloads ranging from 10 to 40 per cent. for short or long periods.

"Are there any large spice factories operating to-day on the method Mr. Clark suggests? If so, I should like to investigate these if possible. The Dwinell-Wright factory here in Boston is run with alternating-current machines, but their business is largely coffee, so that any results they might obtain in their plant would not be applicable to our conditions.

"Mr. Clark has evidently been investigating conditions somewhat similar to those existing in our plant; yet his results are diametrically opposite to those which I have always obtained. I cannot exactly see where one gets enough additional efficiency to pay for the difference in cost between alternating and direct-current machinery when working under the conditions existing in most spice mills."

Concerning the above letter, Mr. Clark, to whom it was submitted for reply, writes as follows:—

"Permit me to add a few words in regard to my article upon induction motors in spice mills, published in your May issue, suggested by Mr. Fallon's exceptions thereto. A little consideration will soon show, I think, that more common points of agreement exist between Mr. Fallon and myself than at first sight appear from his letter.

"My article was based upon the installation of the Dwinell-Wright Company in Boston, and my purpose was to show how admirably the induction motor is suited to the work of coffee and spice grinding. Their business is large in both coffee and spice work, and I personally have been informed that no expense was spared to make the installation conform to the best practice known to engineers. A trip to this plant will soon convince anyone that cost was a secondary consideration. It was not my intention to convey the idea that the work of spice grinding could not be done by direct-current motors, but to point out the peculiar advantages of the induction machine.

"The Dwinell-Wright Company were especially anxious to install motors which would require little or no attendance; the group-drive is also largely used, although some of the larger mills are belted to individual motors; and I think there is no question as to the superiority of the induction motor for such service if one is after an installation that will practically run itself. To my mind the absence of the commutator is a tremendous advantage, even though a direct-current motor may do the work well. It is all a question of being willing to pay for extra security and freedom from the cost of attendance.

"In the matter of overloads, one of the Dwinell-Wright 10-H. P. induction motors was run for several days at nearly 20 H. P., I am told, until the Westinghouse people discovered the reason why the additional mill thrown upon it failed to come up to the full requirements! I agree with Mr. Fallon that separate motors should not be used for very small machines (provided they are in constant operation, however). In a case where first cost is to be kept as low as possible, direct-current motors are, doubtless, to be recommended; but when a concern feels that operating simplicity and the lowest cost of attendance are worth the extra price, the induction motor is hard to beat."

Comparative Speed Tests of Steam and Electric Locomotives

Conducted jointly by the General Electric Company and the New York Central & Hudson River Railroad Company, comparative tests were recently made, over a 6-mile experimental track, of a steam and an electric locomotive. The current was furnished by a 2000-K. W., 3-phase, 25-cycle Curtis turbo-generator, and was converted at a sub-station about 5 miles from the Schenectady plant. A "Pacific" type of steam locomotive was used, and the electric locomotive was of the type already described in these pages.

Six tests were made; in the first, both locomotives drew 8-car trains weighing 513 tons. Both trains started together, with the steam locomotive accelerating faster than the electric locomotive, due to the abnormal drop in voltage from the pressure at the station of 700 volts to a track voltage as low as 325 volts. This drop was due to the restricted cross-section of conductors, and was considerably lower than will obtain in actual practice within the electric zone in the neighbourhood of New York.

At 3000 feet from the starting point the electric locomotive gained the same speed as the steam locomotive, and from that point accelerated more rapidly, so that at a distance of 2 miles from the starting point the electric locomotive passed the steam locomotive, and at the shutting-off point was two train lengths ahead. The maximum speed of the steam locomotive was 50 miles, and that of the electric locomotive was 57 miles an hour.

In the second run the speeds were 53.6 miles for the steam locomotive and 60 miles for the electric. In the third run, 6-car trains, weighing, for the steam locomotive, 427 tons, and for the electric, 407.5 tons, were hauled. Owing to voltage drop, the steam locomotive accelerated more rapidly in this run also, but at the end of a mile was overtaken.

In the fourth run, it was sought to secure, as nearly as possible, results with conditions of voltage like those that will obtain in the actual operating zone. The run was therefore started at a point nearer the sub-station. The electric locomotive then accelerated faster than the steam locomotive and, at a distance of 1500 feet from the starting point, lead by a train length.

The fifth run was made with the electric locomotive and one coach, and a maximum speed of 79 miles per hour was attained. The sixth run was made with the electric locomotive running light and with the power shut off on curves. A maximum speed was attained of 80.2 miles per hour. Had it not been necessary to shut off the current on curves it is believed that the locomotive would have attained a speed of 90 miles per hour in this comparatively short run.

At all speeds the smooth riding qualities of the electric locomotive were very noticeable, especially the lack of "nosing" effects. After the runs the track was carefully examined and no tendency to spread rails was discovered. However, on the sharper curves the high speeds caused the track to shift bodily in the ballast, due to insufficient superelevation of the outer rail.

The Association of Railway Telegraph Superintendents

ANNUAL CONVENTION

THE twenty-fourth annual convention of the association of Railway Telegraph Superintendents was held in the Read House, Chattanooga, Tenn., May 17 and 18. The meeting was called to order at 10 A. M., by President H. C. Hope, of St. Paul, Minn., who introduced the Hon. E. W. Chambliss, mayor of the city. Mr. Chambliss welcomed the delegates to Chattanooga.

The first paper read was by Frank F. Fowle, of New York, on "The Railway Telephone Service; Cost of Line Construction." He said, in part, that the whole question of telephone service and its economy is secondary to the traffic of communication. The use of the telephone is justified when the traffic can be handled in no other way, and when the nature of the existing wire plant is such that to neglect the possibilities of simultaneous use (telegraph and telephone) is a waste.

It is generally true that the volume of traffic decreases with the length of haul, and that the bulk of the traffic is short-haul. The very short-haul traffic—communication over short distances—is almost invariably handled most economically by telephone; the rapid increase in the use of private branch exchanges bears out this view. The inherent advantages of the telephone in this field are quick service and immediate answer. It is important to keep records of the traffic by mail, the telegraph and the telephone, in order to see that each is handling the business to which it is best adapted. One of the uses of traffic records is to see that the telephone and telegraph are not used when the speed of the mail service is sufficient—that is, to keep the various classes of traffic in their respective channels.

Many of the large railway systems of this country now have extensive telephone systems. The longest transmission is from New York to Chicago, 960 miles. Considerable use is made of simultaneous telegraph and telephone systems, in which there is great economy on trunk lines.

Cost may be divided into two parts: operating cost, and the cost of fixed charges on entire plant, interest, depreciation, maintenance, insurance and taxes. Following a study of the expected traffic comes the question of how much will the line cost for a given volume or loudness of telephone transmission. This question is one of increasing cost with increasing efficiency; or in other words, for a given length of line, the louder the transmission desired, the more will it cost.

The choice of a standard of transmission is a matter to be determined by the interests constructing the line and those paying for the service. Standards of transmission are usually defined as those over uniform circuits of particular construction, with only a standard telephone at either end. It is then possible, knowing the equivalents of cables and apparatus in terms of the standard circuit, to design transmission circuits to meet almost any commercial condition.

High efficiency in aerial wires is obtained by using low-resistance wires, and in cable lines by using low-resistance wires and adopting a construction which will give the least capacity. The use of loading coils for improving transmission (Pupin plan) is of great economy for long circuits in cable. There is usually no advantage in loading circuits less than five miles in length. There are few railroad conditions where loading would be of material benefit at present. The loading of aerial wires is not advisable except for long circuits of small gauge. Mr. Fowle gave the estimated life of copper wire as fifty years, and that of iron as fifteen years, for ærial work. The relative efficiency of the telephone and the telegraph is a very broad question and is affected by many considerations. Assuming the average speed of conversation to be 125 to 150 words a minute, and the average speed of Morse sending 30 to 40 words a minute, the traffic capacity of one telephone circuit is equal to four straight Morse circuits, two duplexes or one quadruplex. Eight Morse operators at $65 a month and two telephone operators at $30 a month give a monetary difference in favour of the telephone, for the same service, of $460.

Mr. Fowle's conclusion is that economy in wire use consists in building moderate-haul telephone lines for simultaneous telegraphy and telephony, arranged to handle the long-haul business by telegraph.

In the discussion, C. Selden, of Baltimore, said he did not agree with the basis of comparison adopted by Mr. Fowle relative to the efficiency of the telegraph and the telephone. It would be physically impossible for anyone to maintain conversation at the rate of 125 to 150 words per minute continuously. Relays of operators every few hours would be necessary. Further, in practice, when railway train orders are sent by telephone, at least on the lines of his company, the

Baltimore & Ohio Railroad, each word of the message is spelled letter by letter to avoid errors. It was also thought that operators of the necessary intelligence could not be obtained at $30 a month.

G. H. Groce, of the Illinois Central Railroad, said his company had found that the cost of battery for simultaneous telegraph and telephone circuits was more than the interest on a separate wire for the telephone. He thought there was no economy in the use of such systems unless on very long circuits. It was found generally that the telephone developed a new class of traffic and consequently afforded but little relief to the telegraph circuits.

Relative to the life of copper wire, it was brought out that under ordinary conditions of use copper appeared to be incorrodible. In the vicinity of chemical works, however, instances were cited where copper wire lasted only two years.

W. J. Camp, of the Canadian Pacific Railway, then read a paper on "High-Tension Wires on Railway Right of Way." This paper relates mainly to the best methods to be adopted where high-tension circuits cross or parallel the railway telegraph lines. He cited cases in which it is difficult to keep the telegraph instruments adjusted on account of a loud hum from a neighbouring 50,000-volt circuit that parallels the telegraph lines for several miles. In another case in which a 20,000-volt circuit parallels telegraph circuits at a distance of from thirty to two hundred feet for thirty-five miles, there are no ill effects except when the power wires are partly grounded, in which case, even at a distance of two or three miles, with a river intervening, the effect is noticeable in the telegraph wires.

I. N. Miller, of Cincinnati, Ohio, said that some of the circuits of the Western Union Telegraph Company were rendered unworkable for quadruplex, ticker and Wheatstone automatic service by the recent construction and operation of a high-potential electric railway on the single-phase, track-return system.

Wm. Maver, Jr., of New York, read a brief paper on "Telegraph Interruptions, Due to Sleet and Wind Storms, and Proposed Remedies." This subject has already been treated of by him in these pages. In the discussion it was brought out that there was now a tendency to the use of a greater number of poles per mile than heretofore. Mr. Maver suggested the appointment of a committee to gather data on this subject and to report at the next annual meeting. Messrs. Maver, Foley, Fowle, Bristol and Kinsman were therefore appointed.

The annual election of officers resulted as follows:—

President, E. E. Torrey; vice-president, E. A. Chenery; secretary and treasurer, P. W. Drew.

During the intervals between meetings of the convention, the delegates visited the various points of historical interest in and around Chattanooga. It was decided to hold the next annual meeting of the association in Denver, Colo., on June 20, 1906.

Book News

The Letter of Petrus Peregrinus on the Magnet

Translated by Brother Arnold, M. Sc., Principal of La Salle Institute, Troy. With an Introductory Notice by Brother Potamian, D. Sc., Professor of Physics in Manhattan College, New York. Size, 6½ x 9 inches. 41 pages. Published by the McGraw Publishing Co. Price $1.50.

Pierre de Maricourt, called Petrus Peregrinus, treated of in this booklet, was a man of academic culture of the thirteenth century, and while little is known of his early years, it is probable that he studied at the University of Paris and graduated with high honours. He owed his surname to the village of Maricourt, in Picardy, and the appellation Peregrinus, or pilgrim, to his having visited the Holy Land as a member of one of the crusading expeditions of the time. Brother Potamian, in his comprehensive introductory note to the little volume, tells us that in 1269 Peregrinus was in the engineering corps of the French army then besieging Lucera, in Southern Italy, which had revolted from the authority of its French master, Charles of Anjon. To Peregrinus was assigned the work of fortifying the camp and laying the mines as well as of constructing engines for projecting stones and fireballs into the beleagured city.

It was in the midst of such warlike occupations that the idea seems to have occurred to him of devising a piece of mechanism to keep the astronomical sphere of Archimedes in uniform rotation for a definite time. In the course of his work over the new motor, Peregrinus was gradually led to consider the more fascinating problem of perpetual motion itself, with the result that he showed to his own evident satisfaction how a wheel might be driven around forever by the power of magnetic attraction.

Elated over his imagined success, he hastened to inform a friend of his at home; and that his friend might the more readily understand the mechanism of the motor and the functions of its parts, he proceeded to set forth in a methodical manner all the properties of the lodestone, most of which he himself had discovered.

It is a fortunate circumstance that this friend was not a man learned in the sciences; otherwise we would probably never have had the remarkable exposition which Peregrinus gives of the phenomena and laws of magnetism. This letter to him, of about 3500 words, is the first great landmark in the domain of magnetic philosophy, the next being Gilbert's "De Magnete" in the year 1600. For nearly 300 years it lay unnoticed among the libraries of Europe, but it did not escape Gilbert, who makes frequent mention of it in his great work.

The letter is divided into two parts. The first contains ten short chapters on the general properties of the lodestone; the second has but three chapters, and in these the author shows how he proposes to use a lodestone for the purpose of producing continuous rotation. There are a number of manuscript copies of the letter in European libraries. The first printed edition of it, now very rare, was prepared by Achilles Gasser, a physician of Lindan, a man well versed in mathematics, astronomy, history and philosophy, and was brought out at Angsburg, in 1558. A copy of this print is among the treasures of the Wheeler collection in the library of the American Institute of Electrical Engineers, and it was from this text that the translation was made which forms the main portion of the little volume before us.

Typographically, it is gotten up most attractively, and to read it is to appreciate it.

Electric Railways

By Sidney W. Ashe and J. D. Kelley. Size, 5 x 8 inches. 285 pages. Published by the D. Van Nostrand Co. Price $2.50.

This is a timely and important book on the subject indicated by the title. According to the preface, however, the treatment of the subject is confined to the rolling stock of electric railways. But this statement is a little misleading for, on examination, the work is found to treat of a number of subjects relating to electric traction, other than rolling stock. A chapter, for instance, is allotted to an analysis of train performance; another to units, curve plotting and instruments; another to recording instruments, etc.

There is a chapter on electric locomotives which is rather disappointing perhaps, because it is more general than specific. Very much information that will be of use to students and to electrical engineers is given in the book, on systems of control; on alternating high-speed motors; the repulsion motors; the direct-current series railway motor; car wiring for multiple unit control systems of the different large manufacturers of electric railway apparatus, all of which are plentifully illustrated with diagrams and half-tone reproductions of the apparatus.

The paper and presswork of the book are excellent, as might be expected from the standing of the well-known publishers. There are, however, instances of hasty writing or careless editing in the work which should receive attention in subsequent editions.

Practical Electric Light Fitting

By F. C. Allsop. Size, 5 x 7½ inches. 289 pages. Published by the MacMillan Co. Price $1.50.

This book, according to its sub-title, is "a treatise on the wiring and fitting up of buildings deriving current from central station mains, and the laying down of private installations." The language quoted, as well as the main title, will indicate to the reader that the book relates to British practice. This, it may be said at the outset, should, however, be no detriment to the value of the book to electrical workers in this country, for an examination of its contents will show that it will be many times worth its cost to any electrical worker here by reason of its simple and practical treatment of the various subjects with which it deals.

The book, as the author states, was originally produced as a series of articles in the "English Mechanic," augmented from time to time, and his endeavour has been to provide plain, practical instructions on the subject of electrical installations within the scope of the title, in which endeavour he has been eminently successful.

The book is illustrated with excellent cuts, showing the exterior and interior of the apparatus employed in such installations. Many useful two-page diagrams of circuits for house-wiring are also given, together with directions for testing the wiring, for localizing faults, for setting up steam engines, gas engines, storage batteries, etc., and in short a thousand and one things necessary for an electrical worker to know are clearly enumerated in Mr. Alsop's work.

The Flow of Steam Through Nozzles and Orifices

By A. Rateau. Translated from the French by H. Boyd Brydon. Published by the D. Van Nostrand Company, New York; 74 pages, 4 diagrams and 4 plates. Price $1.50.

In 1895-6, to obtain more complete data for use in the design of steam turbines, Professor Rateau made a series of experiments on the flow of steam through convergent nozzles and orifices in thin plates. The results of these are given in this little book. In verifying the thermodynamic principles involved, he found that the theoretical formulæ, correctly interpreted, were exactly confirmed, and also that the experimental results allow of determining very closely the mechanical equivalent of the heat unit.

The author first outlines the theory of steam flow and, after discussing the velocity and weight of discharge, presents a table of values and a curve for designing the form of nozzle for any particular case.

In the succeeding chapter the method of procedure and the arrangement of the experimental apparatus are described, the results with the convergent nozzle and with an orifice in a thin plate being also given in a number of tables.

The author briefly compares his results with those obtained by Hirn in his experiments on air, and concludes with a discussion of the phenomena of the flow of hot water through nozzles.

Electric Elevator in the Vatican

ACCORDING to recent despatches from Rome, an electric elevator of the latest pattern has been installed in the Vatican. As the apartments of the late Cardinal Mocenni were on the top floor of the palace, he obtained from the late Pope permission to install a hand elevator, which was only used by the Pope and a few of the older Cardinals and visiting sovereigns. Pope Pius X., whose apartments are on the third floor, has now caused a new elevator to be built, which he blessed before it was put into use.

It is said of Prof. John E. Sweet that when an inventor asked for his opinion of a contrivance, he remarked:—"It seems to be a mighty good way to do a thing that doesn't need to be done."

Electrical Lectures at Stevens Institute

THE following special lectures for the senior class at Stevens Institute of Technology have, in part, been delivered during the month of May, and are to be completed this month:—John W. Lieb, Jr., on "The Generation and Distribution of Electricity in New York City;" Philip Torchio, on "Principles Governing the Design of Systems for Electrical Distribution;" Dr. Louis Duncan, on "The Development of the Electric Railway;" Chas. E. Downton, on "Shop Methods and the Apprenticeship System of the Westinghouse Electric & Manufacturing Company;" C. J. H. Woodbury, on "Telephone Line Engineering;" Wm. R. Baird, M. E., L. L. B., on "Patent Law;" Wm. O. Ludlow, M. E., on "Architectural Engineering;" Geo. Hill, C. E., on "Form and Surveying," and "Building and Cost Keeping;" Professor Wm. H. Bristol, M. E., on "Recording Instruments for Pressure, Temperature, and Electricity;" E. R. Douglas, M. E., on "Motor Drive for Machine Tools."

Submarine Signal Installations in Canada

TWO submarine bells for sound signaling have been placed off the coast of Nova Scotia, and tests have shown that the sound may be transmitted five miles. Other bells will be placed at several points on the coast in the Bay of Fundy and on the Cape Breton seaboard. It is expected that all steamers running to Canadian ports will soon be supplied with the receiving apparatus which will enable approach to the coast with safety in all kinds of weather. The minister of marine made a personal test of the submarine telephones on the Metropolitan Line steamers running between Boston and New York, and he is confident that these bells will be of the utmost value to Canadian shipping.

The Bureau of Equipment of the United States Navy has installed a wireless telegraph station at Honolulu. The nearest similar station is at San Francisco, 2180 miles distant. This will mark the limit of distance for space telegraphy up to the present.

There are 38 telephone circuits in Egypt. Trunk lines connect Alexandria and Cairo, and connection with other towns are contemplated.

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Leading Articles

Expert Testimony

AT a recent criminal trial in Massachusetts of more than local interest, an important feature of the case was the introduction of a vast amount of expert testimony, both for the State and for the defendant. Eminent medical authorities appeared in the court room, together with several handwriting experts of wide reputation. As is often the case, the opposing expert witnesses were by no means in harmonious agreement, and out of the trial has grown the renewed conviction that expert testimony is of little real value in legal proceedings. It is consequently of interest at this time to consider the value of testimony by engineering experts under legal summons with particular reference to electricity.

When called upon to give professional testimony in court, the electrical engineer has a notable advantage at the outset over the medical expert, the handwriting specialist, the mining authority and even the civil engineer. Instead of the elusive reactions of micro-organisms, the intricate sinuosities of letter formations, the uncertain probabilities of precious, but hidden, veins of ore, and the wide latitude in structural strength, introduced by the factor of safety, the problems of the electrical engineer rest upon the most definite phenomena.

Long ago, Professor F. B. Crocker, in an admirable address upon the "Precision of Measurements in Electrical Engineering," showed conclusively that astronomy is the only science known to man which is able to surpass applied electricity in accuracy of prediction. With the single exception of the phenomena of lightning, it is no exaggeration to say that the problems of modern electrical engineering are to-day solved on a basis of experimental and mathematical verification which enables even stubborn questions to be definitely run to earth. Given the facts, the deductions follow, and the conclusions become definitely established. In other words, there is not room for that degree of personal equation which appears so prominently in the testimony of experts in qualitative rather than quantitative subjects.

In electric railway work the limitations of definite data are mechanical, rather than electrical. The prediction of possible schedules in terms of the temperature rise of the motors is made with success long before the cars are run upon the track; the dynamo designer accurately predicts the performance of his created machine with little chance of disappointment when he goes into the testing room; the transmission engineer figures his line loss without fear that the power supply a hundred or so miles from the generating station will be inadequate; the telephone expert plans the transposition of five hundred miles of toll circuits with the certain knowledge that inductive disturbances will be powerless to prevent the transmission of clear speech; the lighting engineer plans a distribution system with the resulting voltage drops assured, and the cable specialist figures to a hair the time required to span the Pacific with message impulses, without anxiety as to the showing the cable will make under test. In the laboratory, the Thomson reflecting galvanometer responds with a sensitive leap of its spot of light to the minute electromotive force produced by the dipping of a brass pin and a steel needle into a drop of water, and the telephone receiver speaks of unbalanced circuits in which the millionth of an ampere is a monstrous disturbance.

Upon such a basis as this, fortified by the certainty of far-reaching mathematical investigations, rests the work of the electrical engineer. Dealing with invisible agencies, he produces permanent results that make good his promises in every great piece of electrical engineering, and the value of his testimony, therefore, cannot be overthrown. The power of scientific prediction is the corner stone of applied electricity, and in so far as the testifying expert has mastered the great laws which underlie his daily activities, so far will his testimony agree with that of other skilled witnesses in the solution of any specific problem.

Electricity in Public Libraries

AN attractive field for the installation and use of electrical equipment is to be found in public libraries. The advantages of the incandescent lamp over gas illumination have been so long appreciated by progressive boards of trustees that little need be said upon this point. Librarians well know that the depreciation of books is hastened by the use of gas; that the fire risk is insignificant with a properly installed and used incandescent lamp, and that the freedom from vitiation of the atmosphere peculiar to the electric light recommends it in every case where common sense has a bearing. While the problem of library lighting involves both distributed and concentrated illumination—the former for the shelves, corridors and halls as a whole, and the latter for desk and table work—it cannot be said to involve grave difficulties of design and successful operation. The use of shades, translucent globes or frosted bulbs is necessary for the soft, yet clear light which a library requires, but the large amount of open space commonly encountered in the public rooms introduces a singular freedom of possible arrangement.

Electric buzzers, rather than bells, seem better adapted to the conditions of enforced quiet which are found in all properly managed libraries, and in many cases the telephone is certainly superior to the older speaking tube whistlings and shoutings. For rapid and effective communication between departments, the telephone is certain, in time, to come into much greater use in libraries. A speaking-tube system is never flexible in the sense that applies to the telephone wiring layout, and it is open to the further objection of lack of privacy.

The simplicity and economy of the electric motor when arranged to drive a ventilating fan has led to its widespread use in libraries as well as in other public and private buildings. Aside from the question of operating expense, the motor-driven fan is especially useful in the library on account of its silent performance of duty. Noise is the one element which has to be eliminated in the library.

It is somewhat strange that so little has thus far been done in the way of applying electric motors to the handling of books, considering the success which has been reached in the now well-tried installation of the Boston Public Library. This unique plant obviates the employment of a small army of boys—possibly a hundred or more—who would each be required to tramp about ten miles a day in getting books from the stacks. This waste of time and confusion is avoided by the book-carrier system by which volumes are brought to the delivery room from any part of the building. The library now contains about a million volumes, and has about five acres of book shelves.

Each of the six stacks of books is equipped with an 8-inch gauge railway track leading to an elevator well extending from the basement to the roof. The delivery room is located between the fourth and fifth stacks. When a call for a book is sent in by the transmission of a paper slip through pneumatic tubes to the proper stack the attendant in the stack has only to pick out the book desired and put it in a small car, pushing the latter off a siding upon which it stands, to the main line, where it automatically grips a cable and is carried along to the elevator well at a speed of about 500 feet per minute. When the car reaches the well, it comes to a stop and then rolls upon the elevator, which automatically carries it to the delivery room floor.

The elevator remains in position until the attendant pushes the empty car upon it; it then descends to the proper stack, stops at an upper return track, delivers the car to the track, and then descends to the receiving track to repeat the process with the next car to go upon the elevator. Meanwhile the first car has rolled by gravity down a siding to the main track, caught the cable and has been run back to its starting point, taking the proper switches on the way. Each stack is provided with an independent elevator, and the outfit is driven by 5-H. P. 110-volt motor located in a room at the bottom of the elevator well. The mechanical safeguards against dropping a car into the well, stopping at the wrong place, etc., are marvels of ingenuity. The pneumatic tube system is also electrically operated, and on the delivery room floor is installed a remarkable system for handling book slips and delivering them to different destinations. This is operated by a ¼-H. P. motor.

The Boston Public Library also has a well-equipped printing and binding department, electrically driven. The familiar advantages of the electric drive are repeated in this plant, which is located about a quarter of a mile from the central library building. There are three Mergenthaler Linotype machines in service, each run by ¼-H. P. 110-volt motor, several printing presses, and a paper-cutting machine. The latter is driven by a 2-H. P. direct-connected motor. The cost of power in the printing department last year was only about 1.5 per cent. of the total cost of operation in the department, and the binding department's power cost was less than one-fifth of one per cent. of its total expense; that is, the printing department turned out over 2,000,000 call slips, nearly half a million blank forms, more than a quarter of a million cards, and miscellaneous work at a power cost of $173.88, while the bindery bound over 35,000 volumes, repaired over 3100, and performed other work, with a power cost of but $44.00. As the economy and convenience of electricity become better realized through the presentation of results like these to library executives and trustees by central station men and engineers generally, there is certain to be a marked increase in its use.

Electric Turntables

CONSIDERING the unique advantages of electric motive power for turntable service, it is singular that many large railroads still adhere to the old and unprogressive manually-operated table. Experience has certainly been sufficiently favourable in the installations that have already been in use for several years to demonstrate beyond question the superior economy of the motor-driven equipment. Unfortunately there is sometimes a reluctance on the part of the more conservative steam railroad officials to spend money on improvements, because in various companies the tenure of office is uncertain, and departments are consequently run at the lowest possible expense for both maintenance and operation. The object in such cases seems to be to make a record in the matter of low expenditures, rather than to administer the department business with the broadest future economy in mind. Some railroads constitute notable exceptions to this policy, but in many cases immediate dividends are the sole requirement.

At the recent Railway Appliance Exhibition at Washington, nothing was shown in the way of electric turntable equipment. Surely this is a subject that deserved a better fate at the hands of the progressive manufacturers whose liberality and characteristic American enterprise made that miniature World's Fair of transportation equipment such a conspicuous success. It would seem that an opportunity was thereby lost to press home to both American and foreign delegates to the International Railway Congress the great advantages of the electric drive in one of the most important phases of roundhouse work.

The mechanical operation of turntables was first brought to the attention of railway officers by the great increase in locomotive weights during the past few years. It was found that locomotives weighing from 75 to 150 tons, and even more, could not be turned by hand with sufficient speed to meet the requirements of modern service in terminal and junction yards. Besides this, too many men were needed to handle the table, and a great deal of lost time was caused by the absence of adequate turning facilities. In the winter season the problem became still more troublesome and the delays due to insufficient power were at times peculiarly aggravating.

The result was that some of the railroads experimented with steam-driven tables and found these somewhat more satisfactory than hand-operated equipment; but in the long run the inefficiency of the donkey engine arrangement demonstrated itself.

It was necessary in most cases to carry around with the table the driving engine, boiler and coal bin. Coal and ashes could be handled in but small quantities at best; a skilled engineer was sometimes required by law for the turntable engine's operation, and in point of fuel consumption the engines fully lived up to the characteristics of their tribe. Hence the use of steam-driven turntables has never become general practice.

The electrically-operated turntable is distinguished by few and simple parts; low cost of operation and maintenance; clean and flexible motive power; heavy overload capacity and easily graduated speed control; rapid acceleration from standstill; entire saving of expense for power when not in active service, and ease of operation by an unskilled employee. In many features the service demand resembles the requirements of rapid transit service, and for this reason, as in large drawbridges, the series railway motor finds a special adaptation to the work.

The amount of power required varies widely, depending upon the weight of the engine to be moved, the weight of the turntable, and the construction of bearings and gearing. For most service the smaller types of railway motor will be found adequate, 20 or 30 H. P. covering the usual maximum demands. It is important to figure the work to be done by the table with reasonable accuracy and to test the power consumption by temporary methods, if a proper choice of motor capacity is to be made. The service conditions vary so widely in different installations that care is necessary in comparing established with projected plants, and the ease with which electrical tests can be made should encourage a practical experiment if there is any doubt about the power requirements.

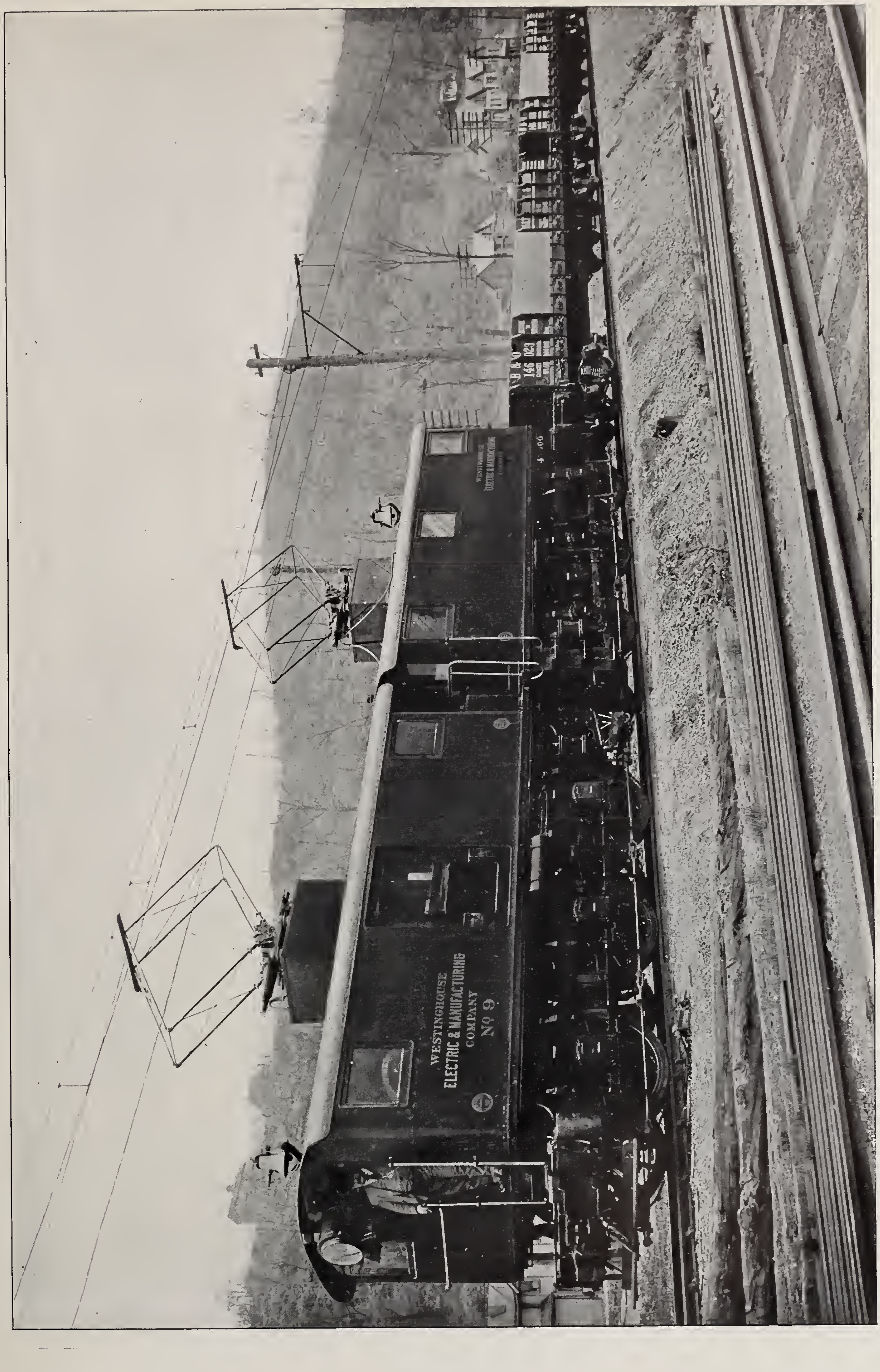
With electrical equipment it is not difficult to turn a locomotive at three times the speed possible by hand, and the acceleration given by the motor largely contributes to this. In a case discussed some time ago, a roundhouse was rebuilt with provision for twice the number of locomotives accommodated by the original structure, and it was stated by the superintendent that this desirable concentration of locomotives was made possible only by operating the turntable electrically.

Where only a few locomotives are handled per day, it is of doubtful expediency to spend the necessary $1000 to $1500 for a modern turntable equipment; but in practically all cases where time is of special importance and where electric power is available, the economy of the motor-driven table is beyond dispute. The total cost of turning a locomotive electrically should not exceed one or two cents where two or three hundred are turned in a day.

A Large Singe-Phase Electric Locomotive for Heavy Freight Service

Of the many interesting exhibits of railway appliances prepared for the inspection of the delegates to the International Railway Congress at Washington, D. C., last month, probably the most novel, and certainly the most important in its bearing on the use of electricity as a

A 135-TON SINGLE-PHASE ALTERNATING-CURRENT WESTINGHOUSE LOCOMOTIVE



THE LOCOMOTIVE IS EQUIPPED WITH SIX SINGLE-PHASE SERIES MOTORS OF 225 H. P. EACH. A 6600-VOLT TROLLEY CURRENT IS USED motive power for heavy railroad service, was the Westinghouse-Baldwin single-phase alternating-current locomotive shown in operation on the Interworks Railway at East Pittsburgh. This locomotive was built by the Westinghouse Electric & Manufacturing Company in order to convince the railway managers of the world of the possibilities and advantages of the use of single-phase current for the heavy electric traction, and to demonstrate the ability of the company to supply the necessary apparatus. It was shown in operation first running light and then hauling a train of fifty new steel gondola cars, weighing approximately 1200 tons.

From the details given below it will be seen that a number of new features are embodied in the construction of this locomotive. It is the largest alternating-current locomotive in the world, the largest to be operated by single-phase current, and is equipped with six of the largest single-phase motors ever built. It is the first alternating-current locomotive for use in America, and is designed for the highest trolley voltage ever used in this country.

The weight of the locomotive complete is 135 tons. It is built in two sections, each having a six-wheel truck with rigid wheel base. These are coupled together and are intended to operate normally as a single unit, but each half may be operated separately if desired. The locomotive is approximately 45 feet long over all, and 9 feet 8 inches wide. The total height above the rail, with trolleys lowered, is 17 feet. The wheels are 60 inches in diameter and are mounted on 3-inch axles, with 6 feet 4 inches between centers. The side frames of the trucks are of cast steel and are spring-supported in the usual manner, the weight on the two inside axles of each truck being equalized. The cabs are of sheet steel with angle-iron supports and are removable as a whole from the truck.

Each axle carries a 225-H. P. single-phase series motor of the single reduction-gear type, making a total of six motors for the locomotive. One side of each motor is supported directly on the axle, and the other is suspended by spiral springs from the locomotive body. The motors are of the same general construction as the standard Westinghouse alternating-current railway motors of smaller size. They are so arranged that forced ventilation may be used and increased output thus secured.

The locomotive is designed for a current of 25 cycles and a trolley voltage of 6600, and one of the most striking points of the exhibition to those who have been accustomed to the enormous currents required in heavy direct-current traction work, was the sight of so large a locomotive accelerating a 1200-ton train over a third of a mile in length and receiving its entire power supply from a single No. 000 trolley wire.

The 6600-volt current is collected from the trolley wire by a pneumatically-operated pantograph trolley on each half of the locomotive and is carried through a suitable oil switch and circuit breaker to an auto-transformer in each cab. These transformers reduce the voltage to 325 for use at the motors. The trolleys may be raised or lowered from the cab by operating an air valve.

The three motors on each half of the locomotive are connected permanently in parallel, and are controlled by means of an induction regulator, which, under the direction of the operator, varies the voltage at the motors from about 140 to 325. The induction regulators are driven by small series motors of the same general type as the main motor. Both regulators are controlled by the multiple unit system from a master switch at either end. They may be stopped at any desired point in their travel, and thus the locomotive may be run at any speed with the same facility and economy as a steam locomotive. Forced ventilation is used with the auto-transformers and induction regulators as well as with the motors, the necessary air being supplied by motor-driven blowers. Motor-driven air compressors are also used.

The locomotive is designed for low-speed freight service. With the motors working at nominal full load output the locomotive will develop a draw-bar pull of 50,000 pounds at a speed of approximately 10 miles an hour. On several occasions, however, when hauling the 50-car train referred to above, steady draw-bar pulls of from 60,000 to 65,000 pounds have been recorded on the dynamometer car and momentary efforts as high as 100,000 pounds have been obtained with no sign of slipping of the wheels. With lighter loads the locomotive may run at higher speeds up to a maximum of about 30 miles per hour.

The first telephone erected in England for practical purposes was recently disconnected at Devizes (Wiltshire). It was constructed in 1879 from a description and illustrative sketches of the instruments contributed by Edison to the "Scientific American," and connected the old town hall with the residence of A. Cunnington, the constructor.

Report of the British Lightning Research Committee

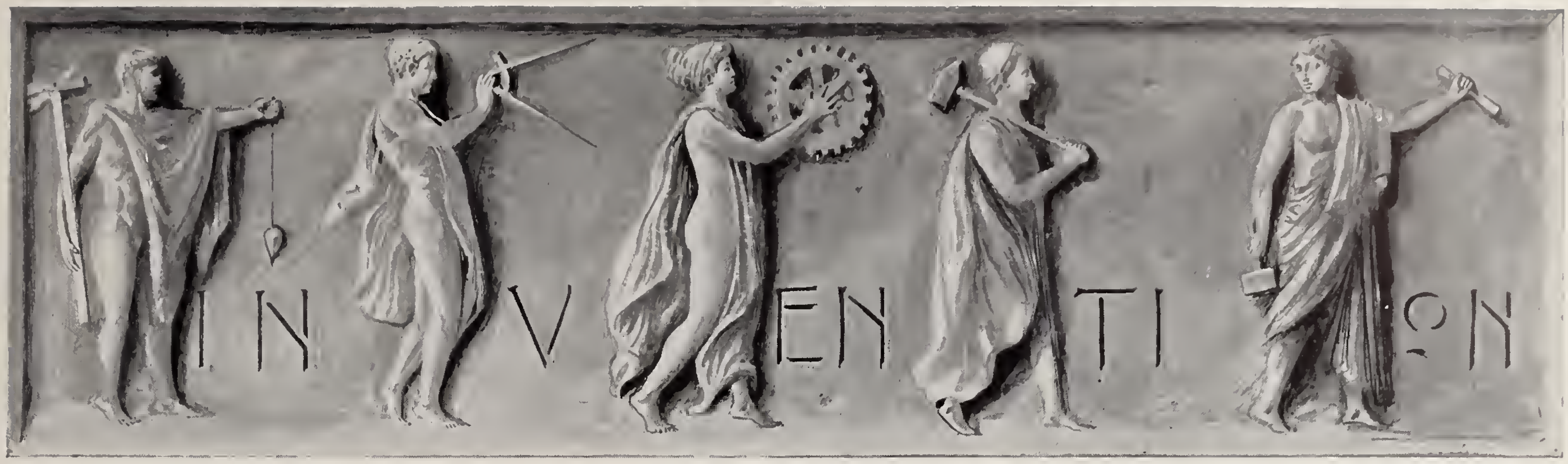
THE report of the British Lightning Research Committee has been recently issued and is abstracted in "The Electrical Engineer," of London. It deals with the distinction drawn by Sir Oliver Lodge between the two types of lightning discharge, designated the "A" and the "B" flash, respectively. The "A" flash is of the simple type which arises when an electrically charged cloud approaches the surface of the earth without an intermediate cloud intervening, and under these conditions the ordinary type of lightning conductor acts in two ways—first, by silent discharge, and, secondly, by absorbing the energy of a disruptive charge.

In the "B" type, where another cloud intervenes between the cloud carrying the primary charge and the earth, the two clouds practically form a condenser; and when a discharge from the first into the second takes place the free charge on the earth side of the lower cloud is suddenly relieved, and the disruptive charge from the latter to the earth takes such an erratic course that no series of lightning conductors of the hitherto recognized type suffice to protect the building.

The report says that probably the majority of the buildings in Great Britain are not efficiently protected against the effects of a "B" flash, although in many cases the conductors may be said to have at least partially fulfilled their purpose by carrying off the more violent portion of the discharge.

Some of the observations throw an interesting light upon the effects due to the oscillating character of lightning discharges. For instance, a discharge takes place over a lightning rod which may be in contact with or approach closely to the metallic portions of a roof. Powerful electrical oscillations are set up in the latter conductors, and dangerously high electrical pressure may be generated on the distant ends of these conductors Absolute protection of the whole of a building could only be assured by enclosing the structure in a system of wirework—a contrivance in the nature of a birdcage. This should be well connected at various points to earth, as nearly all buildings have gas and water pipes and other metallic conductors which are likewise earthed.

The Baltimore & Ohio Railroad is using the telephone for transmitting orders in rather a unique way. The orders are spelled out letter by letter and are repeated in the same way.



Electrical and Mechanical Progress

Small Steam Engine-Driven Generating Units

THE illustration on this page of the steam engine-driven generating unit, built by the Rochester Machine Tool Works, of Rochester, N. Y., shows one of a series of seven of $\frac{1}{2}$, 1, 2, 3, 4, 5 and 8 horse-power, respectively, at 80 pounds steam pressure.

The engine is of the upright, double-cylinder type, with cranks set at 180 degrees. The pistons are $1\frac{1}{2}$ times the stroke in length, and the wrist pins are slightly below the middle, with steam rings above and below. The main bearings are $2\frac{1}{2}$ times the shaft diameter and are bushed with bronze.

The valve is of the balanced working type and is placed on top of the cylinders, the valve chest forming the cylinder heads. The flywheel is of cast iron and is fitted with an automatic governor which changes the throw of the eccentric to suit the load. Lubrication is accomplished by carrying in the crank-case a mixture of oil and water, into which the cranks dip at every revolution and throw the oil to every part inside the case.

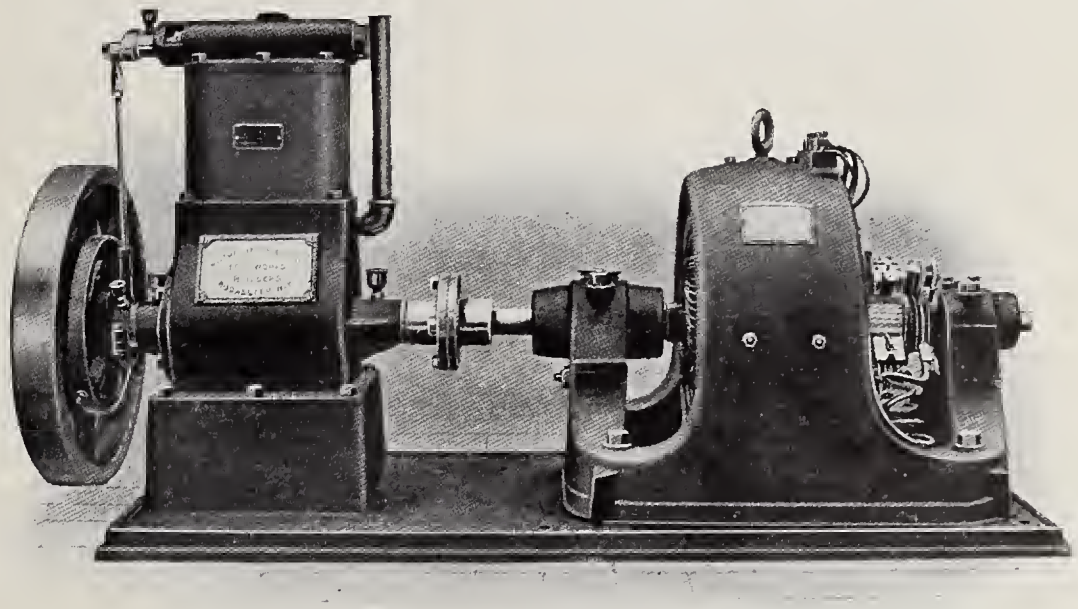
Bed plates can be furnished to meet the requirements of any build of generator, making these engines especially adapted for small, independent equipments for yachts, steamships, search lights, office buildings, night service in hospitals and similar service. The growing demand for small, independent units in large plants, and steamships, for use in making repairs, and at times when it is not desirable to operate the main plants, has made these equipments very popular. They have been on the market for 20 years, and have been shipped to Japan, Russia, South Africa, Ireland, England, New Zealand and other countries.

Neutralizing Static Electricity in Textile Machines

A PROCESS for neutralizing the static electricity generated in textile machines was described by Philip Dana in a paper read at a recent convention of the New England Cotton Manufacturers' Association. The static electricity present in the material being worked causes it to cling to the parts of the machines, resulting in delay and loss of production. The device consists of a source of alternating current, (any 110 or 220-volt alternating lighting systems), a transformer to step the alternating current up in voltage to an amount somewhere between 10,000 and 20,000 volts, and an inductor to distribute this high-voltage current over the substance to be treated. The inductors are fine steel wires, and are incased in hard rubber, fine steel points being flush with the rubber case.

The principle on which it works is that a static charge spontaneously selects from a neighboring alternating charge the kind and quantity of electric current exactly to neutralize itself. If the static charge happens to be positive, it would take from the inductors enough negative current to neutralize itself, and vice-versa.

Static electricity in any material is very small in quantity, although of a



A STEAM ENGINE-GENERATOR SET BUILT BY THE ROCHESTER MACHINE TOOL WORKS, ROCHESTER, N. Y.

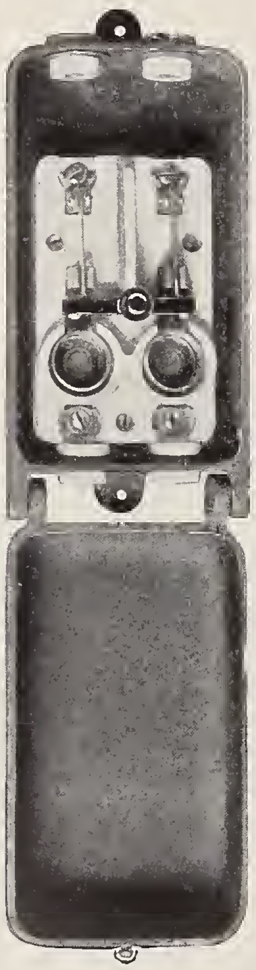
very high voltage, and the quantity required to kill it is correspondingly small. This fact allows the transformers to be constructed so as to limit the maximum output to a few mil-amperes, thus making it perfectly safe for a person to take the whole charge.

While this process has had a limited application in cotton manufacturing, it has, in other branches of manufacture, been extensively used. On paper machines, paper bag machines and printing presses, it has been of very great value, the production being more than doubled in some cases. Some woolen mills have used it successfully on their cards, and another firm has used it on their shearing machines, finding it much easier to brush off from the cloth the dust and short fibres from shearing, where no static electricity existed.

The process is controlled by the Chapman Electric Neutralizer Company, of Portland, Me.

A New Service Switch

A NEW type of entrance box or service switch made by the Troy Electrical Company, of Troy, N. Y., is illustrated on this



A NEW SERVICE SWITCH MADE BY THE TROY ELECTRICAL COMPANY, TROY, N. Y.

page. The National Board of Underwriters require that at all points where service wires enter a building, a service switch be installed at the nearest point practicable. This service switch must be mounted in an iron-clad box and, where the wires are run open or in molding, the wires

A NEW SERVICE SWITCH MADE BY THE TROY ELECTRICAL COMPANY, WITH THE BOX CLOSED

must pass through porcelain bushed holes in the box. Where conduit is used, the box must be suitably arranged for the conduit.

The box illustrated consists of two castings, the cover being nearly as deep as the box itself so as to allow the face of the switch to come nearly flush with the sides of the box. The box is $7\frac{1}{2}$ inches long, $4\frac{3}{8}$ inches wide and $4\frac{1}{2}$ inches deep. These are outside measurements over all, with the exception of the screw-ears for supporting the box to the wall. The total length of the box over the screw-ears is $9\frac{1}{4}$ inches.

Mounted in the box is the standard type of double-pole, 25-ampere, 110-volt knife switch in combination with a fuse plug cut-out. The box is extremely neat in appearance and small and complies with all of the underwriters' rules. The new boxes sell for about one-third of the price of the first ones brought out by the company. They are also made a little larger for 220-volt service, and for the 3-wire system.

A New Hydro-Electric Plant in Colorado

THE Animas Canal, Reservoir, Water, Power & Investment Company, of Durango, Col., is now installing a hydro-electric plant of considerable importance. The power house is located about 20 miles from Durango, at a point affording an effective head of 970 feet available through 2800 feet of pipe. The initial installation will consist of two 2250-K. W. General Electric generators, direct connected to Pelton water wheels, but provision has been made in the dam and headworks for an ultimate development of 30,000 H. P.

The present pipe line, one of the two units, is of sheet steel, varying in diameter from 44 inches at the upper end to 34 inches at the wheels, and of thicknesses from 3-16 inches to 11-16 inches. The pipe is all double butt-strap riveted, with triple riveting at the lower end, and is provided with flanged connections. Thus an exceedingly heavy and substantial pipe construction is assured.

The water-wheel units, two in number, are of the "double-overhung" construction, each unit consisting of two Pelton wheels, one overhanging each end of the main shaft, with the engine-type generator in the center. Needle nozzles are used, which, operated by oil-pressure automatic governors, will insure accurate regulation and economy of water at all stages of load. The wheels are approximately 8 feet in diameter, with centers of cast steel, turned all over and fitted with Pelton buckets straddling the periphery and secured to it by means of turned steel bolts driven in reamed holes. The buckets are fine ground and machined inside to obtain the highest possible efficiency. Each wheel unit will have a maximum capacity of 4000 H. P. to provide for an overload on the generator.

The complete hydraulic plant, including pipe line and water wheels, was manufactured by the Pelton Water Wheel Company, of San Francisco and New York, and the electrical equipment by the General Electric Company; F. O. Blackwell, of New York, was retained as consulting engineer of the company.

A New Single-Phase, Alternating-Current Crane Motor

FOLLOWING the development of the single-phase, alternating-current railway motor and its successful adaptation to the conditions of modern traction service, the Westinghouse Electric & Manufacturing Company, of Pittsburg Pa., have placed upon the market a complete line of motors of similar characteristics but smaller capacity for the operation of electric cranes, hoists, elevators and similar apparatus demanding a heavy starting torque and a wide range of speed variation under control of the operator. A motor of this type is illustrated on the next page.

Like the alternating-current railway motors, these motors are of the series-wound commutator type, with compensating field windings, laminated cores and inwardly projecting poles. The fields consist of laminated cores built up of sheet-steel punchings held between end plates and mounted within cast-iron frames. The frames are of the box type and are closed at the end of substantial brackets which support the bearings. Feet are provided for the convenient mounting of the motor. The belts which hold the end plates to the frame are evenly spaced, so that the bearings may be turned 90 degrees and the motor mounted upright, or with feet bolted to a vertical surface. The large opening around the commutator is closed by a sheet-steel band fastened by thumb screws, and so arranged that easy access may be obtained to commutator and brush holders at all points. The bearings consist of solid shells lined with babbitt metal, and are of ample dimensions for the most severe service. Grease lubrication is used, drip cups being provided under the bearings.

There are four inwardly projecting poles made of laminated steel punched solid with the core and magnetized by field coils of the usual type. An auxiliary field winding is also provided threaded through slots in the pole faces.

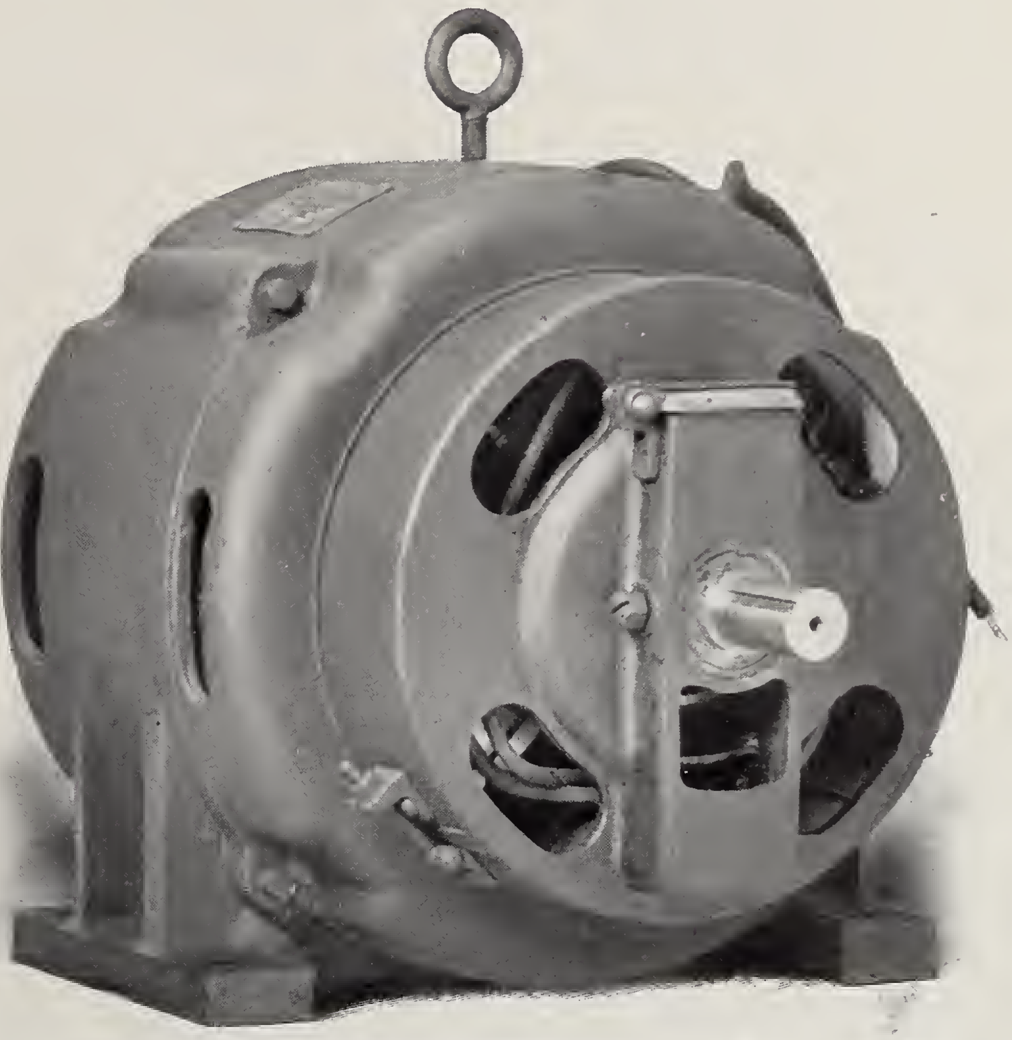
The armature is of the usual slotted drum type, with core built up of circular punchings of soft sheet steel mounted upon a cast-iron spider. In the larger sizes, ventilating ducts are provided between the punchings through which air is forced out against the field coils and core. A uniform temperature is thus maintained at all parts. The commutator is mounted upon an extension of the armature spider. Wiper rings are provided to protect the armature from grease. The shafts are of great strength and are extended at both ends to accommodate pulleys, pinions or brake discs.

The carbon brush holders are the same as the standard Westinghouse holders which have been so successful in direct-current practice, and consist of rectangular boxes machined to fit the brushes. An even pressure is maintained by the long, flat spiral spring, which the smaller vibrations are taken up by a short spring.

The motors are wound for a nominal potential of 200 volts at 3000 alternations, or 100 volts at 7200 alternations per minute, but will operate successfully upon voltages 10 per cent. higher. For other potentials it is advisable to use transformers. These motors are manufactured in sizes having nominal ratings from 5 to 35 H. P., and are wound for 25 cycles per second. For larger capacity, the standard single-phase, alternating-current railway motors are recommended.

The speed of motors of this type may be varied by any method which will vary the voltage impressed at the motor terminals. On account of its simplicity and effectiveness, the rheostatic method of control, similar to that used with direct-current series-wound motors, has been adopted as standard. The controllers and resistances are similar to those used with direct-current motors of similar capacity, and are of the well-known Westinghouse dial or commutator type, according to the size of the motor with which they are to be used. Resistances are mounted in the controller frames. Contact fingers are carried on a moving part having four radial arms, and can be operated by a single handle or a system of bell cranks and levers. The operating rod can be connected to either the right or left-hand side of the rocker arm, so that the controllers can be mounted face to face or back to back, as may be most convenient. A single movement forward or back applies the current for the operation of the motor in either forward or reverse direction. Controllers of the dial type have twelve steps, those of the commutator type sixteen steps, in either direction. With the smaller controller the resistance is formed of wire wound on insulated bars which are supported in the frame by porcelain blocks. With the larger controllers, resistances of the grid type are employed. These controllers differ from those used with direct-current motors mainly in that blowout magnets are not used. All parts are easily accessible and the entire mechanism is simple and easily operated and maintained.

For use with these motors a complete line of automatic electric brakes, similar to those employed with direct-current, series-wound motors and with induction motors in crane and hoisting service, has been developed. The device consists of a set of brake-shoes, levers and magnet coils, which are mounted upon the front end bracket of the motor, and a brake wheel is mounted on the motor shaft. The shoes are lined with a special composition and are applied to the wheel by the action of the armature of an electromagnet. A turn-buckle adjustment provides means for taking up wear. The electromagnet consists of a U-shaped core and a U-shaped armature with two windings, one around each limb. Electrical connections are made across the line through a switch on the controller. The switch is automatically operated with the first step of the controller.



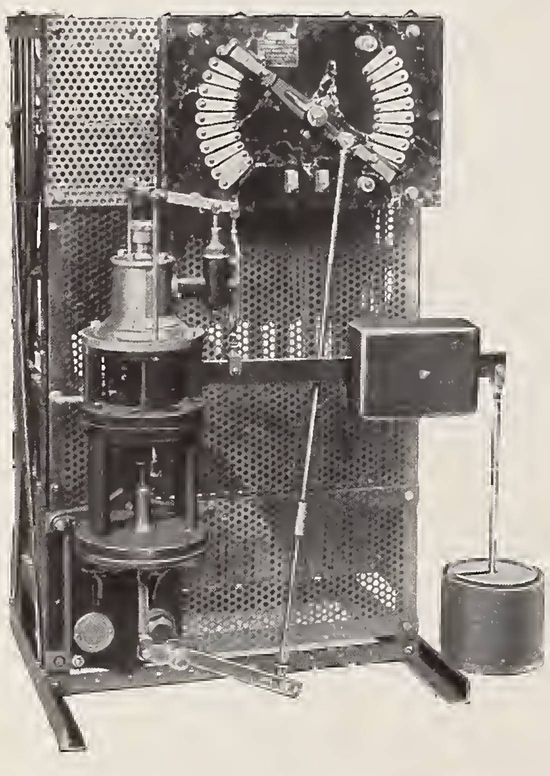
A NEW SINGLE-PHASE, ALTERNATING-CURRENT, CRANE MOTOR BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

When closed, the armature of the electromagnet is raised and the brake released. When the movement of the controller to the off position opens the switch, the armature of the electromagnet falls by gravity and the brake is set. The armature is connected with the brake-shoe by means of links in such a way that it is practically impossible for the brake to fail when the controller is in the off position. Should the power fail while the motor is operating, the brake is immediately set and the load held. As both brake and controller are operated by the same mechanism, it is impossible to set the brake while the motor is connected to the line.

A New Automatic Speed Regulator

A NEW automatic speed regulator designed by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., is shown in the annexed illustration.

The regulator is for use in connection with mechanical stokers, for in-



A NEW AUTOMATIC MOTOR-SPEED REGULATOR MADE BY THE CUTLER-HAMMER MANUFACTURING COMPANY, MILWAUKEE, WIS.

duced-draft or forced-draft systems in boiler plants and in pumping plants, where it is desired that the motor operate and supply water continuously at certain pressures, the volume of water furnished varying with the demand.

In boiler plants the controller is arranged to vary the speed of the motor which drives the draft fan, and the control is taken from the boiler pressure directly. The regulator proper, shown in the illustration at the lower left-hand corner of the resistance frame, consists of a pressure regulator controlled directly by the steam pressure, and a hydraulic cylinder controlled by the pressure regulator, in which the piston is mechanically connected to the rheostat lever. The steam pressure is admitted directly below the diaphragm of the pressure regulator, and the pressure of the steam on the diaphragm is balanced by the weights on the lever. The lever will therefore rise and fall slightly with the rise and fall of steam pressure in the boilers.

The hydraulic cylinder is controlled by a pilot valve and the pilot valve by a floating lever between the crosshead on the hydraulic cylinder piston rod and the link from the regulator lever. The operation of the cylinder is so arranged that the piston will be forced downward when the regulator lever rises, and the relative motion of the piston rod and the link from the regulator weight lever is such that proper operation of the pilot valve stem is obtained. When the pressure rises, slightly opening the pilot valve, water is admitted to the hydraulic cylinder, forcing its piston downward, and thereby causing the pilot valve to close a corresponding amount. Any slight rise or fall of the pressure causes a corresponding fall and rise of the hydraulic cylinder and a corresponding operation of the rheostat lever.

The parts are so proportioned that, with a certain variation in pressure, the rheostat lever will travel from one end of its contact to the other, and for smaller variations, a proportionally smaller travel will be obtained. The result is that, as the pressure rises and falls, the rheostat lever follows the change exactly and changes the speed of the motor inversely to correct the changes in pressure. As the pressure rises, the motor is slowed down, decreasing the draft, and conversely, if the pressure falls, the motor is accelerated, increasing the draft. The boiler pressure may thus, it is claimed, be automatically kept within the limit of 2 pounds above or below a given normal pressure, and, under all conditions of demand on the boiler, the speed of the motor is adjusted within the range set by the regulator, to give a draft suiting the demands upon the boiler.

The speed of the motor may be controlled in several ways, either by resistance in the armature only, by resistance in the shunt field circuit only, or by a combination of these two. These methods only have been cited as being the simplest and the methods most generally used, but, of course, by suitable arrangements, any method of speed control may be adopted. For very large motors, speed control is obtained by means of solenoid switches, and the rheostat lever shown on the drawing is therefore used only to control the windings of the several solenoid switches, since it would be impracticable to handle heavy currents when the motion of the rheostat lever must necessarily be very slow and at times very small indeed.

The arrangement of the regulator, of course, precludes the addition of the automatic release feature without some complications, except in those cases where solenoid control is used. For small equipments it is usual to install in connection with a regulator of the character described above a standard automatic release type of starter. An automatic starter is also advisable, since the regulator automatically adjusts itself to the full-speed condition when the motor is permanently shut down, and apparatus of this character is necessary in starting the motor up after it has been shut down.

A New Smokeless Boiler Furnace

OF late years an increasing amount of attention has been given to the problem of preventing smoke in large cities, and considerable legislation has been effected with this end in view. Various arrangements of mechanical draft have been tried with considerable success, and the adoption of the automatic stoker has in many cases relieved the situation greatly. Much has also been accomplished through attention to more careful practice in hand firing. But the situation in many cities is still far from satisfactory, and there is room for the greater enlightenment of many users of soft coal.

Smoke as seen issuing from the stack of a power plant is composed of water vapor, gaseous products of combustion, coal dust, fine particles of carbon, and carburetted hydrogen gas. The first two elements named are invisible and non-combustible, being products of that portion of the coal which attains complete combustion; hence they are always present. But the remaining ingredients, such as coal dust, fine particles of semi-consumed carbon and carburetted hydrogen gas, are visible, strictly combustible and purely the products of incomplete combustion.

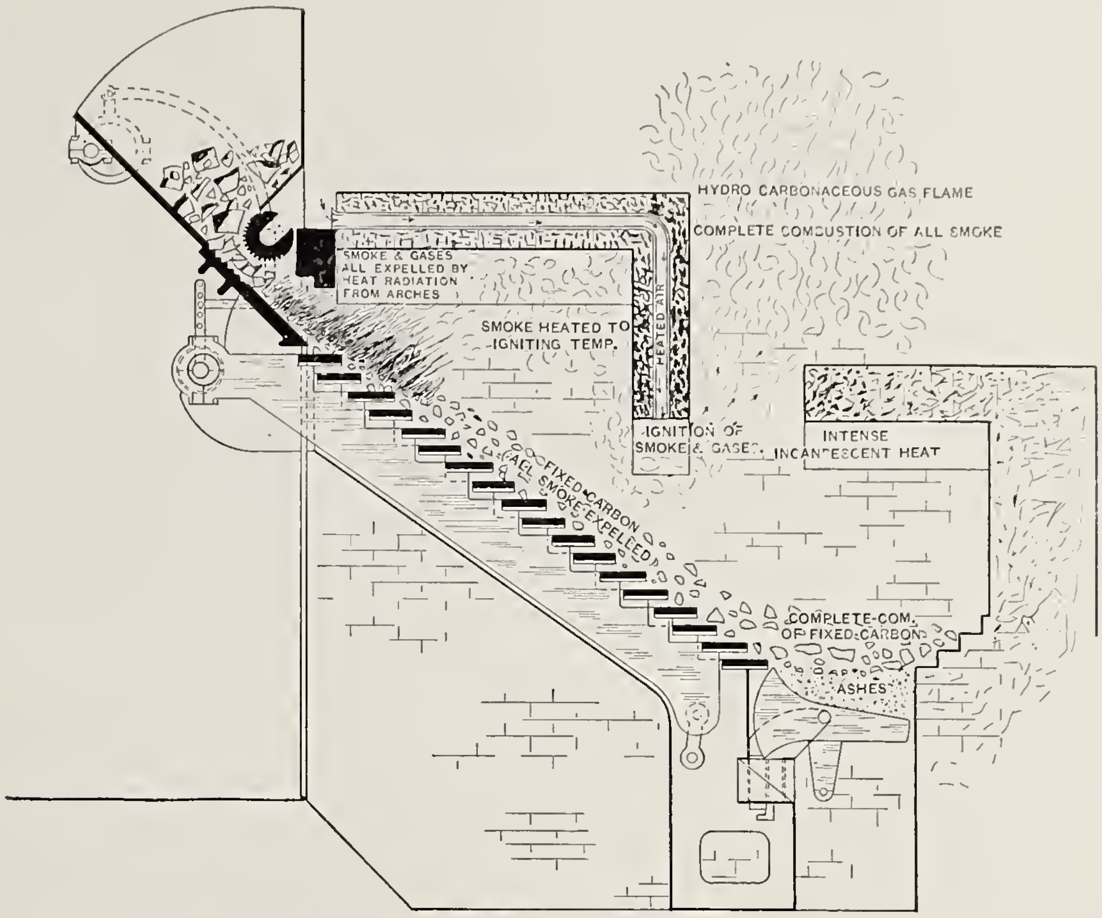
It ought to be a simple process to obtain a very high percentage, say over 95, of the heat units which are in the coal. In order to do this, the only sure way of entirely preventing smoke, a boiler furnace must be so constructed that these small particles of coal will be consumed before they reach the flues. The carburetted hydrogen also, must attain a sufficient temperature in the presence of sufficient oxygen to produce combustion. To utilize as many of the heat units as possible has been the aim of many designers of smoke preventers which have been placed in service. Until recently, success has been realized in part at least by admitting the air into the fire-box at or near the temperature of the steam, but it has often worked out that such a degree of heat is not high enough to allow the introduction of enough oxygen to complete the combustion without lowering the furnace temperature two much. It is essential to maintain the high temperature at all times and at all the points of exit.

For about six months, the Newton & Boston Street Railway Company has had a new smoke consumer in service at its Newtonville, Mass., power plant, in connection with a 125-H. P. Babcock & Wilcox boiler. The apparatus is a combined mechanical stoker and "smoke consumer," and is the first equipment of its kind to be given a commercial test. It was made by the Fulton Fuel Economizer Company, of Boston, and the claim is made for it that it is smokeless, will burn any coal upon the market from slack to anthracite, and that it requires replenishing of the hopper but two or three times an hour.

As may be seen in the annexed illustration the equipment is arranged with arches and check walls so disposed that the smoke and combustible gases cannot escape from the furnace until they are heated to their ignition temperature. A row of tubes about $1\frac{1}{2}$ inches in diameter admits air to the point of the furnace where the unconsumed particles of carbon and carburetted hydrogen are carried, and it is impossible to see any smoke in the fire as the flames ascend to the water-heating surfaces of the boiler.

The feed of coal is positive and regular, movable grate bars being moved through an elliptical orbit by a cam mechanism operated by the driving engine. Three complete revolutions per minute are made by the grate bars. The coal supply consists of a ribbon of fuel about two inches deep. The arrangement of arches forms a reverberatory furnace, and, as the smoke expelled from the coal rises and advances along the ceiling of the fire-box, it becomes heated to a very high temperature before meeting a check wall, where it is diverted downward and is brought in close contact with that portion of the fire-bed where the fixed carbons are burning and giving off an intense heat, at which point the heated supply of fresh air is admitted. There the gases are ignited.

The Newtonville plant is at present equipped with about 1000 H. P. in boilers, of four 125-H. P. and two 250-H. P. units. The operating force boiler were equipped with an automatic stoker, and doubtless this force would be further reduced by the introduction of a modern coal-handling



SIDE ELEVATION AND SECTION OF THE FULTON SYSTEM OF COMBUSTION, INSTALLED BY THE FULTON FUEL ECONOMIZER COMPANY, BOSTON, MASS.

in the fire room consists of three regular firemen, two assistants and a coal passer. It is estimated that three firemen and one coal passer could handle the entire battery of boilers if each system. The stoker in service is open to improvement in certain details, notably in the engine used for driving and in the location of the air openings outside the boiler, but these particu-

A VIEW OF THE FULTON STEPPED GRATE

lars are small considerations in comparison with the efficient and cleanly combustion secured. The weight of ashes produced in the furnace equipped with the new smoke consumer is about one-third that deposited in the ash pit of a second 125-H. P. boiler in the plant.

The cost of the equipment varies from about $700 to $1300, depending upon the size of boiler. In a six-hour test, the steam pressure varied only two pounds, the automatic stoker taking care of all the variations in demand upon the boiler without hand adjustment.

Large Automatic-Release Motor Starters

AMONG the recent large orders received by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., is one of two 1500-H. P., 250-volt automatic release starters for use in the Edgar Thompson Steel Works of the Carnegie Steel Company, Braddock, Pa. The starter proper will be built in the form of a switchboard of white Italian marble, approximately 7 feet 8 inches high and 11 feet long. The several sections of starting resistance are controlled by a number of independent levers, and the levers which will carry the motor current continuously are to have a continuous capacity of 10,000 amperes. The intermediate starting levers, which as occasion demands may also be used temporarily for regulating duty, will have a 6000-ampere capacity.

The switchboard will consist of five panels, each panel containing two levers. An entire panel may be removed from the board without disturbing the other panels, or the parts mounted on them. The levers on the several panels are mechanically interlocked in the manner adopted for the multiple switch type of starters, so that the several levers composing the starter cannot be operated except in a predetermined order. The overall length of each of the levers is a trifle over 3 feet, but by means of a toggle-joint action these heavy switches may be closed with a very small amount of force. The resistance for these starters will consist of standard steel rails, mounted in a steel rack, approximately 20 feet high, 14 feet wide and 27 feet long. There will be about one hundred 25-pound rails and two hundred 40-pound rails used. This enormous capacity of resistance material is provided so that the resistance may be used to control the speed of the motor for short periods of time, even under comparatively heavy loads without permanent injury. The main connections to the starter will consist of six 1,000,000-circular-mill cables.

The motors which these starters will be used to control are of the Westinghouse make, and will be very heavily compounded. The motor armature shaft will carry a fly wheel 20 feet in diameter, weighing approximately 125,000 pounds, and will be directly connected to the standard blooming mill rolls. The motors will be designed to stand very heavy overloads for short periods of time, and mechanically constructed so as to stand the enormous strains encountered in this service. The normal speed of the motor will be 100 revolutions per minute, and allowances will be made so that this speed may be increased 25 per cent. by weakening the shunt field of the motor. If the installation of these motors proves satisfactory, the Carnegie Steel Company will equip the mills in its other plants with motors instead of the cumbersome steam engine now used.

For some time the Pittsburg Reduction Company has had a 1500-H. P., 500-volt motor driving a blooming mill in satisfactory operation at its plant at Messina, N. Y., a 500-volt starter being used similar in construction to those to be installed at Braddock.

A New Type of Dynamo Brush

OF recent years the tendency in dynamo brush design has been towards the production of a brush combining the sparkless collecting properties of carbon with the high current-carrying capacity of metal. A description of a new dynamo brush patented by Messrs. Svenska, of Stockholm, which claims to accomplish this, is given in "The Electrical Review" of London.

It is known as the bronze-carbon brush, but the mass of the brush does not consist, as the name would seem to imply, of a mixture of powdered bronze and powdered carbon, but of pure powdered graphite, of which each separate particle is first covered with a coating of copper and then with one of tin. The method employed for coppering and tinning the particles is a trade secret. After this process is completed, the powder is hydraulically compressed in a dry and cold state, and without any special binding material, into the required shape. The hardness of the brush can be varied at will during this operation. Afterwards, the brushes are heated sufficiently to cause the copper and tin coating to combine and form a bronze coating. In this way every particle of graphite powder receives a coating of bronze, but the smallness of these particles keeps the material quite homogeneous. It will take a polish and is readily soldered, and also possesses lubricating qualities owing to the presence of about 20 per cent. of free graphite.

Tests carried out at the Government Laboratories in Stockholm have proved that the conductivity and the contact resistance of these brushes are the same as those of ordinary plate or gauze brushes. Tests made on a 110-volt dynamo with ordinary carbon brushes and with bronze-carbon brushes show that the difference between them is especially marked at the higher current densities. For instance, at a peripheral speed of 49 feet per second, and a current density of 64.5 amperes per square inch, the loss with ordinary carbons was 34.5 watts, while with the bronze-carbon brushes, under the same conditions, the loss was only 3.4 watts.

With regard to sparkless running, it has been found that the bronze-carbon brushes behave as well as pure carbon brushes, and replacing the latter by brushes of the same size and shape, but made of bronze-carbon, does not affect the running of the machine. The rate of wear of these bronze-carbon brushes is slightly greater than that of metal brushes, but, on the other hand, the wear of the commutator is much less.

Innovations in Nernst Lamps

SEVERAL important improvements have recently been made in Nernst lamps, among which may be mentioned the introduction of a converter coil. This coil is used in circuit with the 220-volt lamps when it is desired to operate them on 110-volt alternating-current circuits, as is often the case in small installations where it is advisable to employ a few multiple-glower lamps without changing the existing low-pressure circuit. This coil is mounted in a suitable case which is fastened to the ceiling over the lamp.

An additional glower is now used in Nernst lamps designed for store lighting, making in all four glowers for this type.

By means of a novel switch attachment, either the four or six-glower lamp may be reduced in brilliancy at will, affecting thereby a proportionate reduction in the current used. The operation of the switch cuts out of circuit half of the number of glowers in the lamp, and this feature is of special value to small consumers using three or four lamps so arranged that one of them cannot be extinguished without the general distribution of light being seriously affected.

In order to protect the heater from further deterioration when the glower breaks, a heater cut-out has been employed. It is believed that this device will considerably reduce the maintenance cost of the lamp, as it is very seldom that a lamp is turned off after the glower breaks, and this generally results in injury to the heater.

For residence or office use, where it is necessary to have light as soon as the switch is turned, a special arrangement is employed in which incandescent lamps are connected in parallel with the heaters. Two incandescent lamps are used in series, and by means of a cut-out the incandescent lamp circuit and the heaters are disconnected simultaneously.

In addition to these improvements may be mentioned the perfected shape of the casing for the lamp so as to protect it from insects and dust, and the use of a spring globe holder and chain suspension to facilitate the trimming process.

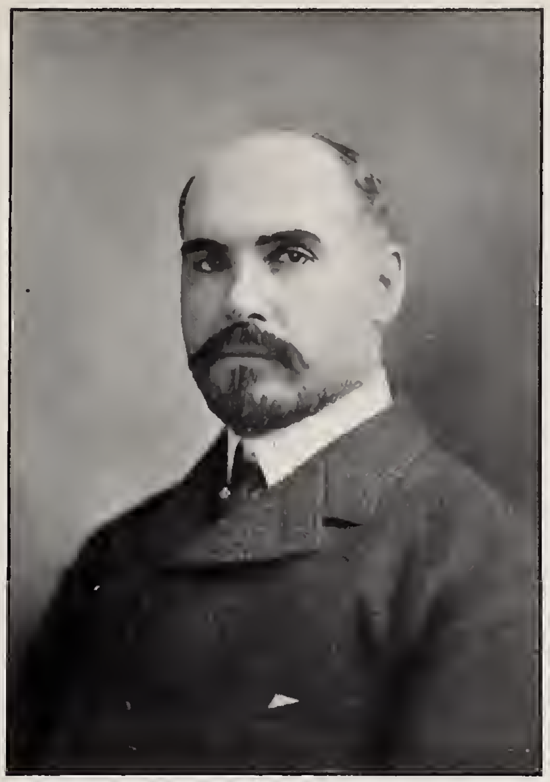
Personal

Baron Alphonse de Rothchild, recently deceased, was one of the honorary members of the National Electric Light Association.

At the recent convention of the Association of Railway Telegraph Superintendents, William Maver, Jr., read a paper entitled "Some Notes on Breaks Due to Sleet and Wind Storms, and Some Proposed Remedies." A committee was appointed to gather data on this subject, and Mr. Maver was appointed chairman.

"The Carnegie Foundation," formed to provide pensions for college professors and teachers, was incorporated on May 10, with the Secretary of the State of New York. The principal office is in New York City. The incorporators are Nicholas Murray Butler, of New York; Alexander C. Humphreys and Robert A. Frank, of Hoboken, N. J., and Henry S. Pritchett, of Boston.

Excellent evidence of the success which Louis R. Alberger, president of the Alberger Condenser Company, of New York City, has achieved for the apparatus turned out by his company, is afforded by the fact that he has completely equipped three of the largest power houses in the world with condensing apparatus of his design. One of these, the subway power house

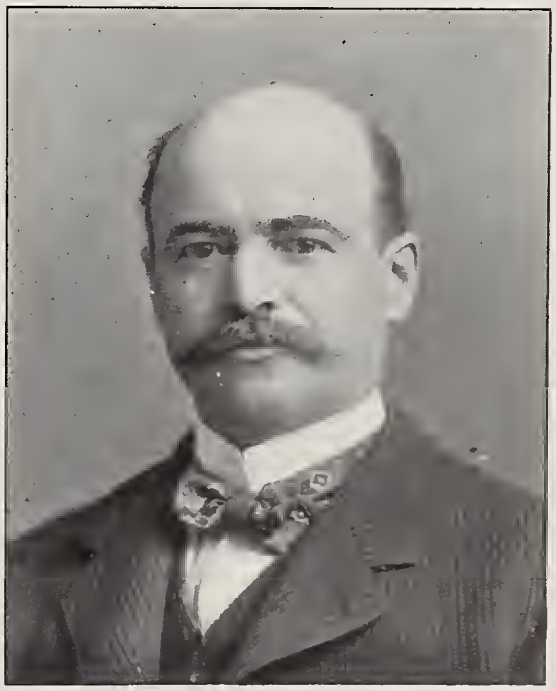


LOUIS R. ALBERGER

of the Interborough Rapid Transit Company, of New York City, has a nominal aggregate capacity of 100,000 H. P., and the condensing apparatus is supplied with water by cross-compound Corliss pumping engines capable of circulating 100,000,000 gallons per day. The plant of the Commonwealth Electric Company, of Chicago, is the first large steam turbine installation to operate in this country and it has been in service now for over two years. One of the innovations to be carried out here was the discarding of the usual basement and the placing of the entire equipment consisting of turbines, condensers, heaters and pumps, all on the main floor. The third plant referred to is the Neasden power house of the Metropolitan Railway Company, London, England. This station also contains steam turbines of large size and supplies electrical current to the London underground railway. The condensing apparatus in this station is quite different from that previously mentioned, but it is also of a high character both as regards design and construction. All of the condensers that Mr. Alberger has installed for steam turbines have been developed along lines of production of the highest degree of vacuum with the least cost of operation. A high vacuum is of so great a value to a steam turbine that its attainment becomes of first importance, and the refinement of the condensing apparatus has brought returns that more than warrant the investment.

The following story is told of a well-known New York electrical engineer, now deceased. On one of his trips to Europe he was entertained at the country seat of a well-known electrical engineer of London. Some months thereafter the New York engineer was favored with a return visit from his former host, whom he invited to his suburban home at E. The first night on passing the guest's chamber a pair of shoes outside of the door attracted the attention of the New Yorker. The intent was obvious. They were there to be polished. But who was to polish them. To ask the cook, waitress or chamber maid to perform this menial work was out of the question, and, of course, there was no "boots" in the New Yorker's establishment. This being the situation, the host quietly picked up the shoes, and carrying them to the basement constituted himself "boots" by shining his guests shoes, which he then as quietly and as deftly restored to their place outside of the door. During the entire stay of the Londoner the host performed this pleasant duty nightly, and when the guest departed he left a handsome tip for "boots," whose work he highly commended. Years afterward the New Yorker used to tell this joke upon himself with gusto, but it is more than likely that the visitor, who is still living and knighted, is totally ignorant of the identity of his "boots" on the occasion of his sojourn at E.

Wallace C. Johnson, of Niagara Falls, recently returned from the West, where he was making an examination of several streams on the eastern slope of the Rocky Mountains for the Canadian Pacific Railway Company. Other work which he has on hand is an examination for a mining company of a water power in the northern part of Nicaragua, consulting work for the



WALLACE C. JOHNSON

Quebec Railway, Light & Power Company, in connection with a new development at Montgomery Falls, near Quebec, and for the Niagara Falls Hydraulic Power & Manufacturing Company, for their work at Niagara Falls.

Hiram J. Slifer is now with J. G. White & Company, of New York, and will have responsible charge of matters relating to steam railway undertakings. Mr. Slifer graduated in 1880 from the Polytechnic College, of Pennslyvania, and since that time has been continuously engaged in railway work, rising from the position of rodman and filling all intermediate offices up to general superintendent. He was successively with the Mexican National, the Pennsylvania, the Milwaukee, Lake Shore & Western, and finally the Chicago & Northwestern Railroad. From 1902 he was in charge of operation, motive power and maintenance on the Chicago & Northwestern lines between Chicago and Denver.

At the seventh meeting of the American Electrochemical Society, recently held at Boston, the following officers were elected for the coming year:—President, Dr. Wilder D. Bancroft, of Cornell University; vice-presidents, Carl Hering, Louis Kahlenberg, E. F. Roeber; managers, C. A. Doremus, C. P. Townsend, W. R. Whitney; secretary, S. S. Sadtler; treasurer, P. G. Salom.

Dr. M. I. Pupin, of Columbia University, has been elected a member of the National Academy of Sciences, in recognition of his work as a physicist and inventor, of international reputation.

W. S. Barstow, of New York City, recently returned from an extended Pacific coast trip.

At a recent meeting of the board of directors of the Westinghouse Electric & Manufacturing Company, held in New York City, E. M. Herr was elected first vice-president, and chief executive under the president. The advent of heavy electric traction and the adoption of electricity by main line railways render the services of a man skilled not only in manufacture, but also conversant with railroad operations, especially desirable at this time. There are few men who are more widely known among railroad managers and in whom more confidence is reposed than in Mr. Herr. He was locomotive superintendent of the Northern Pacific Railway for a number of years, and previous to that had many years' experience in various positions on important railways in the West. For the last seven years he has been vice-president and general manager of the Westinghouse Air Brake Company. The Westinghouse Electric & Manufacturing Company has now four vice-presidents, E. M. Herr, Frank H. Taylor, L. A. Osborne and Newcomb Carlton, making an especially able and efficient force of officials. It is said that the works at East Pittsburg have never in the history of the company been so busy with the construction of electric railway apparatus as at present. This is due to the fact that nearly all the larger trunk lines are now ready to adopt electric power since the Westinghouse alternating-current, single-phase system has proved itself such a signal success in practical demonstrations. The exhibition tests recently made before the delegates of the International Railway Congress with the large 1350-H. P. locomotive of that type gave the visitors for the first time an idea of the possibilities of electric motive power in railway service.

George Gibbs, on June 1, resigned the position of vice-president of Westinghouse, Church, Kerr & Company, of New York City, and also that of consulting engineer of the Interborough Rapid Transit Company, to become chief engineer of electric traction of the terminal operations of the Pennsylvania Railroad in New York City, and also chief engineer of electric traction of the Long Island Railroad. In these two positions he will have charge of all electrical and mechanical engineering and design and execution of work in connection with the Pennsylvania Company's tunnels, yards, terminal, power houses, etc.

Robert McF. Doble, consulting engineer of the Abner Doble Company, of San Francisco, is in Mexico for the purpose of investigating several important hydro-electric long-distance power projects.

Irving H. Reynolds has been elected vice-president and general manager of the William Tod Company, of Youngstown, Ohio.

Obituary

Franklin Leonard Wainwright Pope, son of the late Franklin Leonard Pope, and nephew of Ralph W. Pope, secretary of the American Institute of Electrical Engineers, died at the home of his sister, Mrs. Geo. W. Shirk, M. D., at Cornwall, N. Y., on May 27. Mr. Pope was born in Elizabeth, N. J., July 29, 1880, and graduated from Amherst College in 1903. He was on the staff of the assistant signal engineers of the Pennsylvania Railroad, but failing health compelled him to resign in September, 1904. He spent the winter at Saranac Lake, but the change was not beneficial. He was greatly interested in railroad work and gave every promise of a brilliant future.

Col. Wm. M. Patton, a well-known author of works on civil engineering, died on May 26, at New York, where he had gone for treatment. Col. Patton was the author of a work on foundations, also of a treatise on civil engineering which has become standard. He was well known as a civil engineer, having had charge of much important work. He was at one time chief engineer of the Mobile & Ohio, also of the construction of the Susquehanna River bridge of the B. & O. Railway. He was for a number of years professor of engineering at Virginia Military Institute, and for the last five or six years was professor of civil engineering at the Virginia Polytechnic Institute. He was elected last year to the position of Dean of the department of engineering.

Origin of "Hello! Central!"

An interesting anecdote of the origin of the telephonic "hello" was told by F. P. Fish at the recent dinner in New York given by the Magnetic Club in honor of Thomas A. Edison. Mr. Edison himself was the hero of the story. Mr. Fish said that in the early days of the telephone those who used it greeted each other with the awkward phrase:—"Are you there?" Nobody ever thought of any other words for the purpose until one day Edison had occasion to step to a telephone instrument for his first actual use of it outside the laboratory. As in reply to his own ring the signal came back from the other line, he called out, "Hello!" The idea took root at once in the minds of those who happened to be present, and in a marvelously brief time the new word had been accepted all over the country as the best method of beginning a telephonic conversation.

Wireless telegraph experiments with trains are being made by the electrical engineering department of Purdue University in Lafayette, Ind. One station is at the University and communicates with trains on the Monon, Wabash, Big Four and E. & W. Railroads.

The National Electric Light Association Convention

AT DENVER, JUNE 6-11

WM. H. BLOOD, JR., OF SEATTLE, WASH., THE NEW PRESIDENT OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

As the June number of The Electrical Age goes to press, the twenty-eighth annual convention of the National Electric Light Association, held at Denver and Colorado Springs, is drawing to a close, and publication of the complete report of that gathering must therefore be deferred until next month. This applies also to all but a few of the many interesting papers presented at the meeting, several being printed in this issue. The list complete comprised the following:—

"Report, Progress," T. Commerford Martin, New York.

"The Paramount Importance of Choosing Standard in Preference to Special Machinery," David Hall, Cincinnati, Ohio.

ARTHUR WILLIAMS, THE NEW FIRST VICE-PRESIDENT

"Insulation Testing — Apparatus and Methods," C. E. Skinner, Pittsburg, Pa.

"Automatic Synchronizing of Generators and Rotaries for Lighting and Power Systems," Paul MacGahan, Pittsburg, Pa.

"Notes on Rotary Converters and Motor-Generators for Lighting and Power Systems," Louis E. Bogen, Cincinnati, Ohio.

"The Organization of Working Forces in Large Power Houses," W. P. Hancock, Boston, Mass.

"Report, Committee on Steam Turbines," W. C. L. Eglin, chairman, Philadelphia, Pa.

"Operating Features of the Curtis Steam Turbine," A. H. Kruesi, Schenectady, N. Y.

"Series Alternating-Current Motors for Industrial Work," Clarence Renshaw, Pittsburg, Pa.

"A New Type of Single-Phase Motors for Elevator Work," S. Percy Cole, St. Louis, Mo.

DUDLEY FARRAND, THE NEW SECOND VICE-PRESIDENT

" Long - Distance, High - Tension Transmission in California," John A. Britton, San Francisco, Cal.

"Report, Present Methods of Protection from Lightning and Other Static Disturbances," Alex. Dow, and Robert S. Stewart, Detroit, Mich.

"The Nernst Lamp—Its Present Performance and Commercial Status," E. R. Roberts, Pittsburg, Pa.

"The Choice of an Insulated Cable," Wallace S. Clark, Schenectady, N. Y.

"Some Investigations of Induction Losses," E. P. Dillon, Colorado Springs, Col.

"Mercury Arc Rectifiers," P. D. Wagoner, Schenectady, N. Y.

E. H. DAVIS, THE RETIRING PRESIDENT OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

"Report, Advertising Methods," Percy Ingalls, Newark, N. J.

"Report, Sign and Decorative Lighting," La Rue Vredenburgh, Boston, Mass.

"Free Signs and Flat Rates," C. W. Lee, Newark, N. J.

"Report, Progress of Electric Heating," James I. Ayer, Boston, Mass.

"Report, Purchased Electric Power in Factories," E. W. Lloyd, Chicago, Ill.

"Report, Committee on District Steam Heating," W. H. Blood, Jr., chairman, Seattle, Wash.

"Wrinkles," H. C. Abell, editor, New York City.

"Report, Committee on Relations with Kindred Organizations," James I. Ayer, chairman, Boston, Mass.

"Report, Municipal Ownership," Arthur Williams, New York, N. Y.

"Question Box," Homer E. Niesz, editor, Chicago, Ill.

"Report of Committee on Relations between Manufacturers and Central Station Companies," Henry L. Doherty, chairman, New York.

"Report of Committee on Standard Rules for Electrical Construction and Operation," Charles L. Edgar, chairman.

"The Tantalum Lamp," Dr. Louis Bell.

The opening business session was held on Tuesday, June 6, at Denver, and the final one on Thursday evening, June 8. On Friday evening, June 9, according to the programme, the entire party was taken to Colorado Springs on special trains, and from that time on to the official close of the convention, on June 11, sight-seeing was the order of each day. The entertainment committee had left nothing undone to make the meeting a memorable one, and the earliest available reports indicated that it was a most successful one from every point of view.

The following officers were elected

F. W. FRUEAUFF, OF THE DENVER GAS & ELECTRIC COMPANY

for the coming year.—President, W. H. Blood, Jr.; first vice-president, Arthur Williams, of the New York Edison Company; second vice-president,

CHARLES L. EDGAR

Dudley Farrand, of the Public Service Corporation, of New Jersey; executive committee, Frank W. Frueauff, C. L. Edgar, and John Martin.

Some of the newer electrically-lighted ferry boats plying in New York waters are fitted with a device by means of which the steering wheel cannot be unlocked without throwing a switch which makes the necessary contact for setting the forward lights; while at the same time the lights at the other end of the boat are extinguished automatically by the same movement which locks that wheel in place.

High-Speed, Long-Distance Electric Traction

DISCUSSED AT THE LATEST MEETING OF THE NEW YORK ELECTRICAL SOCIETY

IN a paper on "High-Speed, Long-Distance Electrical Traction," read at the meeting of the New York Electrical Society on May 24, Charles A. Mudge, formerly chief engineer of the railway department of the Allgemeine Elektricitäts-Gesellschaft, of Berlin, described the high-speed tests on the now well-known Berlin-Zossen road. Mr. Mudge was present at the tests and took part in them. They were made under the direction of a company organized for the special purpose, and known as the "Studiengesellschaft für Elektrische Schnellbahen."

The objects of the tests were to study the collecting of current at high voltages, traction and air resistances, best designs of trolleys, motors, transformers, brake gears and trucks, the power required to run at high speeds, the details entering into the construction of the permanent way, and the collection of other data in order to calculate costs of future installations.

As told by Mr. Mudge, the track selected for the experiments parallels the main line running from Berlin towards Dresden, and is used by the ministry of war for giving instruction to the railway corps of the army. The car barn was located five miles from Berlin, at Marienfelde, where the tests were started towards Zossen, $14\frac{1}{2}$ miles distant, over a track having only two decided curves, of $1\frac{1}{4}$ miles in radius each, and almost no grades. Power was supplied from a central station 7 miles distant, to a cable house along the line a little over one-half a mile from the car barn, where it was connected directly to the trolley wires through automatic circuit interrupting devices.

The apparatus installed in the Allgemeine car differed quite materially from that installed in the Siemens & Halske car. The remarks refer only to the apparatus used in the former car. The car body was 69 feet long and $9\frac{1}{4}$ feet wide, and was divided into three compartments, the middle one of which contained the starting rheostat and high-potential switches. The other two compartments were utilized for measuring instruments and for passengers. The transformers were fastened underneath the car floor.

Three-phase current was used, and the highest recorded voltage in the car during any test was 1450. Six current collectors of the sliding bow form were placed in vertical groups of three on each end of the car, two bows working in parallel at each level. The weight of the complete car with 50 passengers was 100 tons, increased by 4 tons during the last year. The 6-wheel trucks were spaced 43 feet, $7\frac{5}{8}$ inches between centers, and the 49 3-16-inch wheels had a base of 6 feet, 3 inches, which was increased later to 8 feet, $2\frac{1}{2}$ inches.

In the first year, 1901, preliminary runs were made to try out the equipment. Dynamometer tests were made of the motors, and friction tests of the bearings showed the rolling friction to be about 10 pounds a ton at 125 miles an hour, which was somewhat in excess of the results obtained in actual operation. No trouble was met with in collecting currents large enough to run the car at 125 miles, with a voltage of 14,000, provided the car could be made to run smoothly. Some trouble was experienced in keeping the sliding bows on the trolley wires, but this was mainly due to the vibrations of either the car or the trolley wires, rather than to any fault in the design of the trolleys themselves.

On account of the weight of the cars and the high speeds attained it was necessary to replace the 67-pound rails with heavier ones of $82\frac{1}{2}$ pounds per yard, and to increase the size and number of ties per rail over the middle portion of the road, which also was to be furnished with guard rails for 10 miles of its length.

Above 90 miles per hour the car began to sway from side to side very decidedly, and it was considered unsafe to run above a maximum speed of 100 miles per hour. This made it necessary to alter the design of the truck, and to allow a portion of the weight of the car, which was carried entirely at the truck center, to be borne by the truck frame. The braking facilities were not at all sufficient, although two shoes were applied to each of the twelve wheels. This was due mainly to the arrangement of levers and to the fact that only two brake cylinders per truck were used. This was changed later to four cylinders per truck, and to a much simpler lever system.

The second series of tests, in September, October and November, of 1902, was occupied mainly in determining the train resistance at different speeds, in measuring the power required for different loads and speeds, in determining the losses in the transmission line, in collecting the necessary braking data for computing the coefficients of friction for different speeds, and in determining the alterations necessary to be made in the car and the permanent way, to allow speeds up to 125 miles per hour. These tests were conducted up to a speed of only 75 miles per hour, as the observations of the previous year showed that the permanent way would not stand much higher speeds.

To determine the train resistance as well as the energy absorbed in running the car, a distance of 4 miles, starting at the car barn, was very carefully measured, and all curves, grades and levels were absolutely fixed. This made it possible to correct the observed data so accurately that the recorded results in this year's report are of the greatest value. The brake tests made in this year were not as satisfactory as those in the following year, on account of the complicated brake rigging used, which did not allow of easy adjustment. The maximum retardation of 2 miles per hour was recorded at 70 miles per hour, with a total brake pressure equal to 155 per cent. of the weight of the car. At the conclusion of the tests in this year it was found necessary to build new trucks, with a 2-foot longer wheel base, to support the car body on the truck frame at some distance from the center pin, and to flexibly support the center pin in the truck, thereby allowing the car body to have a movement of about one inch on each side of the truck center independent of it, and in a line at right-angles to the track. In order to observe the action of the springs and their connecting levers, it was decided to place them on the outside of the frame of the truck. The tests this year were of value in showing what alterations in the car and permanent way were necessary in order to be able to run at higher speeds.

The tests of the third year were the most elaborate and formed a reliable check on the previous tests, giving a substantial basis upon which high-speed work may be attempted.

Data of great value were secured on air resistance, and although the formula may not be straightened out to suit everybody, we know positively that if we run at 50 miles an hour we can expect a maximum air pressure of about 7 pounds per square foot at the front of the car. If we double the speed the pressure will be four times this, and if we triple the speed we shall run into trouble and get nine times this pressure. Shaping the nose of the car properly reduces these figures 10 per cent. Running the 100-ton car at 50 miles on a level track without paying much attention as to how the front is shaped will take about 150 H. P. Doubling the speed would take about six times this amount, and tripling the speed about eighteen times.

These facts are not so serious as they seem when we consider that the amount of power necessary to drive a car or train at 100 miles per hour, with which we would be content at present, can easily be applied to the axles without any alteration in the standard gauge, and in fact with very little, if any, change in the standard truck constructions.

The braking results of this year were most interesting, and showed very distinctly that it is a difficult matter to keep the retardation a constant value with the braking apparatus at present at our disposal. The curve of retardation, instead of being straight, has a most undesirable peak at each end, showing that for ideal conditions it is necessary to increase the brake pressure a few seconds after it has been applied, and then to leave it in charge of an automatic device which decreases it as the speed decreases, and as the coefficient of friction increases.

The enormous brake pressures needed at high speeds to give a comparatively low retardation show very plainly that the coefficient of friction is not going to help us in the same proportion that it is at present; but if it doesn't, electrical means will most likely help us out. For instance, it was found to take about seven-eighths of a mile to stop the car when running 110 miles per hour, the initial brake pressure being 150 per cent. of the weight of the car. If we had had some means of keeping the retardation constant, we could have stopped the car in three-quarters of a mile by using the same pressures. Under the most favourable conditions the car could not have been stopped in less than one-half mile, when running at 110 miles per hour, which would require a retardation of 3¼ miles per hour per second, which is about the limit of braking with this type of brake apparatus. The braking system never failed in its operation during all the tests made, and its absolute reliability inspired a feeling of security.

Basing our ideas upon some of the observations and experiences gained in these tests, we would make use of the following points in approaching a similar problem:—

1. Keep the car body as near the rails as is possible.

2. Arrange all heavy pieces of apparatus so that their centers of gravity lie in the center of the car, or symmetrically placed to it, and as near the earth as possible.

3. All apparatus mounted above the car floor should be as light as their design will permit.

4. Make the overhead trolley contact above the car, in preference to the side of the car.

5. Support the motors flexibly on the axles of the trucks.

6. Give the front end of the car a wedge shape.

7. Support the car body on the truck-frame at some distance from the center bolt, and allow it a flexibility in a line at right-angles to the track, independent of the truck.

8. Make the total wheel base of the truck of ample dimensions, and not less than 20 per cent. of the length of the car.

9. Build the road as straight as possible and where more than one track is used make them further apart than our present practice would suggest.

10. On curves, make the approaches of the elevated side of the track longer than usual.

If it were possible to have the wheels along the sides of our cars and the rails between the floor and roof lines, we should have very comfortable traveling. Any condition approaching this, as keeping the car body near the rails, would share in the benefits thus derived.

That all apparatus should be symmetrically mounted in relation to the center line of the car was very evident as the 100 miles per hour speed was approached. The motors were mounted slightly out of the center line of the truck, and it was found necessary to use 275 pounds per motor to counteract this. The transformers, which weighed 3½ tons each, were mounted on either side of the center line of the car body just behind each truck and a line connecting their centers of gravity did not coincide with either the transverse or the longitudinal center line of the car. This gave rise to a torsional movement which produced a dangerous swinging of the car when running above the speed referred to, which was overcome by placing weights of about one ton each on the side opposite to that to which the transformer was mounted. The fact was thus confirmed that heavy pieces of apparatus should be mounted in the center lines of the cars for high-speed service, as they run smoothly only when their weight is equally distributed upon the wheels.

All apparatus above the car floor should be light. This applies particularly to the trolley construction. If the trolley for high-speed work is to be of a light construction, which is the tendency of most designs abroad, particular attention must be given to the form of the exposed surfaces, on account of the high air pressure, and means must be applied to counteract it. When the current is collected at the side of the car, as in these experiments, any slight swaying of the car is at once felt by the trolley, and the higher the current collectors are placed from the ground the greater is this disturbance. The trolley wires as placed in these tests were also very sensitive to cross winds, and even to the slight pressure of the sliding bow against them, necessitating spacing the supporting poles closer together than they were originally placed, and stretching the wires themselves with very high tensions. Passengers in the car could hear very distinctly the click as the trolleys passed over each support, showing that they received a slight blow at each of these places, detrimental both to the trolleys and to the insulated supports. In this construction of trolleys it is of the greatest importance at high speeds that the lateral swinging motion of the car should be transmitted as little as possible to the trolley; and there must be a considerable flexibility between the trolley base and its contact piece, so that this piece can follow the trolley wire independently of the motion of the trolley base.

Through the experiences gained with this type of trolley it would seem that the current could be better collected above the car roof instead of at its side, in which case it does not matter if the motion of the car is transmitted to the trolley. In fact, if the bow form is used, it would be desirable. But then we run into the trouble and expense of supporting the trolley wire so that it does not sag, which is more essential at high speeds than at those used at present. For these tests, however, on account of the high voltages used, the necessity of three conductors, the cost of installation, and the lack of experience with the catenary form of suspension, the trolley line construction used served the purpose very well, and it is doubtful if any other would have given better satisfaction.

If the motors are direct-connected to the axles, a part, at least, of their weight should be flexibly connected to it. Motors of this power—250 H. P. normal rating—run into weight, and, both on account of the permanent way and the truck, as much of their weight as is possible should be flexibly supported on the axles. This flexibility need not be great and can be obtained through the medium of heavy springs.

Giving the car a wedge-shaped construction may not be possible when using the vestibuled type with multiple unit control, and no definite end relation, in which case it may be advisable to have a portable wedge-shaped engineer's cab on wheels, capable of being quickly attached to the front of the car in making up the train.

It was found that it was a very good thing to hold the car body firmly to the truck frame at points equally distant from the center pin, also to allow it a movement independent of the truck, parallel with the axles. The trucks take curves much more quickly than the heavy car body, which requires a certain amount of time to swing it out of its straight-line path, and should not be attempted too rapidly. It should not receive a blow to turn its nose in the new direction, but a gradual increasing pressure until it is turned out of its former course. This was very well accomplished by the center pin bearing being mounted flexibly in the truck. The 30 per cent. increase of base in the truck was a noticeable improvement over that used in the previous tests. With a greater distance between wheels we have a better chance to equalize the weights upon the axles, since the lever arms and springs between them may be made longer and consequently more sensitive and easier to adjust. In 3-axle trucks the motors will most likely always be mounted on the outside axles, making it necessary to carry a greater percentage of the weight of the car body on the middle axle than is carried on the outside ones. As this weight fluctuates considerably this fact must not be overlooked in designing the equalizing lever arms of the truck, as otherwise the load will be unequally distributed on the axles and possibly disturb the smooth running of the car.

The track used for these tests was built at a greater distance from the main line track than is customary to place parallel tracks in the United States, and consequently the air pressure effects of trains moving in opposite directions, as well as in the same direction, could not be observed very closely. It was evident, however, that there was a slight disturbing influence in the smooth running of the car whenever it passed another train. What this would have amounted to if the tracks had been placed nearer together it is impossible to say, but it is a point that would have to be considered in building new lines, and would suggest placing the tracks further apart than is our present practice. There is no doubt, whatever, that speeds as high as 100 miles per hour can be used with absolute assurance of safety. It may be necessary to adopt a signal service somewhat different from those at present in use, as in traveling at these speeds it is more difficult to recognize colors and to distinguish the forms of objects than at lower speeds. On dark and rainy days it was quite impossible to read signals at this speed, except when of large dimensions or of very pronounced colour. This would suggest placing the signals in the car itself, operated electrically either by direct contact or through inductive means. Such a system was tried at Zossen and worked perfectly, even at the highest speeds.

DISCUSSION

In the discussion following the reading of the paper, F. J. Sprague said that two questions suggested themselves to him,—to what extent will commercial possibilities warrant speeds anything like those attained; and, assuming that for long distances alternating current be used, shall it be the polyphase method as at Zossen, or a single-phase system? His own impression was that taking into account all the practical conditions surrounding trunk line construction and operation, a maximum speed of about 100 miles an hour is all that we can reasonably, for a time, at least, try to reach. Not that cars cannot be operated at higher speeds; but the difficulties which must always stand in the way when we take into account all the essentials of trunk line operation, seem as yet to hardly warrant the commercial use of such speeds.

C. O. Mailloux said further experimentation will be necessary before it can be determined which electric system shall be used. We have something to learn before the electrification of steam roads in general is an accomplished fact, and should proceed gently. He believed there would be steam locomotives 25 years hence.

F. J. Sprague, in again discussing the subject, said that he quite agreed with Mr. Mailloux as to the desirability of going slow in steam road electrification. It was interesting to note that some of the difficulties met with on the Zossen line at high speeds were encountered in the earlier tests on the New York Central electric locomotives. One of the earliest applications of electrical operation on miscellaneous roads is likely to be due to the recognition of the fact that in many cases the concentration of grades and electrical operation, in whole or in part, at such grades, may prove cheaper than the making of costly detours. In such cases, both continuous and alternating-current motors can be used, and which shall be the better is a matter to be decided by local conditions. In spite of the admirable work which has been done abroad with the polyphase system, and granting its possible desirability in certain special cases, he could not but feel that, speaking generally, the multiplicity of conductors will stand as a bar to any general application to trunk line service, and that the later developments in single-phase operation offer, on the whole, more promise of final adoption, where alternating currents are used.

F. H. Shepard briefly described the single-phase locomotive recently built by the Westinghouse Electric & Manufacturing Company, and said that he believed the electrification of steam roads would be gradual, at first in special applications and such terminal propositions as local conditions determine, and that ultimately the expansion of these installations will be quite readily accomplished where the high-voltage, single-phase system is used.

At the conclusion of the discussion the following were elected members:—Timothy Donovan, George W. Elliott, Joseph J. Bigelow, Clement F. Street, F. H. Shepard, A. S. McAllister, Thomas A. Nathans. The nomination committee announced the following nominations for the ensuing year:—President, W. S. Barstow; vice-presidents, Albert F. Ganz, Louis B. Marks, W. S. Rugg, H. G. Stott, Putnam A. Bates, Max Lowenthal; secretary, George H. Guy; treasurer, H. A. Sinclair.

Trade News

The Westinghouse Machine Company, of Pittsburg, announces substantial extensions in its sales organization. These are the result of rapidly increasing business, necessitating the more thorough covering of Southern and Western territories. In addition to the original New York, Boston, Pittsburg and Chicago offices, new branches have been established at Cincinnati, Denver, San Francisco, Charlotte, N. C., and Atlanta, Ga. With these added facilities the extensive mining territory of the West and cotton industries of the South may receive more active attentions. The steam turbine and gas-engine business of the company has increased rapidly during the last few years, and the prevailing activity in this branch of power development augurs well for the future. The representative offices of the company are now as follows:—New York, 10 Bridge street, L. L. Brinsmade; Boston, 131 State street, E. L. Clarke; Pittsburg, Westinghouse Building, William Bradford; Chicago, 171 La Salle street, John B. Allan; Cincinnati, 1111 Traction Building, A. A. Brown; Denver, 512 McPhee Building, C. C. Chappello; Charlotte, N. C., So. Tryon street, Stuart W. Cramer; Atlanta, Ga., Equitable Building, Stuart W. Cramer; Philadelphia, Stephen Girard Building, R. Muckle, Jr., & Co.; San Francisco, 614 Mission street, Hunt, Mirk & Company.

The Windsor & Tecumseh Electric Railway is to be equipped with 300-K. W., 3300-volt Westinghouse single-phase, engine-type generators, direct coupled to Robb-Armstrong engines, and its car equipments are to consist of two 50-H. P. Westinghouse single-phase motors each. As this is the first single-phase road in Canada, its developments will be watched with considerable interest. Another order is from the Chatham, Wallaceburg & Lake Erie Railway Company, which is building a new line of electric railway from Chatham to Wallaceburg, Ontario, a distance of about twenty miles, through a rich farming and fruit-raising country. Four double equipments and one quadruple equipment of railway motors will be furnished by the Canadian Westinghouse Company, Ltd. To take care of its rapidly increasing business, the Hamilton Cataract Power, Light & Traction Company is making extensive additions to its power plant at De Cew Falls. Orders specifying prompt delivery have been placed with the Canadian Westinghouse Company, Ltd., for the following apparatus:—Two 6400-K. W., 3-phase, 2400-volt generators running at 28 revolutions per minute, switchboard apparatus and four 3200-K. W., oil-insulated, water-cooled step-up transformers.

The Rhinelander Power Company, of Rhinelander, Wis., composed largely, if not entirely, of local parties, has completed arrangements to develop the water power of the Wisconsin River at a point about six miles below the city of Rhinelander. A dam will be built giving a head of about 24 feet, and sufficient water is obtainable to develop an average of about 600 H. P. In the rainy season more than 2000 H. P., at a conservative estimate, is obtainable. The Allis-Chalmers Company will furnish the entire electrical equipment, which includes three 400-K. W., 1100-volt three-phase, 60-cycle generators, with three 70½ K. W., 120-volt separately driven exciters, six 150 K. W., 10,000-volt transformers and complete switchboards at both the generating station and the sub-station at Rhinelander. The current will be carried at 11,000 volts over a single three-phase circuit to the sub-station at Rhinelander, a distance of about six and a half miles, and from this sub-station will be distributed at 1000 volts for illuminating purposes, both commercial and street lighting, and also at 440 volts to the mill of the Rhinelander Paper Company and other industries in the neighbourhood of the sub-station. This plant is one of the first long-distance transmission plants on the Upper Wisconsin River.

The Wilkesbarre Gas & Electric Company has placed an order with the Allis-Chalmers Company, of Milwaukee, Wis., for one horizontal cross-compound Reynolds-Corliss condensing engine, with cylinders 22 and 40 inches in diameter and a 42-inch stroke, for direct connection to a 500-K. W., 60-cycle, 2300 volt, alternating-current generator. It will be designed to run in parallel with a Vulcan engine already installed, which will be rebuilt by the Allis-Chalmers Company at the Scranton works. Another order, one of the largest for electric power machinery for a private plant, is that of Sears, Roebuck & Company, of Chicago. It consists of three 24 x 50 x 48 and one 20 x 40 x 42 heavy-duty, cross-compound Reynolds-Corliss engines, three 750-K. W., one 500-K. W., one 100-K. W. and one 50-K. W., 240-volt multipolar, compound-wound, engine-type generators. Another order is from E. R. & W. H. Sponsler, who will install at Middletown, New York, one 225-K. W. and one 350-K. W. Bullock railway generators. These are intended to supply power for the existing lines of the Middletown-Goshen Railway Company, together with its extensions, the whole of which will hereafter be known as the Walkill Transit Company.

The Arizona Smelting Company, with headquarters in New York, has ordered from the Allis-Chalmers Company, of Milwaukee, Wis., the complete equipment for a sampling mill for its plant at Prescott, Ariz. The contract also calls for an electrically-operated converter and two reverberatory furnaces with auxiliary apparatus. Another order is from the Sociedad de Minas y Fundiciones, Carrizal, Bajo, Chanarcitos, for the complete equipment for a fifty-ton, copper-smelting plant to be erected at Carrizal, Bajo, Chili, South America. The installation will include a blast furnace and blower with auxiliary apparatus, and a Bullock generator to supply current for an electric light plant. Other recent orders are from the Twin-City Rapid Transit Company, of Minneapolis, for a vertical cross-compound Reynolds-Corliss condensing engine, for direct connection to a 3500-K. W. 3-phase, alternating-current generator for its power house at the lower dam, St. Anthony's Falls. The Florida East Coast Railway, with headquarters at St. Augustine, Florida, for two horizontal "Reliance" engines, and a Bullock alternating-current generator, with exciter, for the operation of an electric light plant; and the Champion Copper Company, Chicago, for a vertical cross-compound Reynolds-Corliss condensing engine of 340 H. P. for direct connection to an alternating-current generator for its power house at Painesdale, Mich.

The Abner Doble Company, of San Francisco, announces that arrangements have been made with the John McDougall Caledonian Iron Works Company, Ltd., of Montreal, Canada, whereby the latter become sole licensees for the manufacture of the Doble system of water wheels in the Dominion of Canada. the tangential water wheels and needle regulating nozzles manufactured by the Abner Doble Company are well known for their excellence of design and workmanship, and considerable engineering interest has recently been shown in relation to the four 8000 H. P. wheels which that company has built for operation in California power plants. The McDougall Company have extensive machine works in Canada, their plant including machine shops, pattern shop, foundry, forging works and structural material shop. They are therefore well equipped for the building of water wheels and other hydraulic machinery. They already have in hand the building of a 100-H. P. wheel to operate under 170-foot head; taking water through a 3½-inch jet and having a speed of 130 revolutions per minute. The Canadian licensees are prepared to furnish the steel pipe, structural work and all machinery necessary for complete power plants, and the Doble Company requests that all engineers or parties interested in water power developments in Canada, address the McDougall Company direct. They have retained the Abner Doble Company as their consulting engineers.

Kohler Bros., of Chicago, through their Pacific Coast branch, the Abner Doble Company, of San Francisco, have recently installed their system on a new press of the "Portland Oregonian," Portland, Ore., and have closed contracts with the Times-Mirror Company, Los Angeles, Cal., and the "Spokesman-Review," of Spokane, Wash. The Kohler system consists of a multiple push-button control for the electrical operation of printing presses and other machinery. The "Oregonian" has a 50-H. P. equipment, and the proprietors are exceedingly well satisfied with the good results attained.

On May 24, the plant of the Ohio Brass Company, at Mansfield, Ohio, was partially destroyed by fire. As the office and the records, the finishing and machine shops, the insulating building, cooper shop and pattern vault were not burned, the majority of the work is uninterrupted. The company is using every effort to avoid any inconvenience to customers. Temporary sheds have been erected on the grounds, and adjacent plants have offered the use of their moulding rooms. The bond department will continue in a neighbouring factory pending the completion of new permanent buildings.

A syndicate, including several officers of the Illinois Steel Company, has secured riparian rights along the Desplaines River from Joliet to Morris, at a cost stated to be $150,000. It is understood that the syndicate will erect a large power house at Morris developing 15,000 electrical horse-power, part of which will be used by the Illinois Steel Company's Joliet mills, and part sold to local lighting and traction interests.

Dodge & Day, engineers and architects, of Philadelphia, Pa., have been commissioned by the Electro-Dynamic Company to make a thorough examination of the existing methods in their shops at Bayonne, N. J., and submit a report as a basis for changes and improvements contemplated by the management. The business of the company has increased to such an extent that it has become an urgent necessity to speed up the shop, to provide more adequate facilities, or both. Some years ago the Link Belt Engineering Company, of Philadelphia, were running their shops night and day, yet were unable to keep up with their orders. Extensive additions were contemplated to their buildings, but before carrying out their idea they consulted Dodge & Day. As a result, twenty-five per cent. greater business is being done to-day on the same floor area, with night work entirely suspended. Improved methods throughout and the introduction of the Taylor system are entirely responsible for this. The Electro-Dynamic Company hope to accomplish the same results.

The Locke Insulator Manufacturing Company, of Victor, N. Y., have broken ground for a 50 by 150-foot two-story addition to their plant. Two large-sized porcelain kilns are also being erected as an addition to the present equipment. Another building, 40 by 100 feet, will be devoted exclusively to cementing together sections of multi-part porcelain insulators.

New Catalogues

The Kinsman block system for steam and electric roads is illustrated and described in two pamphlets sent out by the Kinsman Block System Company, of New York. One deals with the advantages of the system in a general way, and the other goes more into detail. The parts are shown in sufficient detail to give a clear idea of the working, and both track and locomotive equipment are shown assembled and in place ready for operation.

A new pamphlet recently issued by the Moore Electrical Company, of Newark, N. J., deals with the Moore electric light. Illustrations are given of an installation and of a tube mounted for use in portrait photography.

Deserving of special commendation is the pamphlet on automatic railway block signals just issued by the General Electric Company, of Schenectady, N. Y. As the company has but recently taken up this line of products, it is fitting that the first publication devoted to them should be of more than usual excellence. The cover illustration is a railroad scene at night, and numerous views show the many types of signals and auxiliary apparatus. A diagram shows the connections of a 3-position signal for double-track lines. A recent bulletin is devoted to 125, 250 and 600-volt direct-current, 2-wire switchboard panels with carbon-break circuit-breakers. Another bulletin deals with motor-driven turbine house pumps, and a flyer illustrates and describes rail bonds. A price list of railway line material has also been sent out.

Information regarding motor-driven fans is given in a pamphlet just issued by the Crocker-Wheeler Company, of Ampere, N. J. The fans range in size from 18 inches to 60 inches, and the motors from ¼ H. P. to 7½ H. P. A table gives the revolutions per minute, capacity in cubic feet of air, and the shipping weight.. A bulletin also sent out by the company is devoted to railway generators. Illustrations are given of some of the details and installations.

The Manufacturers' Advertising Bureau of New York City have issued a very attractive little book entitled "Advertising for Profit," setting forth the advantages to advertisers of the advertising bureau established many years ago by Benjamin R. Western, the proprietor of the bureau above mentioned. Portraits of both Benjamin R. and Wm. Hull Western are incorporated in the booklet.

The Cincinnati Screw & Tap Company, of Cincinnati, Ohio, is sending out a series of revised price lists of standard screws, taper-pin reamers and taper pins.

"Hot Stuff" is the expressive heading of a card issued by the Prometheus Electric Company, of New York. It tells the reader that the company's heating and cooking apparatus is standard, efficient, up to date, saving time, expense and temper.

A bulletin issued by the Browning Engineering Company, of Cleveland, Ohio, deals with an automatic grab bucket of the square type. The parts of a bucket-operating mechanism are also illustrated. These are designed to be attached to any locomotive crane, with slight extra cost, for handling the company's grab buckets.

A catalogue of the General Storage Battery Company, of New York, illustrates and describes "Bijur" storage cells, already described in the May number of The Electrical Age. The types illustrated are those for stationary use, those for electric boats, railway train lighting and electric locomotives for industrial railways and those for portable use, the last-named being assembled in rubber jars and enclosed in hardwood cases. The jars are fitted with hard rubber covers, which are sealed in place. Tables of dimensions and capacities are given with a price list of the parts of each.

Gasoline automobiles built by the H. H. Franklin Manufacturing Company, of Syracuse, N. Y., are illustrated and described in a new catalogue just issued. A novel feature in one type is a detachable tonneau, permitting a change from two seats to four seats, or the reverse.

A bulletin just issued by the Electric Storage Battery Company, of Philadelphia, deals with the chloride accumulator in the electrification of steam railroads. Illustrations are given of an installation for the Baltimore & Ohio Railroad and of one for the Long Island Railroad.

A bulletin just sent out by the Northern Electrical Manufacturing Company, of Madison, Wis., is devoted to direct-current generators. Many of the parts are shown in detail, and a number of illustrations of installations are also given. Motors built by the company are also shown in use for a variety of work.

Coal-handling machinery built by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y., is illustrated and described in a catalogue recently issued. The list includes towers, elevators, grab buckets, coal crackers, cable and automatic and industrial railways, trolleys, conveyors, steam and electric hoists, electric locomotives, weighing hoppers, platform scales, screens, valves, blocks, sheaves, wire and manila rope, flat link and crane chains and iron wheelbarrows.

The expansion bolt and shield made by the Diamond Expansion Bolt Company, of New York, are illustrated and described in a catalogue just issued. They are shown in use for fastening cable racks or insulators to brick and stone walls, and for similar work with switch panels, telephone sets and plumbing. Steel drills and special pipe drills, for preparing the wall to receive the bolt, are also illustrated. A cable clamp for telephone work is shown adapted for use in wood or stone.

Oil switches and circuit breakers made by the Hartman Circuit Breaker Company, of Mansfield, Ohio, are dealt with in a bulletin recently issued. They have already been described in these pages, but the bulletin deals with them at greater length. Besides those of the several types of switches, illustrations are given of the laminated-jaw contacts and the terminals, the automatic overload release, and the series transformer used with potentials of 1100 to 22,000 volts. A price list is given of the various types.

In a bulletin just issued by the Stanley Instrument Company, of Great Barrington, Mass., instructions are given for installing and assembling the rotated jewel bearing alternating-current wattmeter made by them. An assembly, with lettered parts, is given of the rotated jewel bearing mechanism, and other diagrams show the connections for single-phase, two and three-wire circuits and three-wire, two or three-phase circuits. The company has also sent out a card giving the prices of the various sizes. A blotter, 8 by 11 inches, bears on one side an illustration of the wattmeter with a brief description of its main features.

Pelton water wheels are illustrated and described in a catalogue just sent out by the Pelton Water Wheel Company, of San Francisco. Its stated aim is to explain to the uninitiated in water wheel practice the primary principle and general functions of the Pelton wheel, and this it does in an admirable way. Under measurement of water, the weir dam and the miner's inch methods are fully explained. The many uses to which the wheels may be applied are well illustrated, a number of views showing installations. Several pages are also devoted to water motors, being the smaller sizes of wheels from 6 to 24 inches in diameter.

Water-power equipment for low heads, built by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, is illustrated and described in a pamphlet just issued. The illustrations are of several types of vertical and horizontal turbines. Tables give the revolutions per minute, cubic feet of discharge and horsepower developed for various heads. The results of tests of a pair of special turbines installed for the Holyoke Water Power Company in Massachusetts are also given.

Portable measuring instruments made by the Westinghouse Electric & Manufacturing Company, of Pittsburg, are illustrated and described in a bulletin recently issued. The list includes voltmeters, milli-ammeters, lamp-testers' volt-ammeters, ammeters, single-phase and polyphase wattmeters. For use with these, are also illustrated series transformers with plug contacts, series transformers without primary coil and voltage transformers with binding posts. Another bulletin deals with direct-current, multiple-arc lamps for 110 and 220 volts. The mechanism is clearly illustrated, and a "bobeche," or inverted bell globe, and diffuser are also illustrated for use with the lamps. Belted type, rotating-field alternators for single, two and three-phase circuits are dealt with in another bulletin. The main features of design are illustrated and described, and a table gives the sizes for each type. A pamphlet of unusual excellence is that recently issued with the title "The Westinghouse Companies in the Railway and Industrial Fields." It contains a frontispiece portrait of George Westinghouse, and gives the history of the birth and growth of the parent and subsidiary Westinghouse companies. Illustrations of the various plants are given with some of the products from each. Two other attractive pamphlets have been issued dealing with fan motors of the desk and wall types. Illustrations show the many ways in which these aid in making summer weather comfortable.

A pamphlet on bank and office lighting by electricity has been sent out by the Nernst Lamp Company, of Pittsburg, Pa. It deals with the advantages of the Nernst lamp for this class of service and contains illustrations of a number of installations in this line.

An Automatic Fire Alarm Operated Over Telephone Wires

A FIRE alarm system that may be installed in connection with telephone service without requiring any change in the regular equipment or interfering with normal operation has recently been patented by W. L. Denio, Rochester, N. Y. According to "The Iron Age," the apparatus consists of one or more signal boxes that may be installed in any building having a telephone and secures its energy from the central office, and so has no local battery to get out of order. One signal box to a building is sufficient ordinarily, but if one box is placed on each floor the signal resulting from a fire indicates the particular floor on which it starts and so saves time in locating it.

In the circuit leading from a signal box are located glass protected push buttons on the walls or columns, and thermostats on the ceilings. The signal box contains an electro magnet, which is energized by the closing of the circuit through either a thermostat or a push button. The magnet unlocks a vibrating pendulum driven by an escapement wheel and a spring, which actuates a revolving star pointed contact wheel, and sends in the alarm. The contact wheels may be provided with a number of points corresponding to the floor, so as to indicate the floor from which the alarm proceeds. The signal box is arranged to repeat the signal a sufficient number of times to insure its being correctly interpreted by the operator in the central exchange. When a box operates it causes a light at the exchange to flicker, and as the operator is able to hear the mechanism of the box, which gives a positive and distinct sound, there is no danger of an alarm being mistaken for anything else. The circuit through the alarm apparatus may be broken after the alarm has been sent in, so that there is no interference with the use of the telephone.

The thermostats when subjected to a temperature of 150 degrees collapse and close the circuit, thus sending in the signal, or if the fire is discovered before a thermostat acts the alarm may be sent through one of the push buttons. It makes no difference if the telephone line happens to be busy or the receiver carelessly left off the hook, the alarm takes precedence, automatically cutting off the telephone while it is working. The operator at the central exchange, receiving a signal, notifies a special operator in charge of the fire calls, who in turn sends the alarm to fire headquarters, being able from the list of subscribers to tell the exact location of the fire. In the meantime the first operator rings the telephone bell in the office or building from which the alarm came to signify that an alarm has been received. It may happen in this way that the occupants of a building will be apprised of a fire in their building before they themselves have discovered it.

The thermostat and push-button circuit is such that it could be almost entirely destroyed and still send in the alarm. If a workman in making alterations about the building had carelessly cut wires in several places the system would remain operative. The usual municipal fire alarm systems simply indicate the neighbourhood of a fire, and time is frequently lost in learning its exact location, whereas with the Denio system the building or even the floor is designated at once. An even greater advantage is that the sending of an alarm need not be dependent upon human agency, and therefore the failure of persons who know of the fire to do the proper thing because they are excited has no disastrous effect. Another advantage of this system is that it uses telephone wires which are not apt to be out of commission, as they are continually being tested and kept in order. Moreover, when a line does happen to be in trouble, there is only one office or building without fire alarm protection, whereas with other systems several signal boxes are usually on one circuit, which, being in trouble, leaves a much larger field exposed.

An invention of a similar character is known as an automatic fire alarm transmitter and comprises signal box, thermostat and push button in one device. It is attached to ordinary telephone lines and sends its alarm in the same way. This transmitter is designed more particularly for use in hotels (one in each room), but it may be attached to any telephone circuit.

Both of the devices described are made by the Denio General Electric Company, Rochester, N. Y.

Early Experiences With the Arc Lamp

IN the May number of "The Century Magazine," Dr. Charles F. Brush has an article on the arc lamp. He writes in part as follows:—

"The first dynamo and lamp actually sold by the Telegraph Supply Company were shipped to Dr. Longworth, of Cincinnati, about January, 1878. I went down to Cincinnati to show the doctor how to run his machine, and one evening while I was there he exhibited the light from the balcony of the building in which he lived, on one of the principal streets. It was a 4000-candle light, and, of course, attracted a large crowd, every man of which was ready and willing and eager to tell his neighbors all about it. I mingled in the throng for a time to hear the comments. One man who had collected a considerable audience, called attention to the solenoid at the top of the lamp and said, 'That is the can that holds the oil,' and, referring to the side rod, said, 'That is the tube which conducts the oil from the can to the burner.' He said nothing at all about electricity—a little oversight, apparently unnoticed by his hearers, and they went away happy in their newly acquired knowledge of the electric light.

"To decrease their electrical resistance and retard the burning of the carbons, we electroplated them with copper, which is still customary. This little scheme of covering the carbons with just enough, but not too much, copper was the only easy invention that it was my privilege to make; and it paid well, considering its seeming simplicity. It yielded, if I remember correctly, something like $150,000 in cash royalties before serious competition set in.

"The use of enclosed arcs has become large enough to stop the growth of carbon manufacture, notwithstanding the steady and large increase in the number of arc lamps in use. The General Electric Company alone sold about 85,000 enclosed arc lamps in 1903—far more than of the open arc variety."

Andrew Carnegie's residence in New York contains one of the most complete electric heating equipments ever built.

The Mercury Arc

E. WEINTRAUB, Ph. D.

A Paper Read at the Seventh General Meeting of the American Electrochemical Society, at Boston, Mass., and Cambridge, Mass., April 25, 26 and 27, 1905.

THIS paper contains results of an investigation on the properties and nature of the conductivity of metallic vapours carried out in the research laboratory of the General Electric Company. The investigation was started with the practical purpose in view of using the arc discharge in metallic vapours, and especially mercury vapours, as a source of light. The principal practical problems to be determined at the time when I began the investigation (more than four years ago) were as follows:—

1. The starting of the discharge in metallic vapours in an instantaneous and automatic way by the current itself.

2. The determination of conditions under which an alternating voltage can be made to maintain an arc in metallic vapours.

3. Determination of the factors influencing the stability of the arc, with the purpose of constructing a lamp stable under varying external conditions.

4. The production of an arc of the character named which would emit rays belonging to different spectral regions in such proportions as to constitute white light.

None of these problems could be solved on the basis of the knowledge then available, and pure theoretical investigations had to precede any attempt of their solution. Each one of these problems will be taken up separately, and particular emphasis will be laid on the results of theoretical importance. The general problem of conductivity is one of the most important in science, treating as it does of the relation between matter and electricity. The subject is of special interest to the electrochemist, whose science can be in the main properly defined as the science of conductivity of a particular kind of matter; namely, of solutions and molten salts. The ionic theory of conductivity that had its birth in electrochemistry found afterwards fruitful applications in the theories of conductivity in gases. Any increase of our knowledge in this last-named branch is in its turn apt to react on the general structure of that theory, and eventually influence the electrochemical ideas themselves.

STARTING OF AN ARC IN METALLIC VAPOURS

The Rôle of the Cathode in the Starting Process.—The distinctive feature of the conductivity of gases and metallic vapours, in contradistinction to that of metals and electrolytes, consists in that under ordinary conditions, in absence of exterior ionizing agents, the current itself has to create the material which is to carry it from one electrode to the other.

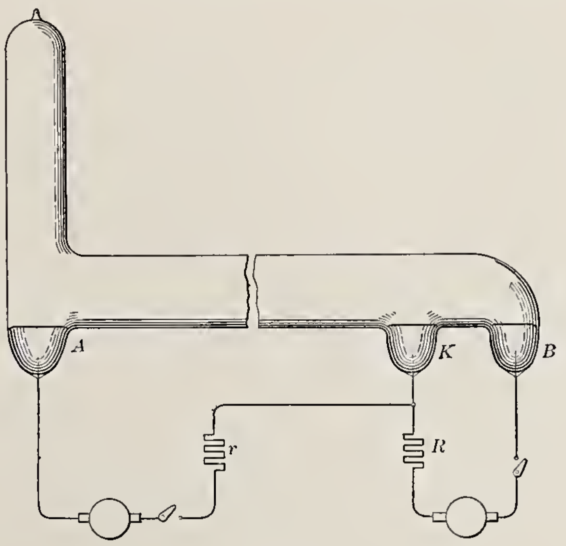


FIG. I

As this material does not exist at the beginning, some special means must be used to start the discharge, and thus we meet in gases and vapours with the problem of starting, a problem unknown in the realm of conduction through metals and electrolytes. If, to take the particular case which interests us here, a glass tube having two mercury electrodes, and exhausted, is connected to a source of moderate electromotive force, no current passes, no matter whether the tube is cold or filled with mercury. Two different ways were used to start the arc discharge. The first one consists in bringing the two electrodes into contact and then separating them. This method is exactly the same as the one used in the carbon arc, the flame arc, etc. The second one is founded on the use of a high-voltage shock. The Geissler discharge through the residual gas or mercury vapour in the tube creates a conductive path, the moderate direct-current voltage follows and the arc discharge is initiated. Both methods were used by the investigators of the mercury arc, especially by Arons, in Germany, and Cooper Hewitt in this country.

The new way of starting an arc discharge in mercury vapour that I want to expound here was the outcome of the theoretical conceptions on the mechanism of the arc and the function of the ionization at the cathode surface that I formed in the course of these investigations. According to these conceptions, an arc discharge in metallic vapours is a discharge deriving its carriers, at least in the immediate neighbourhood of the cathode, from the material of that cathode. The application of a moderate electromotive force is of itself insufficient to start the process by which these carriers are formed out of the material of the cathode. The new fact discovered was that this formation of carriers (the "ionization" process) is started and the arc discharge made possible if a spark or a small arc is produced at the surface of the cathode. The following experiment will serve to illustrate this statement:—

The tube is represented in Fig. 1. *K* is a cup filled with mercury. *A* and *B* are electrodes of graphite, iron or mercury. In the figure they are shown as mercury cups. The tube is exhausted on the Sprengel pump to the highest possible vacuum, and by some means, such as heating from outside, or by the arc itself, the gases are driven off from the walls of the tube and the anode material. Two different sources of direct current are used, one applied to *K* and *B*, the other to *K* and *A*, in such a way that *K* is the negative pole of both. If, now, the little arc *BK* is started by bringing the electrodes into contact and separating them, the other arc, *KA*, starts instantaneously. If the connections are changed in such a way that *K* is the common positive pole of the two sources, the arc *BK* does not cause the starting of the arc *AK*. The fundamental importance of the cathode in the process of starting an arc is illustrated by this experiment in a simple and striking way. We can dispense in the tube of Fig. 1 with the use of two different sources and use the same source with differ-

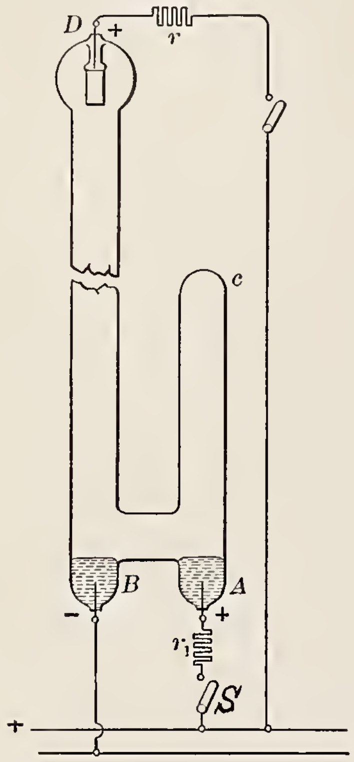


FIG. 2

ent resistances in the two branches. In Fig. 2, *B* is the cathode, *D* and *A* are both connected to the positive pole; r_1 is a large resistance; *r* is a small resistance used for the purpose of regulating the current in the main arc *BD*. By slightly shaking the tube, the arc *BA* starts, whereupon the arc *BD* starts of itself. The switch *S* in the side branch arc *BA* can then be opened and the auxiliary arc discontinued.

For the practical use of this starting method the operations of separating the electrodes *B* and *A* and discontinuing the auxiliary arc the moment the main arc is started must be performed automatically by the current itself. One of the arrangements that I have devised is represented in Fig. 3. *KL* is an iron plunger, *S* a solenoid, and *O* a magnetic cut-out. The solenoid *S*, in pulling up the plunger *KL*, produces the auxiliary arc. The current in the main arc flows through the magnetic cut-out and automatically opens the circuit of the auxiliary arc.

It is interesting to remark that the old method of starting an arc by contact is based also on excitation of the cathode; only, instead of having one arc instantaneously formed by another, we have a continuous growth, a short arc producing a longer one.

As a development of the old contact method I have used the following way, which is based on the use of a carbon filament of high resistance, which first establishes connections between the anode and cathode, so that on closing the switch the current first flows through the filament. By means of a solenoid and its magnetic action on an iron plunger the filament is lifted and the contact between its lower end and the mercury cathode broken. Exactly as in the case of the old form of contact method the small arc lengthens until the carbon filament is short-circuited by the arc.

I shall not attempt the description of all the schemes and arrangements used. I myself devised a number of them, and Steinmetz, Whitney, Wood and other members of our laboratory have invented a number of ingenious ways of producing the same result. A series of different types of lamps have thus been developed. They are all founded on the principle of the excitation of the cathode and differ merely in mechanical details.

Influence of the Conditions Prevailing in the Space Between the Electrodes on the Starting Process.—The space separating the electrodes has an important influence on the velocity with which the starting takes place, but this influence is mainly of a negative character. The space must present as little hindrance as possible to the flow of ions starting from the cathode surface. Accordingly, the degree of vacuum must be the highest obtainable, and the more careful the exhaustion, the more instantaneous is the starting. If foreign gases, or inert ordinary mercury vapour, are present, the starting is slow. The ionized vapour is seen to rise from the surface of the cathode and slowly move along the tube, impeded in its use not only by the gases present in the tube, but also by the mercury vapour which volatilizes from the heated surface of the mercury cathode. When the vapour reaches the anode the arc will eventually start, but if the pressure of the foreign gases is high enough the arc does not establish itself at all. Although it is relatively easy to produce the high vacuum necessary for the instantaneous starting, it is not easy to drive out completely the gases absorbed on the walls of the tube and in the anode material.

The vacuum in the lamps is liable, in some cases, to get worse with use, and some means had to be provided which would render the starting of the arc instantaneous, even with a somewhat impaired vacuum pressure of foreign gases (above 0.01 mm.). As inert mercury vapour also hinders the propagation of the ionized vapour, even perfectly exhausted lamps start harder when hot than when cold. I found that the propagation of ions and the starting of the arc are facilitated if a carbon filament of high resistance is suspended from the anode in such a way that its lower end is distant but a few inches from the mercury surface. When the ionic stream reaches the lower end of the filament a small current is established which helps the starting of the main arc.

Function of the Anode in the Starting Process.—In contradistinction to the cathode, the anode plays no rôle whatever in the starting process. It receives the carriers of the current without any previous excitation.

CONDITIONS OF STABILITY OF THE ARC

The Influence of the Conditions at the Cathode Surface.—In the study of the conditions of the stability of the mercury arc one meets with a phenomenon which is being observed in all arcs, *i. e.*, the existence at each impressed voltage of a lower limit of current, below which the arc is not stable and dies out. The experiments performed on the mercury arc led me to the conclusion that the physical cause of it is in the conditions

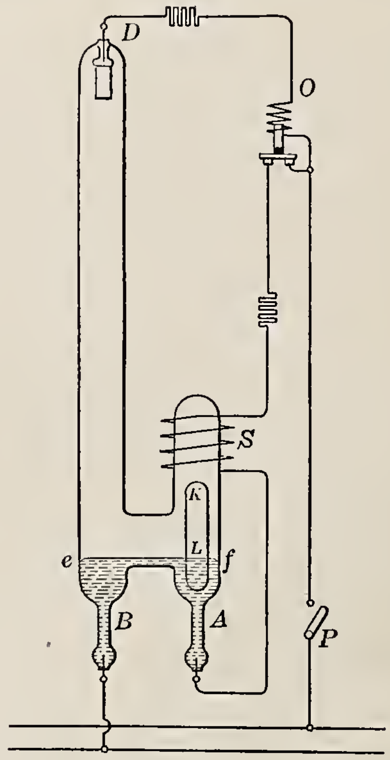


FIG. 3

prevailing at the very surface of the cathode. Under ordinary circumstances there is a bright spot on the surface of the mercury cathode, which spot is continually wandering about on that surface. The wandering of this spot has not had as yet any very satisfactory explanation. This spot is, according to the conceptions expounded here, the place where the production if ions takes place, and the continuous motion of that spot means a disturbance of the ionization process and a danger to the existence of the arc. The wandering of the spot can be avoided in two different ways; either by making the surface of the cathode small, of the same magnitude as that of the spot,

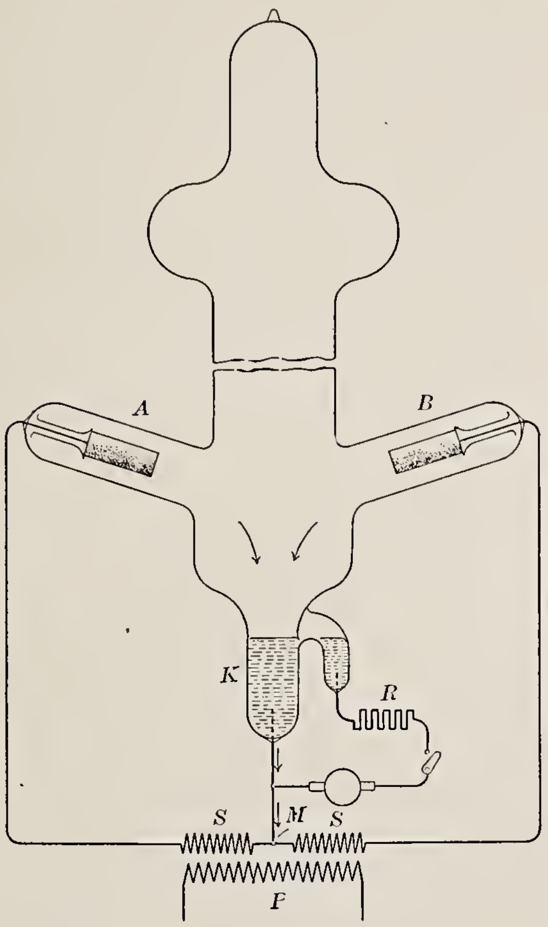


FIG. 4

or by having a wire of iron or platinum project above the surface of the mercury. In this latter case the cathode spot is centered on the mercury surface right around the metallic wire. In order to limit the surface of the cathode, without changing anything else in the tube, narrow tubes of refractory material, such as silica or porcelain, are fastened inside of the mercury cathode. The arc is started by means of a carbon filament which dips into that small tube. The filament is lifted by the passage of the current, the current broken and the little spark produced inside of the narrow tube. The rest of the mercury surface outside of the small tube is then inert and does not carry any current. This is, by the way, an experiment showing strikingly that the arc has its root in the cathode spot.

Both methods lead to the same result, the lowering of the minimum current at which the arc subsists. With 120 volts applied and about 80 volts consumed by the arc, the low limit of current is normally at about 3 amperes. When the cathode surface is made very small, this limit decreases to 1.5 amperes, and with a platinum wire it becomes as low as 1 ampere. These values can be made much smaller if reactance is placed in the circuit or if the impressed voltage is higher.

Influence of the Conditions Prevailing in the Space Between the Electrodes on the Stability of the Arc.—The conductivity of the arc depends on the relative amounts of ionized and inert mercury vapour. If a sufficient condensing space is provided, so that the pressure of the ordinary mercury vapour volatilized from the cathode is kept down to a certain value, the conductivity of the arc is almost exactly proportional to the current. (The current creates its own ions; Ohm's Law is applicable.) The voltage across the arc is accordingly almost independent of the current. If, however, sufficient condensing space is not provided, the amount of inert mercury vapour rises continually, and with it the resistance of and voltage across the arc, until finally, when the voltage across the arc comes too near to the impressed voltage, the arc goes out. Foreign gases present in the tube have influence similar to, and even more pronounced than, that of mercury vapour.

The statements above give a complete description of the influence of the conditions prevailing in the arc itself on its stability. They have no noticeable effect on the value of the lower limit of current.

Influence of the Conditions at the Anode.—The conditions prevailing at the surface of the anode have no appreciable effect on the stability of the arc. If the anode is made of mercury, great amounts of mercury vapourize because of the heat generated at the anode. This increases the amount of mercury vapour in the arc, and thus indirectly changes the conditions of stability of the latter. This is obviously a secondary effect; otherwise, the anode has just as little effect on the stability of the arc as it has on the starting process.

THE ALTERNATING CURRENT ARC IN METALLIC VAPOURS

We have seen in the preceding that the ionization process at the cathode must be initiated if an arc discharge in metallic vapours is to be established, and that this ionization process must be kept up by the supply of a certain amount of energy if the arc is to maintain itself. It is in these facts that lies the explanation of the difficulty that previous investigators have found in maintaining an alternating current arc between metallic vapours. With every change of polarity the ionization process at the cathode dies out and moderate electromotive forces are insufficient to start that process by themselves on the surface of the other electrode when the latter becomes of negative sign. It is therefore obvious that if an alternating electromotive force of moderate value is to maintain an arc in metallic vapours, one metallic electrode must permanently keep its negative sign, notwithstanding the perpetual change of polarity. This, if realized, would mean a unidirectional flow of current in the arc, and consequently rectification of the alternating current.

If, referring to Fig. 1, the electrodes *K* and *B* are connected to a source of direct current, *K* being the cathode, and a source of alternating electromotive force of a few hundred volts is applied to *K* and *A*, that half of the alternating current which has the direction *AK* (*K* cathode) passes, since the ionization process at the surface *K* is kept up by the direct current arc; the opposite half wave is completely suppressed. The arrangements by means of which both halves of the current wave are made to pass in the arc and are superposed in the same wire are mainly applications of

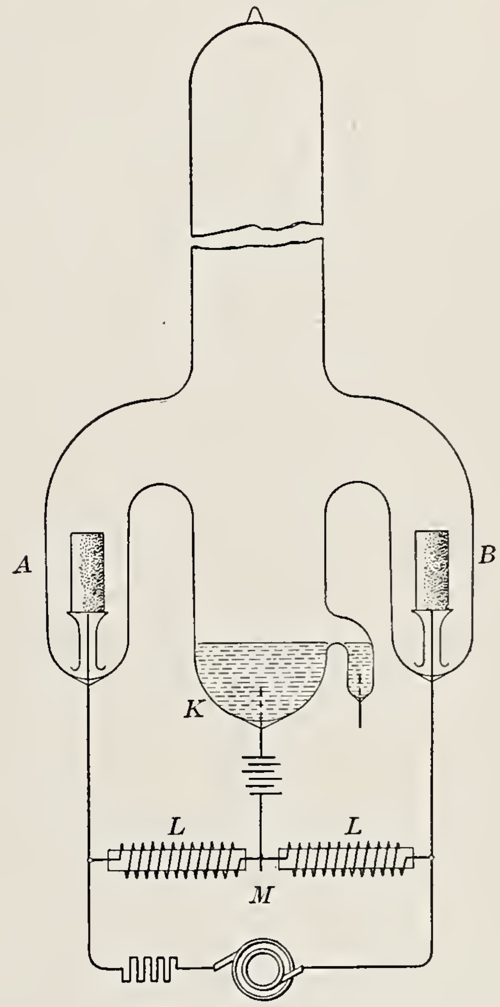


FIG. 5

electrical principles to the given case. Of all the devices used by me I mention but two. In both of them the tube contains three electrodes, one of mercury, the others of graphite, iron or mercury. The one electrode of mercury serves as the cathode, the two others, which we will suppose to be made of graphite, serve as anodes of the rectified arcs.

In the first arrangement, represented in Fig. 4, a transformer is used, the ends of the secondary of which are connected to the two graphite anodes. A wire taken out from the middle of the secondary is connected to the cathode. One half wave takes then in the arc the direction *AK*, the other the direction *BK*, and both are superposed in the same direction in the neutral wire of the transformer. The current derived is pulsating, and if the rectified voltage or current is low, usually a small direct-current arc, springing from the same cathode, is necessary to keep the cathode alive during the zero point of the current. If a constant current transformer is used, this direct-current arc can be dispensed with.

In the second method the alternating voltage is directly applied to the two graphite electrodes and two reactance coils are connected in the way shown in Fig. 5. As in the first arrangement, two arcs are playing in the tube, both having the same cathode. The reactances store up energy, while the current flowing in them increases and discharges through the arc in such a direction as to keep the cathode *K* alive. In this case, as in that of the starting method, described in the first section, a great number of modifications and combinations have been devised, both for monophase and polyphase currents, the description of which would add nothing of theoretical interest. By means of arrangements of this kind I succeeded in rectifying voltages up to 15,000, giving direct-current voltage as high as 6000 to 7000 volts. This last arrangement may become of importance, even for laboratory use, when unidirectional high voltage is desired.

One phenomenon is being observed in the mercury arc rectifier which is of theoretical importance. As is seen from the figure, the alternating voltage is applied directly to two electrodes, which, when the rectifier is working, are surrounded by a highly conducting vapour. Without the knowledge of the cathode properties and the necessity of creating an ionization center on its surface, the fact that no short circuit takes place would be incomprehensible. Under certain conditions, however, this short circuit takes place, one of the two electrodes becoming the cathode of an arc discharge. This phenomenon was termed "arcing" of the rectifier. There is no doubt that under normal conditions a small leakage current flows between the two anodes of the rectifier.

A number of experiments have shown that if an electromotive force is applied to two exploring electrodes placed in the mercury arc a slight leakage current of the magnitude of 1 milli-ampere flows between those electrodes.* The question of arcing is accordingly identical with the following one:—Given two electrodes, separated by a highly ionized vapour and an electromotive force applied to them, under what conditions will a cathodic center form and the small leakage current transform into an arc discharge? By a series of experiments a number of factors influencing the arcing have been determined, so that rectification could be carried up to many thousand volts alternating current, with practically no arcing at all. It would lead me too far to treat this difficult question here. One point of theoretical interest will be mentioned later on in connection with the question of the nature of the ionization process at the cathode.

ARC DISCHARGE IN VAPOURS OF ALKALI METALS

With the purpose of adding red lines to the spectrum of the mercury arc I investigated the arc discharge in vapours of other more or less volatile metals. Alkali metals proved especially suitable. The experiments showed that the regularities found during the study of the discharge in mercury vapours hold good for all other metallic vapours. The cathode phenomena, the bright cathode spot, the behaviour toward alternating voltage are exactly the same. Accordingly, all of the experimental facts established in the previous sections hold good for the discharge in metallic vapours in general.

ON THE MECHANISM OF THE IONIZATION PROCESS AT THE CATHODE

In the preceding paragraphs the important rôle of the processes taking place at the cathode surface has been experimentally proven. An insight into the mechanism of these processes would give us a basis to the theory of of the arc discharge, and of the conductivity of gases in general. The first question I tried to answer by experiments was, whether the ionization process at the cathode is accompanied by an actual transfer of matter or not. The attempt of previous workers on arcs to answer this question in case of the open-air arcs was unsuccessful. The mercury arc presents a better opportunity for the study of this question, since the arc takes place in a vacuum and the mercury undergoes no chemical change. Unfortunately, the phenomenon is complicated by the volatilization of mercury, due to the heat generated at the electrodes.

If two mercury electrodes are used, the mercury actually distills over from the anode to the cathode, the amount of heat generated at the anode being greater than that generated at the cathode. To simplify conditions, a graphite anode was used in all the experiments. In this case the mercury distills over in great quantities from the cathode into the condensing space surrounding the anode. This mercury is, however, in the greatest part produced by mere volatilization of the cathode. If the mercury cathode is cooled artificially, so that the heat generated is conducted rapidly away, the amount of the condensed mercury diminishes considerably, and if the wandering of the cathode spot is avoided by the projecting wire method, this amount is still further diminished. The amount of mercury that condenses under these conditions in the condensing chamber surrounding the anode is very small and constitutes but a small part of the amount required by Faraday's Law. The largest part of it is, however, still due to mere volatilization which cannot be completely avoided.

An attempt was made to get quantitative data by using mercury arcs with cathodes made of less volatile material than mercury. If a piece of graphite or any other conducting material that does not combine with mercury, and a mercury cup, both enclosed in an exhausted tube, are connected to respectively the negative and positive poles of a source of an electromotive force, the electrodes brought into electrical contact and separated, an arc is formed with the solid electrode as cathode. The behaviour of these solid cathodes is the same as that of the mercury cathode. A bright spot is wandering on the surface of the solid piece, and wherever that spot strikes the cathode disintegration of its material takes place. This disintegration is characteristic of the cathode of a metallic arc in an exhausted space. If a piece of charcoal is used as a cathode the motion of the cathode spot leaves fine lines and grooves burned, so to say, into the material. The loss of weight of these solid cathodes is usually very small. The largest part of it is, however, due to the mechanical disintegration of the material which accompanies the electrical one, which circumstance deprives the results of theoretical significance. We can, therefore, conclude from these experiments that a transfer of matter either does not take place at all, or is so small as to be of the order of magnitude that would be required by the value of

* The experiments have shown that this leakage current is exactly proportional to the current in the arc. It is to this kind of conductivity that we probably owe the possibility of measuring the potential between two exploring electrodes sealed into the path of the arc by means of an ordinary current-using voltmeter.

the electronic mass accepted in the modern theories.

The second question of special interest in connection with the theory of the arc refers to the cause of the ionization process at the cathode. The formation of current-bearing particles does not in all probability take place at all in the arc itself. The potential drop in the arc and that at the cathode surface (about 5 volts) are so small that production of ions by collision seems to be excluded. As the anode plays no appreciable rôle during the starting and the running of the arc, we are led to the conclusion that in an arc through metallic vapours in an exhausted space the cathode is the only place where the current-bearing material is formed.

The assumption that the cathode is one of the places where ionization takes place has been made by many previous investigators. In view of the fact that solid bodies heated to a high temperature are known to render gases conductive (effect that I observed myself in the case of mercury vapour), the ionization process at the cathode was attributed by some of the investigators to the high temperature prevailing at the cathode. The experience that I have had on arcs in metallic vapours, and special experiments made to elucidate this point, do not support this view. The boiling point of mercury being low, it is necessary, of course, to limit the supposed area of a high temperature to the cathode spot itself.

The facts that speak against this assumption are as follows:—

First. As mentioned above, the cathode spot moves rapidly along the surface of the cathode. If high temperature were a necessary condition of the ionization process, the cathode spot would not be expected to move constantly away from the exceedingly hot part to the cold part of the surface.

Second. If the spot is fixed by means of a platinum wire, no evidence of a high temperature in that spot can be found. The faint light emitted by the spot surrounding the wire reminds one, especially when the current is not very high, rather of a phosphorescent light than of light produced by high temperature.

Third. Efficient cooling of the cathode does not produce any change, either in the cathode spot or in the arc. To cool the cathode efficiently, I used the following method:—

A platinum cap, sealed into glass, is connected to the negative pole and a surface of mercury to the positive. By heating the mercury, some of it was made to condense on the platinum cap, so that this thin layer of condensed mercury could be used as a cathode. The cap was cooled by rapidly flowing water. The arc showed no difference in its behaviour, with the exception that the cathode spot wandered about with an extraordinary velocity along the mercury layer. In this case one can still claim that some infinitesimally small point of that layer has at any moment an exceedingly high temperature. One will, however, admit that this assumption is not a very probable one.

Fourth. If solid cathodes, such as graphite, iron, platinum, etc., are used, the cathode spot on the surface, to judge by its colour, has not a very high temperature, so that the rapid distintegration is not due to volatilization by heat, but rather to purely electrical causes. If, by an auxiliary current, the solid cathode is heated up in such a way that one part of it, by reason of its higher resistance, is brought to a very high temperature, the cathode spot wanders about the surface of the cathode without showing any preference for the hot spot, which would be expected if high temperature were the cause of ionization.

Fifth. In the case of an "arcing" rectifier, where we have to deal with the formation of the cathode spot, temperature of the solid electrodes plays but an unimportant rôle. The electrodes may be very hot while surrounded by ionized vapour without causing arcing. This is very significant if compared with the relative ease with which at first sight seemingly unimportant factors produce arcing. If, for instance, the electrodes are of mercury, a drop of mercury hitting the surface, or any other mechanical disturbance, is liable to produce a cathode at the point where impact takes place. These and a number of other facts, for which I have not space here, led me to the conclusion that the temperature of the cathode is not the cause of ionization in the case of metallic arcs in an exhausted space. The temperature of the cathode is probably in some way connected with the boiling point of its material and is a result of the ionization process rather than the cause of it. The facts quoted above are not, of course, intended to disprove the influence of high temperature on ionization, which is too well proven in other cases. In arcs in metallic vapours considered here, the temperature of the cathode does not seem to be the ionizing agent.

The time has not yet come to give a complete theory of the arc. In working for years with the mercury arc I had, however, to make for my own use some working hypothesis, and as this hypothesis seems to agree with all the facts that I have observed and was helpful to me in the course of my investigation, I will outline it here briefly, without, however, trying to give in detail its justification, as this would require an article for itself. In some points this hypothesis agrees with the views of previous investigators, in some others it differs.

Starting from the hypothesis developed by a number of modern scientists, according to which the conduction in metals is due mostly to the negative electrons, and from the postulate that the mechanism of conduction in different states of matter must have the same general characteristics, I assume that the mechanism of the conduction in the arc is similar to that in metals and that an arc is, electrically considered, in the main a flow of negative electrons directed from the cathode toward the anode. While in the metal the number of electrons is a given quantity, and the conductivity accordingly constant, the number of electrons crossing the surface of the cathode and entering the arc must be proportional to the current. Accordingly, the conductivity of the arc is proportional to the current. The process of starting an arc serves to initiate the process by which the electrons are driven out from the metal into the space. The starting is probably produced by purely electrical causes. If this process, by means of which the negative electrons are projected out of the metallic mass, is started, it goes on of itself so long as a sufficient amount of energy is applied. The disintegration of the cathode is a mechanical accompaniment of this electrical process.

The light emitted by the arc is not due directly to the radiation of the electrons. These negative electrons are probably the same in all arcs, and the light emitted changes according to the molecular material through which these electrons move.

In a recent lecture on lightning rods, Sir Oliver Lodge called attention to a very common error—that of making the rods of too great conductivity. A small cross section should be used, and the rod be made of iron rather than copper, as the rod of less resistance passes the current too quickly and produces a shock, due to the inductive effect, besides being liable to side flashes, while a light iron wire causes the current to leak down more gradually, and perhaps to fuse the wire in so doing, with little perceptible disturbance. A number of conductors are better than one, and may be readily renewed.

Emergency Starting of a Steam Turbine and of a Reciprocating Engine

By A. S. MANN

A Paper Read at the Recent Scranton Meeting of the American Society of Mechanical Engineers

IF a large steam turbine is cold and at rest, how quickly can it be started? Can it be brought up to speed as readily as a good cross-compound engine that is cold all over?

Most station men would have doubts as to the adaptability of the large turbine of, say, 1500 K. W. or 2250 H. P., for emergency work. So much has been written about the sensitiveness of a rotating disc to the changes of temperature and the effects of unequal expansion that it is easy to imagine difficulties in the rapid start.

The possibilities of an engine with a 62-inch low-pressure cylinder in starting practically cold and coming up to synchronous speed are well understood. A station manager would criticise an engineer who would open his throttle as fast as he dared without wrecking his piping system and let his machine jump into the work. One turn at a time on the throttle is about all that is considered safe, and even then a close watch is kept for groaning valves and cold back bonnets. Every time the starting valve is moved to increase the steam flow, the engine is allowed to take its full increment of speed, due to that particular throttle position, before the supply valve is moved a second time. There are ten large oil cups, and frequently more, that must be opened and adjusted before the machine moves at all, and oiling is to be done about the air pumps and other auxiliary apparatus.

Most engineers would consider ten minutes as rather a fast start and fifteen minutes as a more usual starting period, including time taken for warming up; in fact, it may not be overstating the case to say that if it were known that an engine-driven plant were to be called upon in emergency for power, and it were essential that the briefest possible time were to elapse between the call and the taking of the load, one or more engines would be kept in motion all the time, turning slowly and hot all over.

This question makes itself very prominent when the steam station is operated as an auxiliary to a large source of high-tension power, which is itself in the construction stage, and has a large overload capacity of its own to carry, supplying all sorts of apparatus that use electric power, railway and lighting circuits simultaneously. At such a time all sorts of accidents will happen to the high-tension water-driven plant, most of them due to the necessarily temporary character of many of the electrical connections. It takes months before an intricate system of wiring can be thoroughly relied upon, for it takes months before the temporary work of construction can be replaced.

The station under consideration is equipped with three Curtis turbine-driven, 40-cycle, 10,000-volt alternators, each of 1500 K. W. normal capacity. During the summer months the station is operated as an auxiliary to a water-power plant, taking all sudden overloads. A signal has been arranged, a $\frac{3}{4}$-inch whistle, so that it can be blown instantly should the power fail. A blast of that whistle means—cut in two turbines and bring the third up to speed. The load will be heavy, and all auxiliary apparatus must be in regular operation.

Each turbine has a surface condenser, and there are three or four pumps to be started for each pair of turbines—one circulating pump, one combined hot-well and feed pump, one pressure pump for the step bearings and one dry-air pump—all motor driven. The exciter is driven by a steam engine and must be started also, for it supplies current to a portion of the auxiliary apparatus. The boiler room has steam up at all times, supplying a system for manufacturing purposes other than power, and slow fires are kept in enough boilers to make steam needed for the normal load. Forced load means forced fires. The boilers have under-feed stokers, equipped with pressure blast, and will respond quickly to a 50 per cent. excess call for steam. The operating force for this plant is about equivalent to a force for an engine-driven one. Engineers and oilers, however, are busy about the building on construction work, installing new apparatus and taking such work as their regular occupation when the turbines are not running.

At the sound of the whistle the water-tender starts a blower on the extra row of boilers, all blast dampers are opened up and all stokers are allowed to feed at the maximum rate. Each fireman dumps his free ash and bars over his red fire. The man in charge of the coal and ash conveyor starts the pressure pump for step bearings. One of the turbine men starts the exciter which supplies current to the auxiliaries, besides its own field current; a second turbine man starts the circulating pump and then his turbine. The hot-well pump and the air pump are started by the oiler. These movements take place simultaneously. The force is organized upon the lines that obtain in a fire station; each man has his specific duty, and after performing it looks to see that there is nothing more for him to do. Only a few seconds elapse between starting the first pump and starting the first turbine.

The turbine throttle is opened as fast as an 8-inch steam valve can be opened without endangering the steam piping system. It is not considered advisable to open the throttle valve as fast as a man's strength will permit; but if nothing unusual occurs in the pipe line, sentiment does not spare the turbine. One electrician attends to the switchboard and telephone. As soon as the machine approaches speed, the synchronizing system is cut in and the main switches are got ready. One and one-half minutes will do all the work here outlined, including the time taken in mustering the crew from various parts of the building—not a trivial matter.

Manipulating an engine regulator so that it shall be at a precise speed and at an exact phase relationship, not more than 1-1500 part of a second, away from some other machine, is no matter that can be hurried, and one minute is fast time on such work. But the whole thing, phasing-in and all, has been done in 2½ minutes, including full load on the turbine, which started from a standstill. This performance has been gone through a great many times, and our record book shows that out of 43 such calls, 10 starts were made in 2½ minutes, 18 in 3 minutes, and 15 in 3½ minutes.

We have taken the time in a number of instances when all the auxiliaries have been in motion and it only remained to start the turbine and phase it in on the line; the only valves to open in such cases are the throttle and one small oil valve. The two quickest starts have been made in 45 seconds and 70 seconds, respectively, including phasing-in. Others range between 1 minute 10 seconds and 1½ minutes. These two quickest starts were made on a turbine which had stood for 24 hours with the throttle valve shut tight, though there was a slight leakage past the seat. After the throttle valve is off its seat it is not more than 30 seconds before the turbine is up to speed. A cross-compound reciprocating engine of the four-valve type, 2250 H. P. capacity, can be brought up to speed from a standstill in 5 minutes if it is hot all over. These 5 minutes are to be compared with the 70 seconds required for the similar turbine operation.

A reciprocating engine, which is turning over slowly with the throttle valve just off its seat or with by-pass open and having all its oil cups open and regulated, can be brought up to speed, say 75 turns, in 2½ minutes. These can be compared with the 30 seconds necessary for bringing the turbine up under the same conditions—that is, about one-fifth the time necessary for bringing up the engine. If the engine is cold all over and has all its oil cups shut tight, all its auxiliaries quiet, 15 minutes are called a rapid start. Starts have been made under such conditions in 12 minutes. When we start a cold turbine, we open up the valve and let her turn, and in 2 minutes we are ready to bring her up to speed, and she will be at speed in 2½ minutes, dividing the engine's time by more than four.

A combination of the moving picture machine and the phonograph, invented by a German named Herr Noggrath, has been secured by F. F. Proctor for entertainment at the Proctor circuit of New York theatres. The name of this specialty is the "Phono-Bioscope."

Protecting Telegraph and Telephone Lines Against Lightning

In discussing a paper entitled "Lightning Protection for High-Voltage Circuits" at a recent meeting of the New York Electrical Society, already mentioned in these columns last month, F. W. Jones, electrical engineer of the Postal Telegraph-Cable Company, spoke of the methods employed by his company in protecting its lines. It may be interesting to refer to these here somewhat more fully than was possible in connection with the report of the meeting.

Prior to 1880, according to Mr. Jones, telegraph electricians were able to successfully cope with all ordinary lightning discharges to prevent their harmful effects upon electrical apparatus in telegraph stations. It was found to be economical and efficient to use the plate arrester, which consisted of a small brass plate having a surface of about six inches, separated from a similar ground plate by a sheet of mica, which had been perforated by a few small holes. The thickness of the mica was adjusted to prevent the currents used for telegraph purposes from jumping across the line plate to the earth.

For the protection of telegraph poles out in the open country, a length of telegraph wire was run from a coil of the wire, placed under the foot of a pole, up the side of the pole through staples terminating about three inches above the top of the pole. Since 1880, after the introduction of overhead electric light and power wires, which form a network under and over telegraph wires throughout the country, the company was compelled to increase the space between the line plate and the ground plate to such a distance that the high-voltage currents from electric light and power wires would find it impossible to jump across the space between the plates and so result in a destructive arc.

These arresters are used at intermediate and other stations that are closed for the night, but a more sensitive arrester, having a space of only ten mils or 0.01-inch, is used at large terminal stations which are kept open during the twenty-four hours. At these stations, beside the sensitive arresters, cartridge fuses are employed and are regulated to blow at one-half ampere at seventy degrees in about thirty seconds; but, at all intermediate offices that close for the night, it is found necessary to use cartridge fuses which do not blow under twenty amperes, for the reason that lightning would be constantly opening sensitive fuses and deprive the company of the use of the wires until the operator arrived at the office in the morning. In all such offices, the instruments are kept cut out of the circuit when not required for use, and in the instrument circuits there are as sensitive fuses and arresters as the signaling currents will permit.

Cases are on record of high-potential currents passing over one-half ampere fuses and forming an arc across plate arresters which had a ground space of ten mils, and there forming an arc which has caused a fire that destroyed the office.

At present, then, the menace from electric light and power wires by reason of their high voltages and their liability to become crossed with telegraph wires, in almost every town and village in the country, is much more serious to the company than lightning is, or has ever been.

During the lightning season in the far West, the company's overland Pacific lines are occasionally interrupted by lightning cutting the hard-drawn copper wires between the poles, the ends of the wires being melted to points, and the wires, sometimes for two or three inches on both sides of the cut, having very fine globules of copper adhering longitudinally in a row on the under side. Lightning rods, as previously described, have been erected upon every fifth pole.

The loss of electrical apparatus by lightning in the company's stations very rarely occurs under the present system of protection, but constant watch must be kept of the foreign visitors—electric light and power currents.

The importance of a good ground wire as emphasized by the lecturer is very great. Some years ago it was suspected that the ground wire of the Western Union Telegraph Company in Cheyenne, Wyo., was defective. It consisted of a wire running from the apparatus in the Western Union office to a large plate of zinc buried in a small river or creek near the town of Cheyenne. It was found that the water in this creek, on account of the solid rock bottom which existed up and down the stream for many miles, was highly insulated, presenting a considerable resistance between the telegraph wires and earth. This was ascertained by sinking a plummet upon a wire in an artesian well, making a good earth connection.

The Postal Telegraph-Cable Company recognizes the importance of a good earth in the following rules contained in its book of rules governing the "Wiring of Offices":—

29.—The importance of a good ground wire is very great. It should connect to earth as direct as possible and be without kinks or sharp bends which prevent the free discharge of lightning. A good permanent ground must be secured by connecting the wire to a water or gas pipe (preferably water pipe). If a gas pipe is used the connection in all cases must be made between the meter and the street service pipe, but if this is not practicable when an inside connection is made, care must be taken to make a metallic connection around the meter between the building pipe and the street pipe, so that the meter will interpose no harmful resistance, and the removal of the meter will not disconnect the ground wire.

30.—Where the water and gas pipes of cities, towns or villages cannot be used, proper ground connection can only be had in moist earth or in a river that does not flow a long distance in a channel of rock. A sheet of zinc or tinned copper, about one-sixteenth of an inch thick and four feet square, should be buried horizontally in a hole deep enough to get below dry sand, rock or earth. The bottom of the hole, which must be where the earth is always moist, should have a layer of crushed coke two feet deep on which the plate is to rest, and over the plate a layer of crushed coke two feet thick. The hole should be filled up with moist earth. Connection with the plate should be made by a hard-drawn copper line wire, the end being well soldered across the surface of the ground plate for the full distance of four feet if possible.

31.—In places where lightning is severe and causes trouble in quadruplex and duplex relays, a table lightning arrester should be inserted between their main and artificial circuits, the mica plate in such arrester to be about two mils in thickness, or sufficient to prevent the main line currents from jumping and grounding through the arrester.

32.—Fuses are not intended primarily for protection from lightning, but are to protect our offices and apparatus from electric light and other foreign currents.

33.—In certain localities where terrific thunder storms are liable to occur, and from which buildings may receive strokes of lightning that no known arrester can render harmless, experience has shown that telegraph offices have suffered much less, in proportion to their number, by damage from lightning bolts than other classes of buildings.

34.—It is very important that the proper thickness of mica plates be maintained in arresters and that no fuses except those of the required capacity be inserted in fuse blocks.

35.—Arresters are to be carefully examined after severe lightning storms and kept clean and dry.

As to telephone line protection, H. C. Carpenter, of the New York Telephone Company, said that telephone apparatus in general is of a most delicate and highly inductive nature. The great number and extent of telephone lines, the general character and location of the equipment and the nature of the service given with it require that adequate protection against any high-potentiol discharges be provided. The extremely low potentials and currents carried over normal telephone lines mean that very little stress need be given to the dissipation of telephone current arcs, this being apparently the most important element of high-tension lightning protection.

Very much, as is mentioned by Mr. Jones, aside from lightning discharges, it is essential to provide means to dissipate unfriendly currents traversing along telephone lines, due to crosses with other high-tension power circuits. If we find any stray heavy currents on telephone lines, we wish to get rid of them as rapidly and completely as possible, rather than keep them with us. This means that the combination horn and fixed coherer would not suit telephone conditions.

Experience has proved that the most prominent source of complaint resulting from high-tension charges on telephone lines is the breaking down of apparatus due to induced lightning discharges. It is not an infrequent occurrence in outlying districts where aerial lines predominate, for a single lightning discharge, which perhaps does not strike any telephone lines, to produce inductive charges on several hundred telephone circuits. If it were not for the individual lightning arrester protection on these lines, great damage to apparatus would result. With the protection, the discharges all pass to ground, with perhaps the only bad result of a few grounded lines caused by loosened carbon dust bridged across the small air gaps of the lightning arresters.

The occasional crossing of telephone lines with power circuits, either of high-tension transmission or low-tension railroad circuits, again brings in the lightning arresters. The standard lightning arrester for telephone work is well termed a "sneak current and lightning arrester." It is designed in the form of two small carbon blocks, with parallel surfaces separated by a thin sheet of mica but a few thousandths of an inch thick. A portion of this mica is cut away to allow a thin air gap to separate the two carbon surfaces. One of the surfaces is grounded, and the other connected to one side of the line. A low temperature, fusible metal plug is frequently cast in the ground carbon. A charge of about 300 volts or more jumps across the small air gap and carries the discharge to ground. If the charge results from a cross with a power circuit having plenty of current behind it, the fusible metal plug melts, introducing a direct low-resistance ground to carry off the power current. On many lines which might be susceptible to power crosses, these protectors are supplemented with a long, low-capacity enclosed fuse, which blows as soon as the grounded current reaches any material value.

One of the interesting features of telephone lightning protection will be appreciated when it is considered that a conservative figure of the number of telephone lightning arresters in service in New York City and its suburban territory aggregates probably not less than three to four hundred thousand. If the lightning arrester were destroyed after each successful discharge, telephone interests would suffer severely. Where the greatest number of telephones exist, such as in the thickly populated and business portions of the city, telephone circuits are principally underground and give substantially no trouble from lightning discharges or high-tension crosses.

A somewhat new phase of the question of telephone line protection is being introduced by the development of the loaded aerial toll line circuits. These circuits, as is probably generally known, are of a highly inductive nature, the individual loaded sections being practically isolated inductively from other sections when considering high-frequency lightning discharges. Where these loaded lines leave aerial circuits to enter underground cables, special choke coils are being considered, if not in some cases already provided, to prevent lightning discharges from entering the underground circuits. The loaded lines are being protected by combination metal ground and short-circuit jump gap arresters. Lightning discharges striking or induced in the isolated sections of these lines, it is hoped, will jump to ground, or cross the loading coils without serious results.