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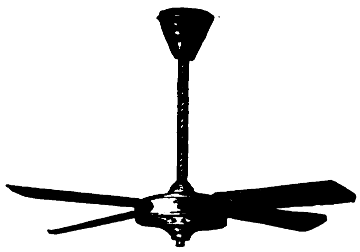

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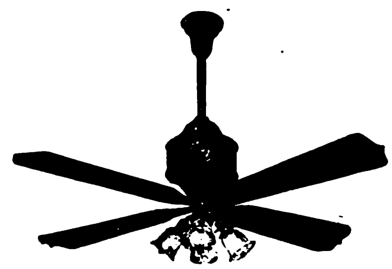

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EDITORIAL

LEADING ARTICLES

Water-Power and the People

In the whole great and varied field of electrical science and invention there is probably no single application of their principles that has had a more widespread economic effect than the long-distance transmission of power. Springing from the invention and subsequent improvement of the alternating-current transformer, the development so begun has already passed far beyond the dream of the prophets of its early days. From sending a few kilowatts a matter of some two or three miles, the distances and quantities of power involved have grown by leaps and bounds with the constant advance of insulating and transforming appliances, until to-day the transmission of 100,000 kw. at 100,000 volts over hundreds of miles is in sight, and to-morrow it will be commonplace. And yet this thing has hardly begun.

It has been stated that the introduction of the electric car has changed the evolution of the city. But the application of electrical transmission of water-power over great distances has changed the evolution of nations. Particularly has this been true of those peoples occupying lands where nature has been ungenerous in the matter of coal. Perhaps the most striking instance may be found in the cases of Switzerland, Italy and Mexico. In these lands, with their poor coal supply, and their hundreds of mountain streams, the changes worked by the gathering of their waters into long-distance transmission power plants has been hardly less than magical. Old communities, long asleep with the dust and dry rot of industrial torpor, have sprung into new life. Mines once valueless have been enabled to take place among the world's greatest producers. Millions of acres of land, that since the present age began produced nothing, have been brought under irrigation made possible and profitable by the use of the energy of the waters before they are turned on the soil.

Nowhere has the fact, only clearly recognized in later days, that "the problem of civilization is the problem of energy," been more forcibly demonstrated than in the awakening of men in these ancient communities by the thrill of electrical energy, cheaply and abundantly supplied from "white coal."

In our own country, oft-cited examples of this truth, that may be put more briefly, "energy means civilization," are the Rocky Mountain sections and the Pacific Coast. In these regions some of the first really long-distance transmissions were brought into being. In none has the art been more energetically or skilfully applied. Unhampered by precedent, unfettered by custom, free from the "dead hand" of the past, the people of the wide West have more richly reaped the great blessings of the new era than any elsewhere. The vast creation of wealth, born of the electric development of the water-powers of the United States west of the Mississippi, more than any other one thing, has opened the eyes of Americans to what the possession of this power is going to mean.

To these conditions is due the fact that to-day the subject of the ownership and exploitation of water-powers has become one of the livest questions of the day. Men whose opinions have always carried weight have even stated that it is the most important of pending problems. Legislation on the subject, both Federal and State, is becoming general. Widespread and passionate technical and popular discussions show that the public interest in this branch of its heritage is fully aroused. This power disposition subject has disturbed confidence, and even involved the standing of high Government officials.

In all this motion and commotion it is disquieting to see how wide are the differences of opinion as to the proper course to pursue. Many leaders who are in accord on most other vital topics are wide apart on the water-power question. Is not the reason for this to be sought in the fact that few really know much about it? The whole subject in its modern phase is so new that we hardly know where to turn for information.

We venture to suggest that one of the best sources of enlightenment is to be found in the study of the experience of foreign countries. Switzerland now enjoys the reputation of being the best-governed country in the world. After scenery, water-power is her strongest asset. She seems to have gone a long distance on the way of its conservation and utilization for the greatest good of her people. France and Italy also have done much in the same line, where we are but just coming to realize that there is much to be done.

In this situation, the appearance of a compact and comprehensive paper on the public utility of water-power by Rene Tavernier, the distinguished chief engineer of the French Department of Public Works, and Marshall O. Leighton, chief hydrographer, United States Geological Survey, is especially timely. This digest of the legislation past, present and proposed of the European countries foremost in water-power development might be carefully studied by many of our legislators. We are glad to note some evidences that the President has profited by its perusal, as may be seen below.

Without attempting to go into a review of this valuable paper, we wish to briefly call attention to two salient facts that are there pointed out. One of these is that water-power, since the development of electric transmission, has become a public utility, in the fullest sense of the term. What is a public utility? The lawyers will tell us that a public utility is an enterprise in which there exists a public use. But what is a public use? No hard and fast definition can be given, but it may be stated generally to be a use of or for the government or the people *at large*. The distinction, however, between those uses of the public which are still private affairs and those that have become public is not easy to draw. The reason is that the status of any public-serving enterprise may change with the extent of the public interest therein. Thus to-day, in this country, the business of handling letters is a public utility, but the express business is not, as yet. To-morrow it will become one.

If an enterprise thus becomes a public utility by reason of the extent of the public interest and concern therein, it is easy to see how, as the uses and benefits of water-powers have increased from the narrow limits of the community on the bank of a stream to the compass of whole vast cities and sections, as has become the case, water-powers have come into this class. The mechanical and electrical energy involved in their exploitation is just as important a factor in the industrial life of the people as mail-carrying or railways—perhaps even more so. Yet there are but 12 States of the Union that have as yet made any attempt to safeguard their water-powers—and these existing laws are considered but as a beginning—while legislation concerning railroads is generally conceded to be overdone.

"But what about the practical necessity for such legislation now?" This is the query of the average American, with his dread—born of a woful experience—of too much law. The introduction to the paper above referred to states clearly:

"The development of water-power has become a national question in France, as well as in Italy and Switzerland. In those countries has arisen a national policy of regulation and encouragement that will ultimately draw great industries within their borders. The United States now maintains an industrial leadership that cannot be retained if other countries pursue policies that more strongly attract manufacturing enterprises. The menace to American industrial leadership is already on the horizon. The water-power sites of Europe are close to the world's great markets. Is there anyone in the United States so confident of this country's industrial leadership as to assert that the wholesale development of their large and cheap powers will not seriously affect our status? Trade and production are entirely cosmopolitan. The cheapest sources of energy will be used, without reference to any particular flag, if they are located in a region convenient to the market. This nation has now no water-power policy worthy of the name. The President has recognized this defect, and in a special message on the conservation of natural resources, transmitted to Congress, January 14, 1910, has advocated a comprehensive measure to meet the situation. Unless this or a similar proposal is adopted, the United States must give way to those countries which have well-defined policies."

In the message above referred to, Mr. Taft closes the subject of water-power on public lands with the statement that so long as the Government retains control, and can prevent the improper union of water-powers now on Government lands with other power plants, "competition must be maintained and prices kept reasonable."

This brings us to the other fact that impresses one the more this question is studied. The water-power development of any given region is and must be a natural monopoly. This is self-evident from the natural laws of the flow of streams. To avoid the waste of a large part of the power of any river system, the scheme must be pursued as a whole. The attempt to develop "sites" here and there, without reference to the courses of the stream above or below a pair of more or less arbitrarily selected levels, means waste. The proportions of the total developable power of any water-course that will be wasted by isolated plants strung hither and thither along its banks will depend on many conditions, but it will always be large. The flatter the stream grades, the greater the proportion likely to be wasted. We know of more than one river which is thus half developed by a string of plants so arranged that fully half the total power of the stream is wasted under conditions that make its recovery impracticable. It may be stated that in one instance at least it was shown that had the five companies owning consecutive plants along a 6-mile course of the stream united and built one plant instead of the six actually built, nearly twice the power could have been developed for less than half of the money actually spent. To prevent this kind of wasteful exploitation is the duty of the engineer.

Consolidation of the plants of any one river system is logically inevitable. With the power obtained distributed over a large area, the power market is a natural unit. As pointed out in the introduction above quoted, the power on any stream fluctuates with the seasons, and important power demands are those which require a steady supply with reservations for the "peak" loads. With the increase in demand, more power must be found, more streams and sites must be developed. The united reserve power of all those streams must be under one management, ready to be directed anywhere in the field as a "peak" demand comes on. In no field are the advantages and economies of a united development and administration more striking than in this one. And under proper regulation, investor and consumer will alike realize the benefits of these economies.

For these reasons, at the risk of *lese majesty*, we beg to state that it seems to us that in the statement above cited, the President shows more of the lawyer than of the engineer. Competition in electrical water-power development is, in our opinion, to be avoided, just as in any other natural monopoly. Regulation, not competition, is the key to the wise and far-seeing solution of our water-power problem—regulation and encouragement. The idea of competition, instead of consolidation and regulation, sticks in the American mind with a tenacity that sometimes tends to try us. It belongs to a phase of industrial evolution that is fast dying, and the sooner the phase and the idea are dead and buried in a common tomb, the better for the whole industrial world.

To the new era belongs consolidation of capital, brains and labor, always, be it remembered, under wise regulation and control for the common good. Nowhere can this grand trinity of industrial forces be better employed than in the harnessing of our great water-power as fast as the power markets can be developed. But our plea is for a broad view of the matter, with every move based on the ultimate development of the streams as a whole.

With encouragement from State and National Governments; with the clear understanding of the situation by the people; with careful conservation and wise regulation of power prices, we believe the United States can hold her own in this field with any region in the world.

Conservation—not as hoarding, but as avoiding waste.

Legislation—not hasty and harassing, but liberal and encouraging.

Development—not piecemeal, but of each power-giving stream group as a united system.

Regulation—not by the frictional forces of competition, but by the wise will and sovereign power of an enlightened and energetic people.

These must be the national watchwords, and through them shall this people more fully realize the blessings of its great inheritance.

Midland Railway Electrification

The installation of single-phase electric power on the small branch of the Midland Railway running from Lancaster (England), via Morecambe, to Heysham, described in this issue, by Messrs. Dalziel and Sayers, is especially interesting from several points of view. For one thing, it illustrates the thoroughness and caution that are distinguishing characteristics of British procedure. The Midland, serving the densely populated districts of central England, enjoys a traffic density that few railroads in this country can approach. The question of electrifying its motive power had long been discussed, but the feeling that the time was not yet ripe, and the desire to try out the various competing systems of electrification that have been proposed, led the management to utilize a comparatively short branch line to test out the single-phase apparatus manufactured respectively by the leading American and German exponents of that system.

In this country, under somewhat similar conditions, the experiment was tried on the main line. There are, as is well known, good and sufficient reasons in each case for the adoption of courses that are so directly opposed to each other, and the results in each case have abundantly justified the procedure.

The Midland experiment while far from being an instance of trunk-line electrification, and more strictly comparable with high-tension interurban lines, is nevertheless an instance of steam railway electrification, and its operating experience, which has now extended for over two years, throws light on what can be expected of the performance of similar equipments in trunk-line work. This was undoubtedly the underlying reason for dividing a comparatively small contract for motive-power apparatus between two widely different manufacturing companies.

The record of this little 8-mile branch, both as to installation and operation, show up very well for American practice in so far as it is represented therein. The scheme of suspending the catenary and of current collection show how much the experience of both sides of the Atlantic has been borne in mind.

The fact that the usual collector troubles seem to be almost entirely absent, that there is but little or no sparking, and that the wear on the wire has so far been negligible speaks well for the somewhat original methods used. The device used in anchoring must greatly reduce the maximum strain in the suspended overhead structure and tend to its greater security and stability. The resulting advantages would be even greater in this country, as there are greater extremes of temperature.

The wise European practice of spending money on accident prevention in preference to trusting to chance in this respect is illustrated by several features. At each grade crossing there are loading gauges constructed on both sides of the track to prevent any load or vehicle that is too high to pass under the contact wire being driven over the track. Another instance is that the door of the high-tension compartment on the Siemens cars are mechanically interlocked with the bows so that it cannot be opened until they are down. Also the normal position of the Siemens bow is down, while that of the Westinghouse bow is up. We agree with the authors that the former is preferable.

The New Storage Battery

The application of the storage battery to making life easier for generating apparatus in power plants that are called upon to operate under large variations of load has reached a stage where many millions of dollars are invested, and in the great majority of cases there is no doubt that these millions are well spent and earning a fair return on the investment The application of the storage battery to the propulsion of vehicles has likewise been pushed to a point highly creditable to the skill and energy of those who have devoted their time, brains and money to this field. In its march toward the goal of a larger usefulness, however, the storage battery has been tremendously handicapped by three very serious disadvantages: high first cost, high maintenance cost, and an efficiency relatively low as compared with that of almost every other form of electrical apparatus. To these three clogs which affect the value of the battery in all its applications must be added the one of a great weight in proportion to the output of energy obtainable. While of secondary importance in stationary battery plants, this last becomes of the greatest importance in the case of vehicle propulsion.

The numerous attractions of the storage battery system for automobile and traction work, the flexibility and independence of the electrically propelled vehicle, as well as its freedom from the many offenses of its ubiquitous competitor, the gasolene motor, have won for it a noteworthy place in spite of the quartet of objections just noted. But the many friends of the battery have always felt that things were at far from their best, and have looked forward to the advent of improvements which would lead the accumulator out of its troubles and into the field that it ought to fill.

When, therefore, some seven years ago, the master-mind of electrical invention announced that, as the result of a long series of experiments, a new and different sort of storage battery was forthcoming from his laboratories, great interest was felt. Proportional to this was the disappointment when, after being a short time on the market, the nickel-iron battery was withdrawn, until it was known that the withdrawal was merely temporary and was made because the inventor felt that there was still room for improvement.

Recently has come the announcement that the battery is now on the market, and is designed especially for traction service. From the description published elsewhere in this issue, it appears that the two striking features are long life—which is to say low maintenance cost—and decreased weight per unit of output. According to the claims made for it, the battery cannot be injured by overcharging, does not deteriorate if left discharged, can be easily disassembled, and has nearly twice the output, weight for weight, that can be gotten from other batteries.

These assertions, if they can be substantiated, mean that the new battery is a long step in advance. Before us lies a comparative statement as to the costs of operation and the cost of maintenance for a number of different users of electric vehicles, and in most of them it appears that the cost of maintenance of battery is quite comparable with the charging cost. Wherever the service is constant and the rate for current is not exceptionally low, the battery maintenance cost is apt to become greater than the charging cost. The reverse is true where service factor is low and the batteries are properly looked after. Now, even with this handicap, the electric automobile and wagon are competing everywhere with their horse-propelled and gasolene-propelled counter-types, and if the high-maintenance charge is reduced by virtue of the robustness and long life of the nickel-iron battery, the electric-vehicle industry is in sight of a hopeful development.

To this advantage must be added the gain in mileage due to the reduced weight. The output per pound of the two types now manufactured are 14 and 16 watt-hr. respectively. This cutting down of the "dead" weight is not the least promising feature of the new battery, and it will be interesting to see its effect on the mileage records, particularly in the case of the lighter types of vehicle, where the battery has been the principal weight factor.

Public Service Commissions' Reports

The two public service commissions of New York State have made public their annual reports.

REPORT OF THE FIRST DISTRICT COMMISSION

Some of the principal features of the report from the first district, which covers New York City, are:

First, that only three lighting and power companies in the district have applied for permission to issue bonds in 1909. The Kings County Lighting Company desired to issue $450,000 worth; the commission allowed $200,000. The Bronx Gas & Electric Company desired to issue $740,000 worth; the commission allowed $625,000. The The Kings County Electric Light & Power Company has applied for permission to issue $5,000,000 worth, and the case is under consideration.

The commission has devoted much time to complaints and to the inspection of meters. It is also trying to keep track of all rates and changes, and the report contains a summary of rates charged by the various companies.

The commission, as last year, pleads for more power, and claims that court decisions "have devitalized the public service commission law." Especially as regards the "watering of stocks."

REPORT OF THE SECOND DISTRICT COMMISSION

The report of the second district commission, which covers the rest of the State, also devotes much space to the question of security issues.

The dividend experiences of the electrical corporations, electric railroad corporations and gas corporations of which the commission has supervision were as follows:

Total number of corporations, all classes	310
Total number paying no dividends	237
Total number paying dividends	73
Total number paying no dividends on common stock	243
Total number paying no dividends on preferred stock	16
Total number paying dividends on common stock	67
Total number paying dividends on preferred stock	15
Amount of common stock paying no dividends	$126,956,530
Amount of common stock paying dividends	53,859,074
Amount of preferred stock paying no dividends	15,317,400
Amount of preferred stock paying dividends	18,461,072

Commenting on these facts, the commission says: "The very remarkable showing made by these tables and summaries demands but little comment from the commission at this time. Attention should, however, be directed to the fact that they have no wide range of use except by way of suggestion for investigation. The significance of the facts which they disclose depends wholly upon the further fact not disclosed, whether these stocks represent actual cash investment in the properties of the several corporations, or whether they are lacking in that particular characteristic.

Authority was granted by the commission during the last year for the issue of $142,855,035 of stocks, bonds and other evidences of indebtedness, making a total of $252,839,681.34 authorized during the 30 months of the commission's existence. Of the total authorized in the last year, the following were for electrical corporations: Stocks, $1,991,500; bonds, $6,036,500. For gas and electrical corporations combined, $2,528,600 bonds were authorized. Electric railroads were authorized to issue $4,154,000 stock and $4,950,360 bonds.

Electrical corporations have been required to make periodic tests of consumers' meters, using standards that are checked for accuracy by inspectors of the commission. Of 78,116 electrical meters tested, 69,000 were found accurate within 4 per cent., 20 per cent. were found 4 per cent. or more slow, and 11 per cent. were 4 per cent. or more fast. In the commission's supervision of this work, 174 electrical station standards were checked for accuracy.

The commission asks for "additional employees, so that traveling auditors may be sent about through the State to assist the smaller corporation and municipalities operating public utilities who are required by law to report to the commission." The corporations, while rendering an important and usually highly appreciated service in their respective communities, are, because of the smallness of these commnuities, limited to extremely slender revenues, such that the cost of the services of skilled accountants seems one of the expenses most easily avoided and, therefore, least necessary to incur. Most of the municipal plants are particularly in need of such aid, and many of them have made requests for it.

The reports furnish an interesting bird's-eye view, so to speak, of the conditions of electrical light, power and traction companies in the Empire State. The table giving statistics regarding dividends in the companies in the "up-State" district shows that 237 out of 310, or more than three-fourths, of the corporations over which this commission has jurisdiction paid no dividends in 1909. Fifteen corporations only paid any dividends on preferred stock, and 67 on common. Altogether there is nearly $127,000,000 of common stock and some $15,000,000 of preferred that is non-dividend paying. This makes an aggregate of more than $142,000,000 of electrical stock that is yielding no return.

Discussing this situation, the second district commission points out that the significance of these figures depends almost entirely on what these stocks represent.

The public at large has a fairly good idea of what the most of this stock represents. That it, or at least the investing portion of it, is not much alarmed may be seen from the fact that this same commission reports that it has granted permission to issue new stock for electrical corporations to the amount of somewhat over $6,000,000. If to this be added bond issues permitted aggregating upwards of $13,000,000, it would seem that there is still faith left in the earning abilities of electrical properties. That this is the case is, of course, largely due to the public impression that such stocks as now issued, under the commission's supervision, must have some real basis. This is probably the case; but the commission is not satisfied as to the scope of its powers in this matter of security issues, and again urges that its powers be extended.

A strong plea on the same line is made by the first district commission, and it is to be hoped that this matter will be given the careful consideration that its importance deserves.

Activity in the security issues business has been very limited in the first district, the total permits being no stocks and only $825,000 worth of bonds. Probably the first district has had a load of this kind of matter on hand sufficiently large to hold its attention for awhile. The motives for issuing new securities of the kind that are under the commission's scrutiny is certainly not very attractive in view of the present condition of most of those now in the field.

Tungsten Production in the United States

The production in the United States in 1909 of tungsten concentrates reckoned at 60 per cent. of tungsten trioxide was 1958 short tons, valued at $746,130, according to figures compiled by Mr. F. L. Hess, of the United States Geological Survey, from returns received from producers. These figures represent the exact production for the first 11 months of the year plus the estimated production in December. Of this amount Boulder County, Colorado, produced 1401 tons, valued at $550,280. In 1908 the total production was 671 short tons, valued at $229,955, and there was, therefore, an increase in 1909 of 1287 tons in output and of $516,175 in value, or about 200 per cent. The greater part of the tungsten mined is used for the production of tungsten irons. A few carloads would supply all of the demand for tungsten lamp filaments.

Distant Control Switchgear

STEPHEN Q. HAYES

PART II

Panels, pedestals, cabinets and control desks having been described in Part I of this paper, Part II will cover the circuit-breakers, switches, etc., operated from the switchboards.. Part III will take up the arrangement of the circuit-breakers, bus bars, disconnecting switches and their structures and mounting, as well as the general arrangement of power plants with distant control switchgear.

The apparatus covered by this portion of the paper, as stated in the introduction, will be considered under the following sections:

A General features of manual operation.

B General features of pneumatic operation.

C General features of electrical operation.

D Manually operated air-break main switches and breakers.

E Pneumatically operated air-break main switches and breakers.

F Electrically operated air-break main switches and breakers.

G Manually operated oil-break main switches and breakers.

H Pneumatically operated oil-break main switches and breakers.

I Electrically operated oil-break main switches and breakers.

J Manually operated air-break disconnecting switches.

K Pneumatically operated air-break disconnecting switches.

L Electrically operated air-break disconnecting switches.

M Manually operated field switches.

N Electrically operated field switches.

O Manually operated field rheostats.

P Electrically operated field rheostats.

Q Control switches and indicators.

R Auxiliary apparatus.

While it will be obviously impossible to go very thoroughly into all of the subjects covered by these headings in the limits of this article, it is the intention to touch briefly on the most prominent features of the abovementioned sections.

Section A—General features of manual operation.

The earliest electrical power plants containing a few machines of small output and moderate voltage were easily controlled from switchboards where all of the switches, meters, etc., were placed on panels. As voltage and output increased it became necessary to utilize more space for the switching devices and to operate them either by compressed air or by mechanical or electrical means from a central point. Any method of distant control as applied to the switches and circuit-breakers has the advantage of keeping the circuits of high voltage and large power away from the switchboard proper and minimizing the danger to the operator and the damage by failure of a switching device. As applied to rehostats, it furnishes a more suitable location for the heat-producing resistances and faceplates and frequently permits reducing to a minimum the length of the connecting leads between them. As applied to other portions of the equipment the advantages are various.

Manual operation of the distant control apparatus was the first and most obvious means of taking care of the conditions to be met. Any one or more of the mechanical devices for transmitting motion between two points is applicable to this class of work, and many different arrangements have been adopted.

The simplest scheme is that of providing a long pole for the operation of apparatus that is otherwise difficult or dangerous to reach, and this method is usually employed in America for manipulating disconnecting switches that are not opened under load and that are seldom operated. One or two of these operating poles, as a rule, suffices for an ordinary station, and the cost is negligible. For certain classes of work this pole operation is satisfactory, but its drawbacks for more extended service are self-evident.

For the distant mechanical operation of oil switches and circuit-breakers American practice with its oil switches usually designed for an up-and-down motion favors the use of bell cranks and rods—the latter ordinarily being a piece of standard gas pipe screwed into suitable terminals attached to the bell cranks, operating handles, etc. As far as possible, the different portions of the mechanical transmission are arranged in tension for closing the breaker to avoid bending stresses, although a reasonable amount of compression can be taken care of without unduly increasing the weight of the mechanism.

In order to allow for lost motion, a tension spring is sometimes included in the transmission, and occasionally a clevis or union joint of some kind is furnished to take up the slack caused by wear at the bearings. Owing to the weight and inertia of this type of mechanism, it is not very satisfactory where the distance between the handle and device to be operated exceeds 50 ft., as measured along the various horizontal and vertical members.

By the use of parallel motion devices with two rods in each member it is possible to have the operating mechanism in tension at all times, both in closing and in opening, and to use lighter tubing or rods, but the duplication of parts is a serious handicap to this arrangement.

A modification of this parallel motion scheme is to use wire, rope or chain passing over pulleys or sprockets, and with such a method the limit of satisfactory operation is greatly extended. This scheme is used, to a great extent, in Europe, where the oil switches are frequently designed to be operated by a rotary motion.

Shaft transmission, either vertical or horizontal, with spur or bevel gears, chain and sprocket mechanism or similar devices, are usually employed for the operation of rheostats in America, while in Europe this method of transmission is also used for oil switches, disconnecting switches and other devices.

Section B—General features of pneumatic operation.

When the plant of the Niagara Falls Power Company was designed in 1893 the generators of 5000-h.p. capacity required switches of such size that hand operation was almost a mechanical impossibility and the switches supplied by the Westinghouse E. & M. Company were operated directly by compressed air. The direct-current circuit-breakers and switches for the Consolidated Traction Company of Pittsburg were installed by the Westinghouse Company in 1896 and were pneumatically operated, as were the first large oil switches furnished by the General Electric Company to some of the large stations in Boston, Brooklyn, Chicago and New York.

These were followed by plants for the Kings Bridge and Metropolitan stations in New York and the St. Lawrence Cons. Company at Mes-

Continued from January issue

sena, where the electro-pneumatic system was used. Practically all of the more recent plants in America, requiring an auxiliary source of power for the operation of the switchgear, have used the direct electric control by means of motors or solenoids. In some of the very latest plants, however, where the momentary power required for the operation of the apparatus is very great, compressed air is being used. In Europe pneumatically operated switchgear is almost unknown.

The main advantage of pneumatic operation is the comparative simplicity of the pipes, valves, operating cylinders and similar parts with the high pressure that can be concentrated on the mechanism when needed. The disadvantages come from the necessity of air-compressors, storage tanks, piping, valves and other appurtenances, with the troubles arising from moisture, condensation, water in the exhaust and the troubles inherent in a device that is apt to discharge moist air and water near high-tension apparatus. The losses in the piping are also considerable and limit the distance for which the direct-pneumatic operation can be employed to advantage.

The electro-pneumatic scheme minimizes these last troubles, and has practically superseded the direct-pneumatic control for all new installations where compressed-air operation is required.

Section C—General features of electrical operation.

In the vast majority of American and European power plants where an auxiliary source of power is used for the switchgear electrical operation is employed.

Most of this apparatus now in service is designed for use on a 125-volt direct-current circuit, although 250,-500 or any other available direct-current voltage can be used. In generating stations the exciter bus is often the source of the direct-current supply, but where a voltage regulator is employed that causes the voltage of this exciter bus to fluctuate, it is often advisable to install a small storage battery of about 40 ampere hours capacity in order to have a constant operating voltage. This battery is usually charged from one of the exciters, a small motor generator set, or by using suitable resistances in series with a trolley circuit or other direct-current circuit.

Where for any reason it is not desired to install a battery and it is necessary to operate the devices from an exciter bus with fluctuating voltage, the solenoids or motors can sometimes be especially designed so that the variation in voltage will not materially change the pull of the solenoid or the speed of the motor.

In substations the breakers, etc., are often designed for operation from the direct-current bus, and if the station has been completely shut down and no direct current is available, the first one or two breakers must be closed by hand. A small battery can often be used to advantage in such a station and it can be charged through a resistance from the bus. In transformer substations a small battery charged from a motor-generator set of about 5-kw. capacity is nearly always installed.

From time to time it has been proposed to operate the various devices from alternating-current circuits, and while induction regulators are sometimes operated by small alternating-current motors and special breakers, such as those for the overhead trolley position of the handle gives no clew to the position of the breaker. For such cases or where an auxiliary source of power is used for operating the devices some very ingenious methods of signaling have been designed. For a breaker of any sort a mechanically operated switch is usually provided, and this switch is thrown from one position to the other by the movement of some part of the mechanism of the main breaker. A certain amount of lost motion is usually provided so that unless the breaker goes all of the way in or out the position of the signal switch is not altered. From these signal switches circuits are run back to the switchboard to operate electro-mechanical indicators — signal lamps or similar devices. These indicators or lamps are often arranged to form part of a miniature bus circuit to show the connections that have been made by the breakers.

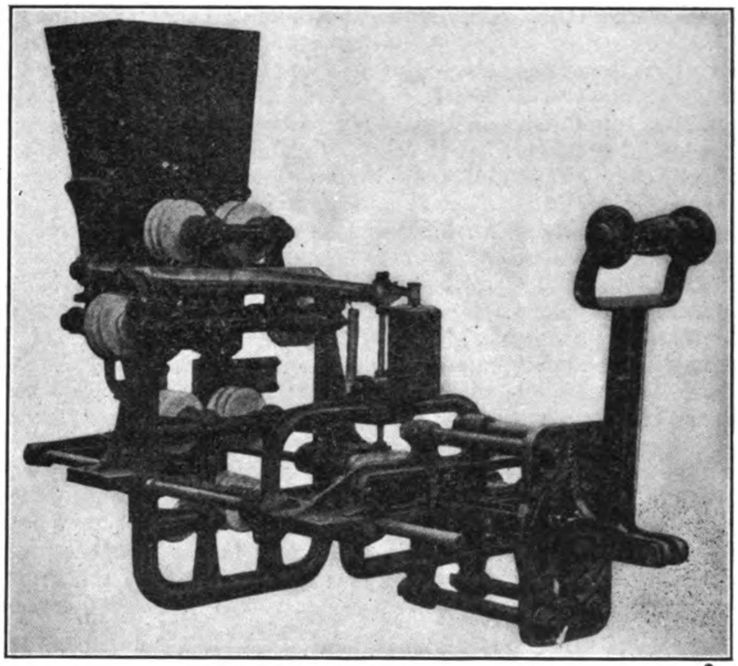


Fig. 1.—EUROPEAN (OERLIKON) HAND-OPERATED AIR-BREAK CIRCUIT-BREAKER, COMPAGNIE VAUDOISE

lines of the N. Y., N. H. & H. R. R., have been operated from alternating-current solenoids, the direct-current operation is so much cheaper and the additional complication due to its use is so small that alternating-current operation has made very little headway.

With any system of distant control apparatus it is necessary for the operator to know whether the different pieces of apparatus have actually closed or opened or performed the function assigned to them. With manual operation the automatic opening of a breaker sometimes operates all of the mechanism back to the handle, so no other indication is needed, but in other cases the latch or toggle joint is at the breaker and the

In addition to the indicator, or the pair of red and green lens signal lamps that show whether a breaker is open or closed, a lamp is often supplied that will light up only when a breaker has been tripped out automatically, but will not be illuminated if the breaker has been intentionally tripped by the operator at the switchboard. In other cases a mechanical device attached to the control switch indicates the last movement made and when the mechanical indication differs from the electrical, it is evident that the breaker has opened automatically.

Where motor operated rheostat face-plates are used, a device is often placed on the face-plate that closes the circuit of an indicating lamp on the switchboard when the arm is bridging two contacts. The winking of this light as the arm revolves gives a record of the number of contacts passed over by the moving arm. With motor-operated governors, induction regulators, valves, etc., lamps are sometimes provided on the switchboard, and so connected that they will light up when the motor has reached the limit of its travel in one direction or the other. Similar signaling devices have been designed to take care of all of the conditions arising in power plants of various kinds.

These indicators and the control switches used with the electrical operation are described under Section "Q" of this article, while the method of their mounting on the panels, desks, etc., has been illustrated in the earlier part of this article.

Section D—Manually operated air-break main switches and breakers.

With the low voltage and small amount of power prevailing in the earliest direct-current lighting plants, simple knife switches were able to easily open any of the circular underload, but as the voltage increased and amounts of power became great various devices were adopted to take care of the arc arising at opening.

The first scheme was to apply a spring attachment to a knife switch that insured a quick opening, and this arrangement is still used for small amounts of power and low voltages, and fuses are employed to give whatever automatic protection is desired. When the direct-current railway system was started it was soon found that with 500 volts or more and the fairly large currents that were to be handled fuse protection was not satisfactorily and automatic circuit-breakers of different kinds were designed.

The earliest circuit-breakers were practically knife switches with automatic features, but the rapid burning away of the contacts necessitated some means of reducing the vicious arcs at opening the circuit.

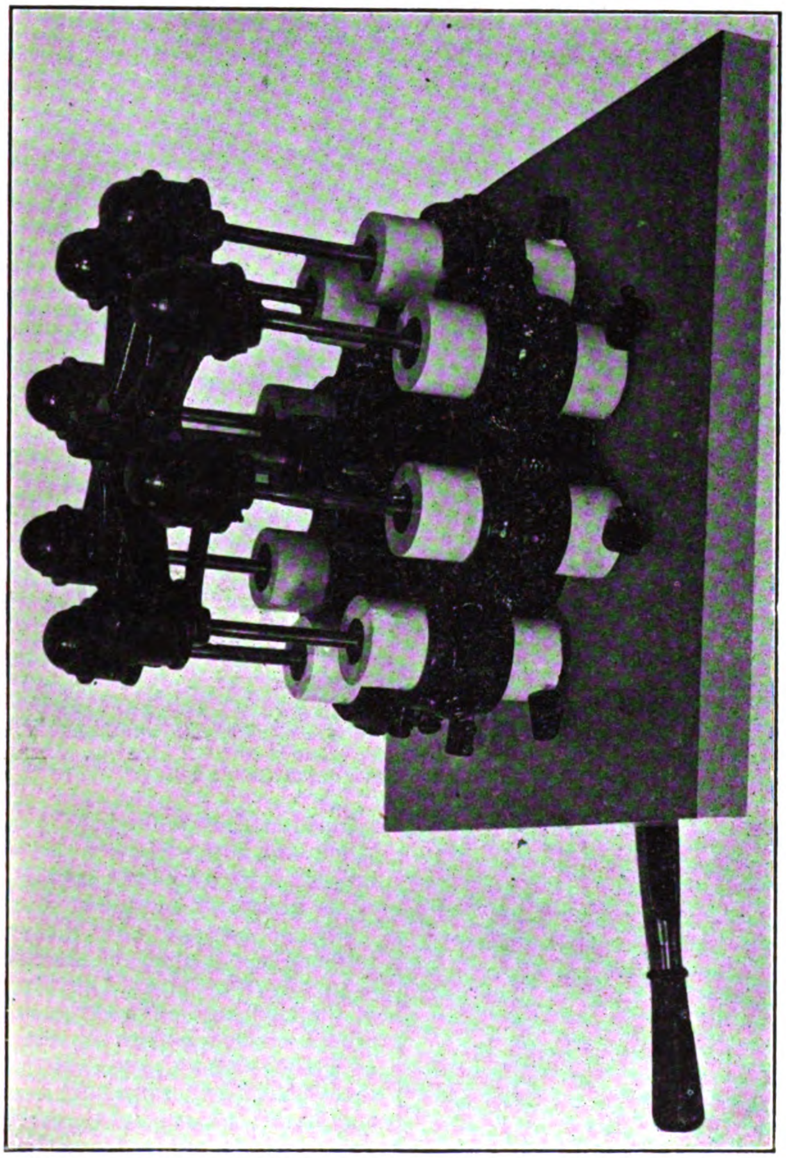


Fig. 2.—AMERICAN (WESTINGHOUSE) HAND-OPERATED PLUNGER SWITCH

One of the earliest designs that has stood the test of time was a circuit-breaker with auxiliary carbon contacts developed by the Westinghouse E. & M. Co. While the types have been modified from time to time to keep step with progress, the carbon-break feature has been adhered to and has become the practically universal standard for heavy direct-current service. These have built in capacities up to 14,000 amperes, or even higher, and for voltages up to the highest used for direct-current railway service.

Another early type was provided with auxiliary contacts that opened in a strong magnetic field that offered protection to the main contacts. This type of breaker was developed by the General Electric Company and was used until comparatively recent years, but has now been almost entirely superseded by the carbon-breaker. Other manufacturers in America and Europe have adopted the carbon-breaker as the most satisfactory for practically all classes of direct-current service. The general features of some of these breakers are clearly evident from the cuts and descriptions that will be found later in this article, so they will not be described here.

In most cases these direct-current carbon-breakers are located directly on a switchboard panel, usually at the top, to get the arc above the operator's head, but they have also been arranged for distant mechanical control, as well as pneumatic and electrical operation.

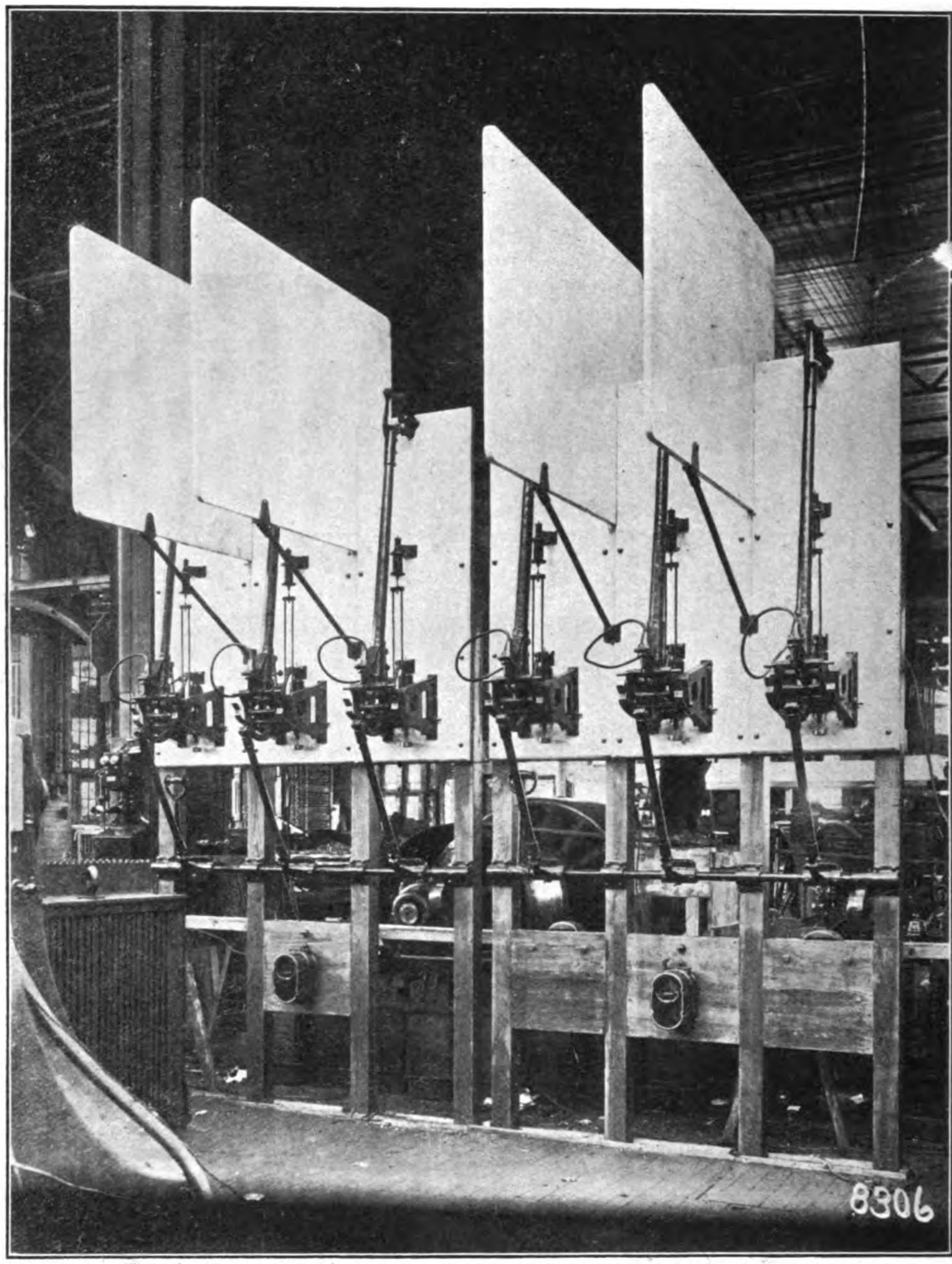
In Europe, however, the automatic breakers for direct-current service are usually distant control and are provided with auxiliary contacts, with or without magnetic blowouts. Such a breaker is shown in Fig. 1 and is the type used frequently for exciter and tramway service. To American eyes, accustomed to a compact carbon-break device mounted on a switchboard panel, this device seems unduly complicated and expensive, but with the European idea of keeping all live circuits out of reach, it is well suited for its purpose. The handle and dial-plate are usually placed on a panel, or pedestal, while the switch proper is mounted apart with the contacts in a blow-out compartment.

For alternating-current service the early plants of 1100 or 2200 volts with small amounts of power were controlled by plain knife switches on the front of a panel board, and this was shortly followed by placing the switches on the back with the handles sticking through the board. The next step was to cover over the switch or enclose the contacts and this developed into the so-called plunger switch.

Fig. 2 shows the portion of a plunger switch that is back of the switchboard panel and that is operated from the front by means of the steel shaft passing through the central casting. This switch was the result of gradual development on the part of the Westinghouse Company between the years 1894 and 1904 and was very satisfactory for currents up to 200 amperes and voltages up to 2200 volts. With this type of switch the circuit is opened in the interior of a porcelain cylinder and the resulting arc, heating the air in the enclosed space, blows itself out through a vent provided for the purpose. The cooling effect of the porcelain walls of the cylinder greatly aided in extinguishing the arc. The illustration shows a four-pole double-break switch with the eight cylinders connected in four series of two each to increase the breaking capacity. In moderate-sized plants these switches gave, and are still giving, good service, but as the capacity of stations increased it was found that another type of switch, namely, the oil switch, was better adapted to the severe conditions to be met.

Other companies in America built modified types of this switch, using lignum vitæ, applewood or some other tough, close-grained wood in order to secure greater mechanical strength than could be obtained with the porcelain available, but these had the drawback of charring. Modifications of this design are still in use for single-pole plug switches.

While the plunger switch in America was seldom used to handle more than 400 kw. at a voltage of 2200 or 3300, and was never provided with over-load features, this type was developed in Europe for higher voltages, larger amounts of power and was arranged with over-load release to act as an automatic circuit-breaker.



AMERICAN (WESTINGHOUSE) HAND-OPERATED CARBON CIRCUIT-BREAKER, COMPANIA HIDRO-ELECTRICA SAN ILDEFONSO (MEXICO)

Fig. 3 shows one of the switches supplied about 1903 by the Oerlikon Company for the La Dernier station of the Compagnie Vaudoise in Switzerland which was used for the control of a 1000 kva., 13,500 volt, 50 cycle, three-phase generator. As may be noted, this three-pole switch is provided with six porcelain cylinders with terminals for three incoming and three outgoing leads. The metal plunger rods mounted on porcelain and provided with cross-connections complete the circuit when the switch is closed and provide two breaks per phase when the switch is open.

The rather complicated mechanism with its rack and pinion movement and heavy coiled spring is so designed

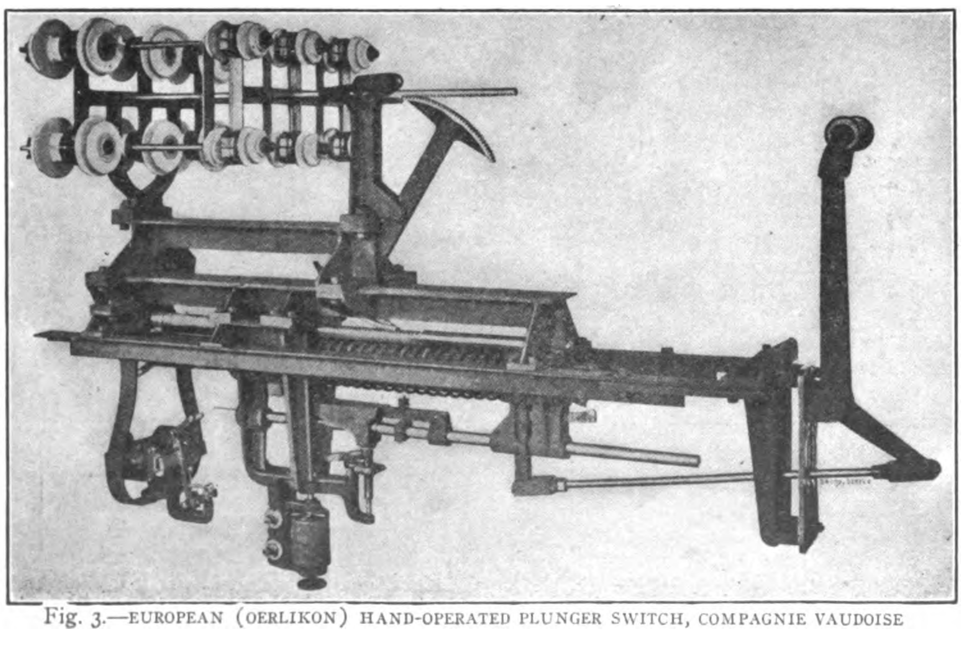


Fig. 3.—EUROPEAN (OERLIKON) HAND-OPERATED PLUNGER SWITCH, COMPAGNIE VAUDOISE

that in case of an over-load the tripping coil is actuated, releasing the switch from the operating handle in such a manner that the switch cannot be held closed on a short-circuit. The automatic tripping of the breaker causes a small movement of the handle that is sufficient to call the attention of the operator to the fact that the breaker has opened. Adjustable time-limit relays are provided for the generator circuits.

In America, prior to the almost universal adoption of oil switches, the use of the carbon-breaker was extended to alternating-current circuits of fairly high voltage and fairly large amounts of power. Fig. 4 shows one of the 22,000-volt, three-pole carbon-breakers supplied by the Westinghouse E. & M. Company for the receiving station of the transmission system of the San Ildefonso Hydro-Electric Co. in the City of Mexico. Each of the two incoming lines of about 7500-kw. capacity was provided with one of these breakers, and in addition to the over-load protection, each breaker was provided with a reverse-current relay and a special transformer arrangement to hold up the voltage of the alternating-current tripping circuit, notwithstanding the heavy line drop that would occur as the result of a short-circuit near the receiving station.

A breaker of this sort when opening under heavy load was apt to draw a long flaring arc, which placed a rather serious strain on the insulation of transformers and similar apparatus. Large marble barriers between the poles prevented the possibility of adjacent arcs coming together to form a short-circuit, and sufficient head-room was always provided to allow room for the arc to blow itself out without reaching the ceiling or the roof trusses. With this type of breaker the contacts and mechanism are in plain sight and can be readily inspected while in operation.

Section E—Pneumatically operated air-break switches.

Probably the earliest example of the use of an auxiliary source of power for the operation of switchgear is illustrated in Fig. 5, which shows one of the four-pole, double-throw switches supplied in 1896 by the Westinghouse E. & M. Co. to the Niagara Falls Power Co. for the control of the 5000-h.p., 2200-volt, two-phase generators in their No. 1 station, where there are 10 of these machines installed. This switch is practically two switches, mounted back to back, with the air cylinders, valves, piping and mechanism between them. The main jaws are mounted directly on a marble slab and the switch blades attached to a movable cross-head, make the connections between them. In order to prevent serious arcing when opening under load arrangements are made for connecting in a high resistance just before the main contacts are opened, and the circuit through the resistance in afterward opened by means of the plungers working in the cylinders of non-arcing metal. These switches were located underneath the platform containing the control pedestals shown in Fig. 11 of Part I of this article, and the piping for the compressed air was short and direct. The field switches were also pneumatically operated and located under the platform.

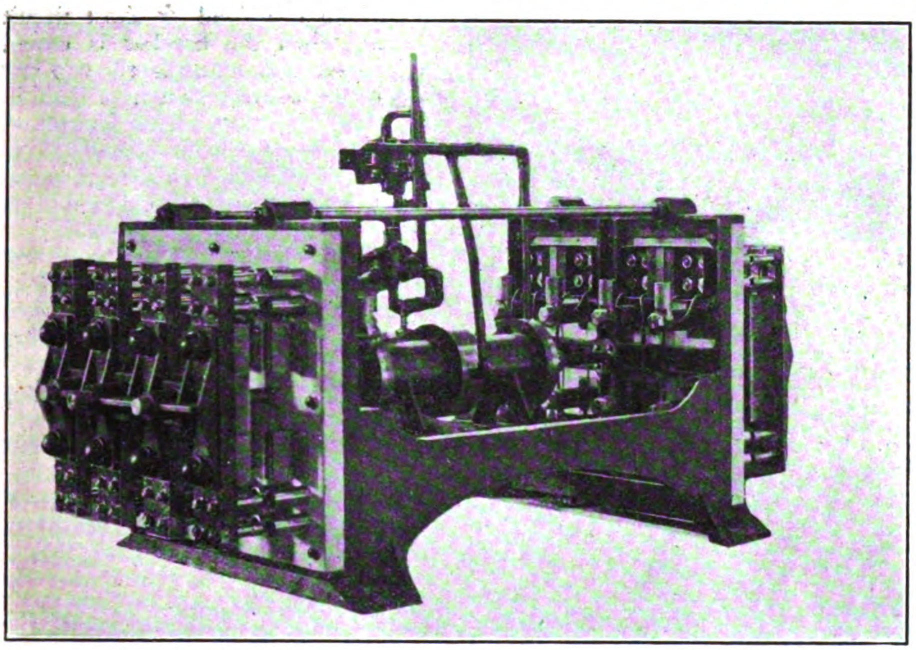


Fig. 5.—AMERICAN (WESTINGHOUSE) PNEUMATICALLY OPERATED AIR-BREAK SWITCH, NIAGARA FALLS POWER COMPANY

Pneumatically operated carbon-break circuit-breakers and double-throw brush contact switches were supplied by the Westinghouse E. & M. Company in 1898 for the Consolidated Traction Co. of Pittsburg for direct-current street railway service. This was one of the last installations using the direct-pneumatic control.

Electro-pneumatic operation has been found to possess so many advantages over the direct pneumatic for this class of service that the latter is almost obsolete. An early example of the electro-pneumatic control as applied to carbon circuit-breakers is shown in Fig. 6, which illustrates one of the three-pole breakers supplied by the Westinghouse Company to the St. Lawrence Construction Co. at Massena and to the Kingsbridge Power station in New York in 1900. In this breaker the piping and valves were so arranged that when the breaker was closed and the latch or toggle caught the air supply was cut off, and the same thing occurred when the breaker was tripped.

Section F—Electrically operated air-break main switches and breakers.

In many modern plants using electrical control for high voltage alternating-current circuits it is often desirable to use the same system for the exciters or other direct-current circuits, and there is quite a field for electrically operated carbon-break switches and circuit-breakers for this class of service.

The electrical operation of carbon circuit-breakers can be secured either through the use of a solenoid or a motor. The solenoid control is usually simpler, more rugged and cheaper, but requires momentarily more current for its operation than does the motor-driven mechanism for a breaker of the same capacity, and these relative advantages and disadvantages governed the design of this class of apparatus by different manufacturers.

Fig. 7 shows two 800-ampere, three-pole, solenoid-operated, carbon-break circuit-breakers supplied by the Westinghouse E. & M. Co. to the Rio de Janeiro T. L. & P. Co. for use with 200-kw., 250-volt exciters. The two breakers are arranged to connect the exciter to either or both of the two sets of direct-current bus bars and their general construction is evident from the cut. Each breaker is provided with a double-contact push-button depressed by the brush of one pole when the breaker is closed and released when the breaker opens, and this double-contact push-button operates the signal lamps on the control desk.

Fig. 8 shows a 4000-ampere, 750-volt, single-pole, carbon-break circuit-breaker made by the Westinghouse E. & M. Co. The general design of the breaker with the laminated copper brush contacts and carbon auxiliary contacts is evident, and has become practically the standard construction in America for heavy capacity direct-current service. The double-throw knife switch is used for the operation of the signal device.

Fig. 9 shows a 10,000-ampere, motor-operated carbon circuit-breaker supplied by the Cutter Company to the Indiana Steel Company. This breaker is provided with a device that disconnects the worm gear and shuts down the motor when the breaker has closed and its toggle has locked. It is also so arranged that in case of an over-load or short-circuit existing when the breaker is closed the breaker will immediately trip out even if the control switch is held in the "close" position. This feature of being "non-closable on over-load" is one that is embodied in a large number of breakers of all kinds and is a very valuable and useful one.

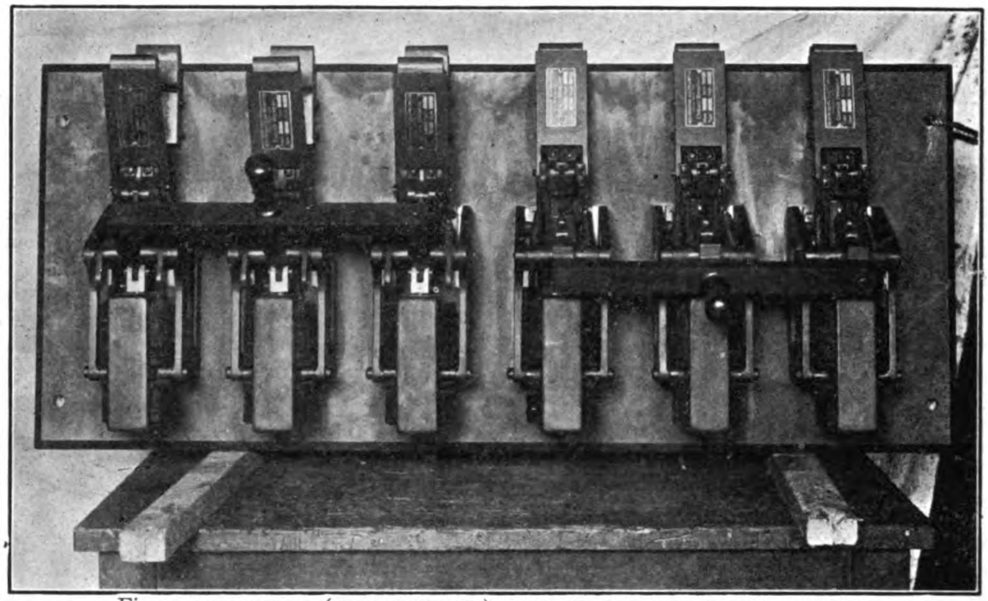


Fig. 7.—AMERICAN (WESTINGHOUSE) SOLENOID-OPERATED CARBON-BREAKER, RIO JANEIRO L. T. & P. COMPANY

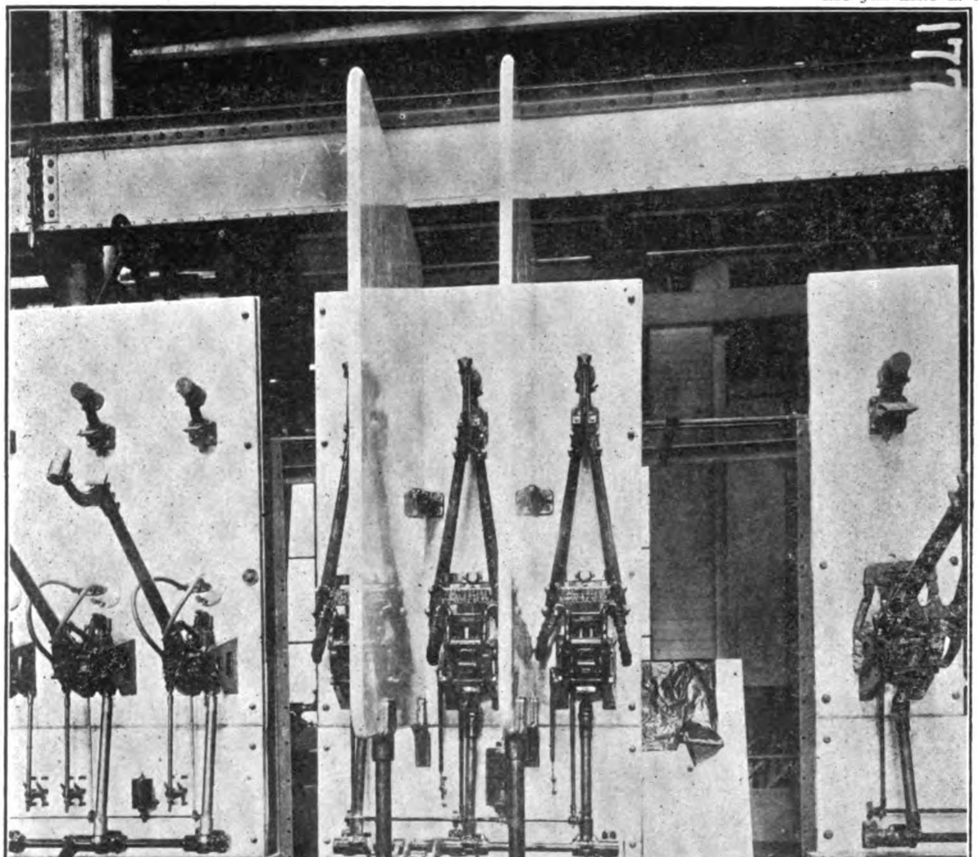


Fig. 6.—AMERICAN (WESTINGHOUSE) PNEUMATICALLY OPERATED AIR-BREAK CIRCUIT-BREAKER, ST. LAWRENCE POWER COMPANY

The terms "oil switch" and "oil circuit-breakers" as used by various manufacturers are practically synonomous, although some makers draw different distinctions between the two pieces of apparatus. With one maker an "oil switch" has knife contacts and the switch when closed has no tendency to come open, while the "oil circuit-breaker" has cone, wedge, brush or similar contacts that tend to open and must be kept closed by a latch, toggle or similar device. In this article the term "oil circuit-breaker" will be used throughout as covering a device for opening the circuit under oil with any condition of over-load that may exist at the time. These circuit-breakers may be either automatic or non-automatic, and the automatic ones may be provided with relays for over-load, under-load, reverse current, etc., and these may be made instantaneous, adjustable time limit, inverse time limit, etc.

As the essential feature of the oil-breaker is the opening of the circuit under oil and the smothering of the arc in a rather restricted space, it was found that the explosions that occasionally occur when circuits of large power are opened under oil would sometimes rupture the oil tanks, or even destroy the breaker. The amount of power that could safely be handled by an oil circuit-breaker depended on strength of its tanks, the amount of oil and similar features of design and in general it was not safe to use a small breaker on a system of large capacity if, under certain easily possible conditions, the breaker might be called on to open a short-circuit with the entire power of the station concentrated on it. As the result of long tests and experience it has become customary, particularly in America, to assign an "ultimate-breaking capacity" to various types of breakers. This is usually given as the maximum kilowatt-amperes capacity in normal rating of generators connected to the bus, on which it is safe to use a certain breaker. As an actual fact, the maximum current rating seems to have more to do with breaking capacity than the kilovolt ampere rating, and it is usually a simpler problem to control a 10,000 kilovolt-ampere current at 66,000 volts than at 6600 or 660.

In determining the ultimate-breaking capacity to be assigned to a breaker, due consideration is given to the following points that materially affect the amount of power that can be safely handled. With a non-automatic circuit-breaker, such as usually employed on generator circuits, the chances are very remote that such a piece of apparatus will ever have to open very much more than the over-load capacity of the generator or, at the worst, the amount of current it can develop under short-circuit conditions. With an automatic-breaker, however, which will trip out, due to an overload or short-circuit on a feeder, it is possible in some cases to have the entire energy of the station concentrated on that short-circuit, and opened by the breaker, particularly if provided with an instantaneous release. The momentary energy at the point of trouble may far exceed that which the machines could continuously develop even under short-circuit conditions, so an instantaneous automatic-breakers has exceedingly severe conditions to meet. If a time-limit relay is used the conditions are somewhat improved. While it is practically impossible to calculate the exact amount of energy which a breaker might be called upon to open in a given station, it is known from tests and long experience in design that circuit-breakers have a reasonable factor of safety when connected to bus bars fed from generators with a certain combined kilovolt-ampere capacity, and this has been termed the "ultimate-breaking capacity" for which a breaker can be guaranteed. Under favorable conditions the breakers may be used on bus bars having a somewhat greater capacity, while under extremely adverse conditions of poor oil, etc., it is possible that a breaker might fail to satisfactorily open the circuit when pushed to the extreme limits, but taken all in all, the ratings usually given by the manufacturer are conservative.

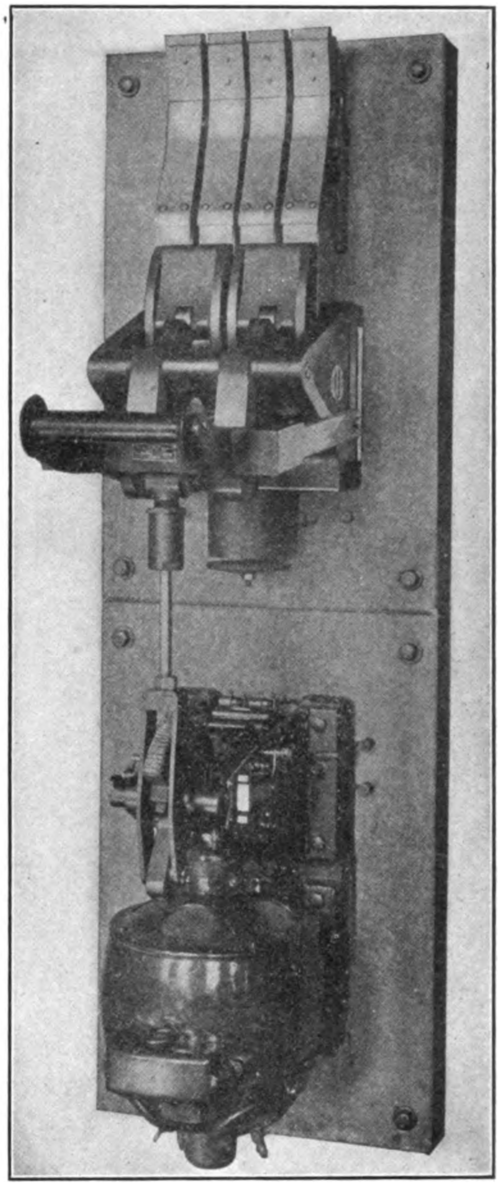


Fig. 9.—AMERICAN (CUTTER) MOTOR-OPERATED CARBON CIRCUIT-BREAKER, INDIANA STEEL COMPANY

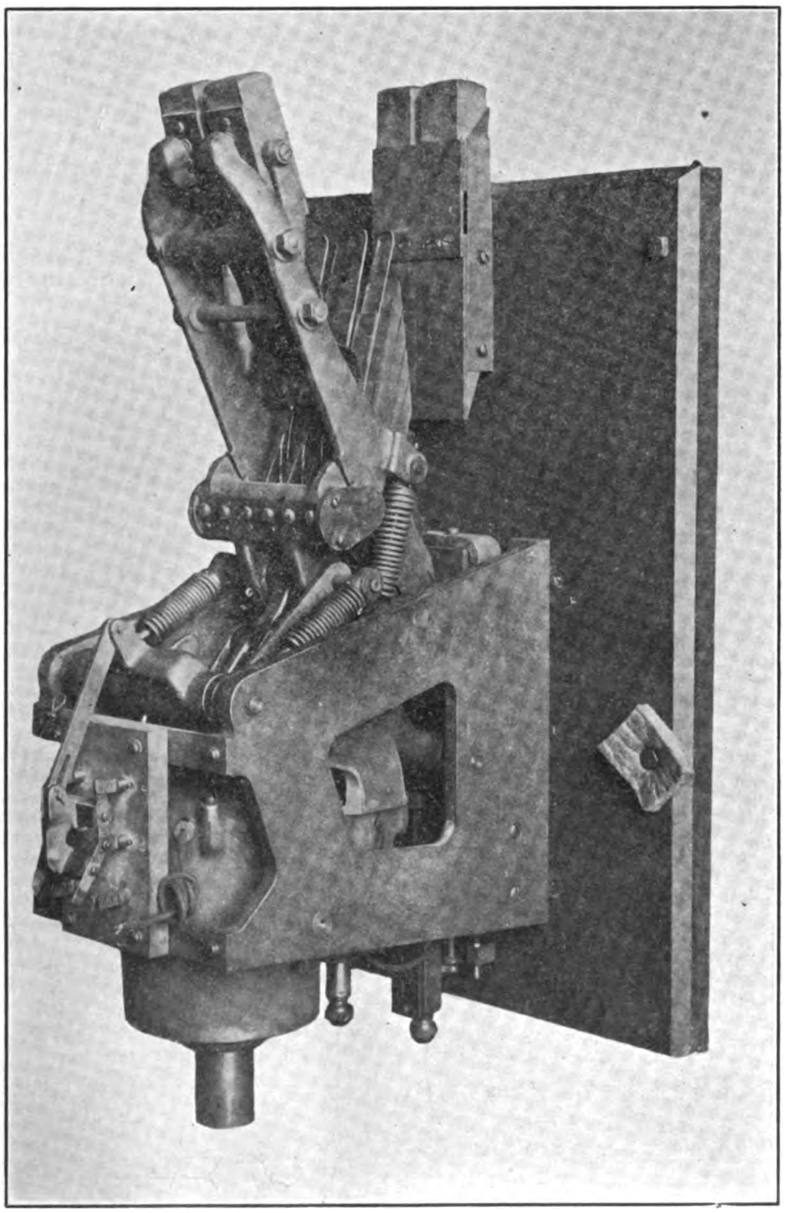


Fig. 8.—AMERICAN (WESTINGHOUSE) SOLENOID-OPERATED CARBON CIRCUIT-BREAKER

Where a double set of bus bars is installed, or the bus bars are sectionalized, it is sometimes possible to use smaller breakers, although the total capacity in the station may exceed the "maximum-breaking capacity" of the breakers. Usually water-wheel-driven units have not the same over-load capacities as steam-driven units and smaller breakers might answer in a water power plant than would be considered safe in a steam plant. For substation work, where there will be a certain amount of drop in the feeders from the generating station, smaller breakers can often be used. It is also occasionally feasible to use a few large breakers and the rest small ones. As a general rule, however, it is not well to over-rate the breakers without submitting the entire proposition to very careful consideration.

The rating figures, where any are given, in the descriptions of the various oil circuit-breakers as to the ultimate-breaking capacity are those considered safe and conservative by their designers, but it should be stated that few of the breakers, particularly of the larger sizes, have even been tested to the point of break-down, as it is practically impossible to obtain the necessary amount of power for testing purposes even in the largest plants. It should also be noted in connection with the smaller breakers that a breaker of a certain type, good for the maximum current and maximum voltage for which that type is built, can seldom be supplied, and the product of maximum current and maximum voltage will sometimes exceed the ultimate-breaking capacity.

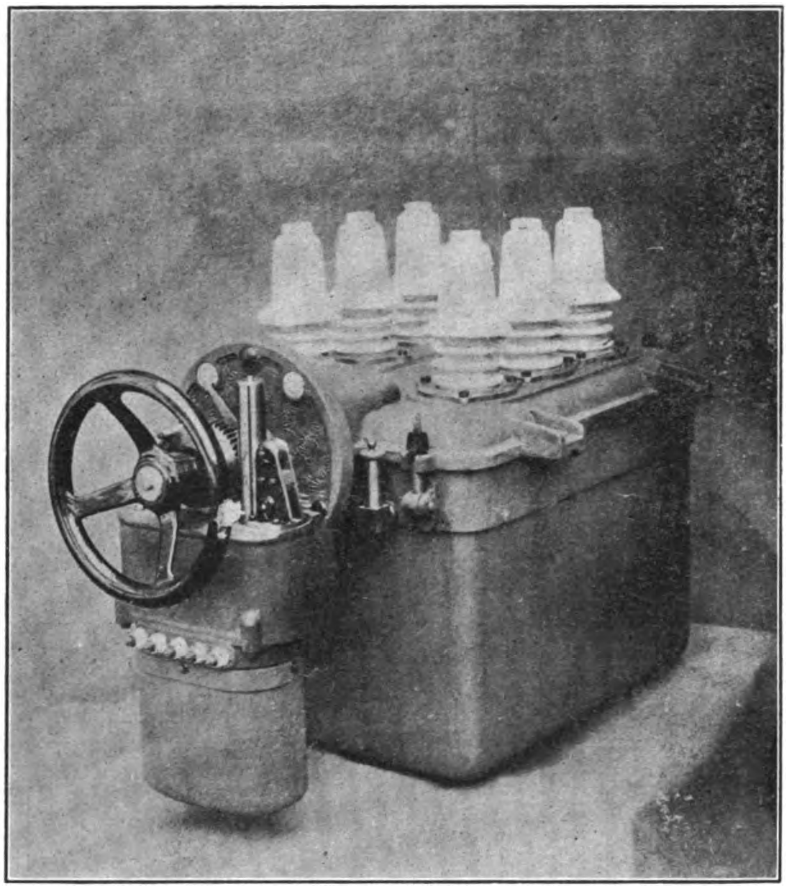


Fig. 11.—EUROPEAN (MAGRINI) MECHANICALLY OPERATED OIL CIRCUIT-BREAKER, CAMPO COLOGNO STATION

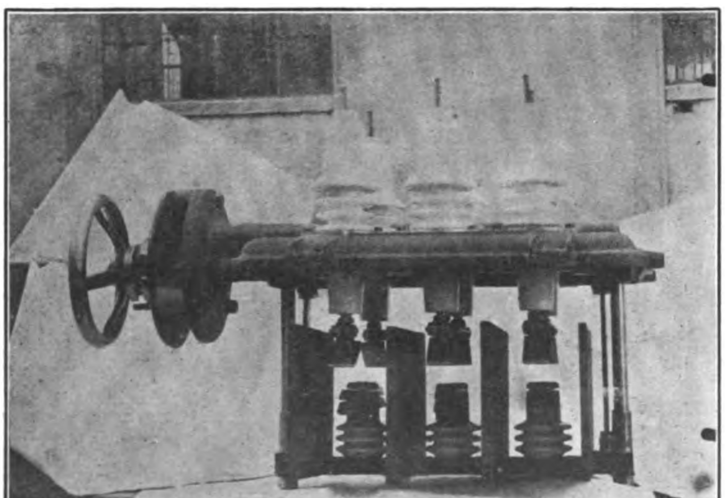


Fig. 12.—ABOVE OIL CIRCUIT-BREAKER WITH TANK REMOVED

As European practice leans toward the use of manually operated oil-breakers even for large capacity, and American practice tends toward using an auxiliary source of power for distant control switchgear, the European oil circuit-breakers are included under Section G, while the American breakers are described under Sections H and I, although the manually operated European breakers illustrated are frequently arranged for electrical operation, while the American breakers, particularly in the smaller sizes, are often made for manual operation.

Section G—Manually operated oil-break switches and circuit-breakers.

Fig. 11 shows a three-pole oil circuit-breaker of Italian manufacture arranged with a hand-wheel for direct manipulation. As may be noticed, the hand-wheel shaft is provided with a rack and pinion device so that a solenoid located in the tank casting and pulling directly on the rack can operate the breaker. The dial-plate is provided with discs marked "Aperto" and "Chiuso," "open" and "closed," so that attendants can determine from the position of the pointer whether the breaker is open or closed. For direct mechanical operation rope drive is used. The top casting is provided with mounting lugs and the heavy iron tank can be dropped off to get at the contacts. For the larger breakers of this design a screw mechanism located on the floor is provided for lowering the tank.

Fig. 12 shows a breaker of similar design with the tank removed and the contacts, barriers and operating mechanism visible. As may be noticed, the stationary butt contacts are attached to the porcelains in the top of the case, and they are slanted at an angle of about 45 degrees and pivoted to secure a good bearing surface against the movable contact. The three sets of movable contacts are attached to porcelains mounted on a metal cross-bar, which also carries the wooden barriers that separate the poles. This movable cross-arm slides on the vertical guide rods and is operated by a crank-shaft mechanism in such a manner as to get a straight up and down motion.

Fig. 13 shows the rear view of one of the generator control cabinets supplied by the Alioth Company to the Campo Cologno generating station in Switzerland of the Brusio transmission for the control of a 3000-kw., 7000-volt, three-phase generator, of which there are 12 in the plant. This cabinet contains the oil circuit-breaker, field switch, field rheostat, instrument transformers and similar devices. To American eyes the automatic oil circuit-breaker seems very small for a plant of 36,000 kva., but in actual service it seems to give entire satisfaction.

Fig. 14 shows the way in which the Alioth Company combine the breakers on the low-tension and high-tension side of a transformer bank in the Castellanza station in Italy of the Brusio transmission. The three-pole breaker on the right controls the low-tension end of the bank of transformers, while the single-pole breaker with three double breaks per pole on the left with two other single-pole breakers that do not appear in the illustration control the high-tension circuit. All of these breakers are worked by one common shaft that is operated by a long double arm-handle placed on the transformer

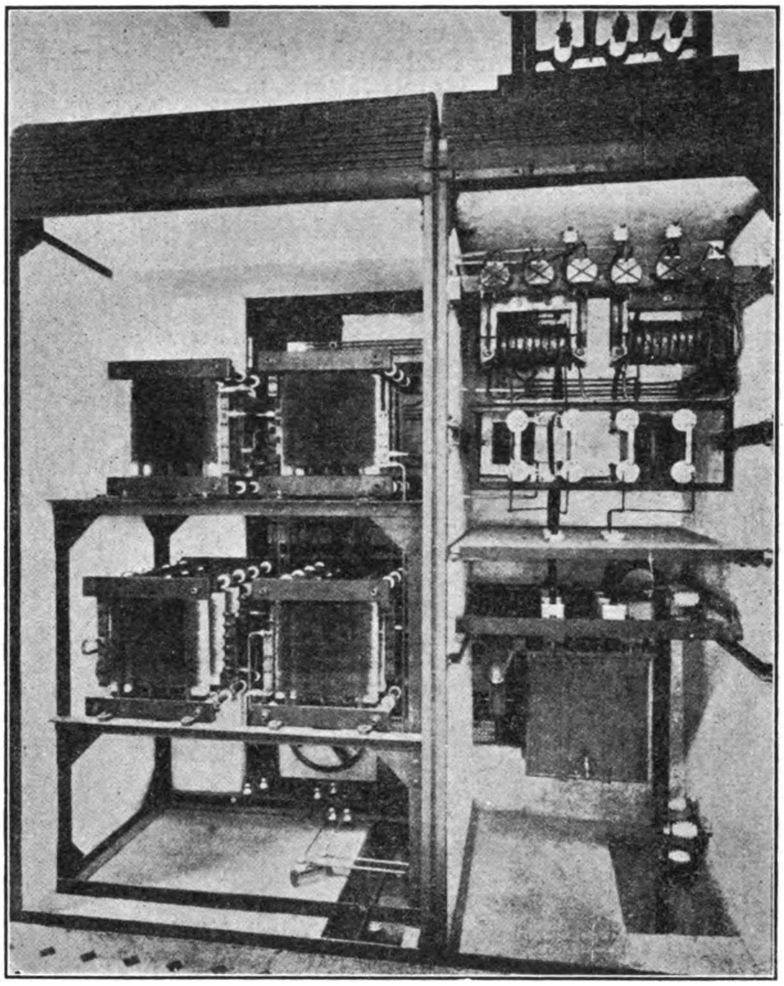


Fig. 13.—EUROPEAN (ALIOTH) OIL CIRCUIT-BREAKER, CAMPO COLOGNO STATION

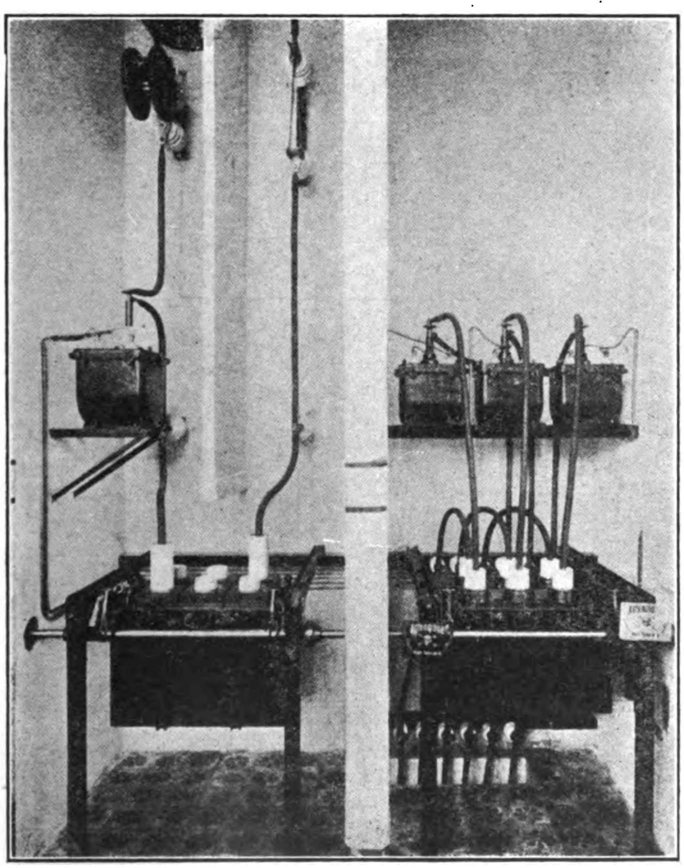


Fig. 14.—EUROPEAN (ALIOTH) COMBINED HIGH- AND LOW-TENSION BREAKER, CASTELLANZA PLANT

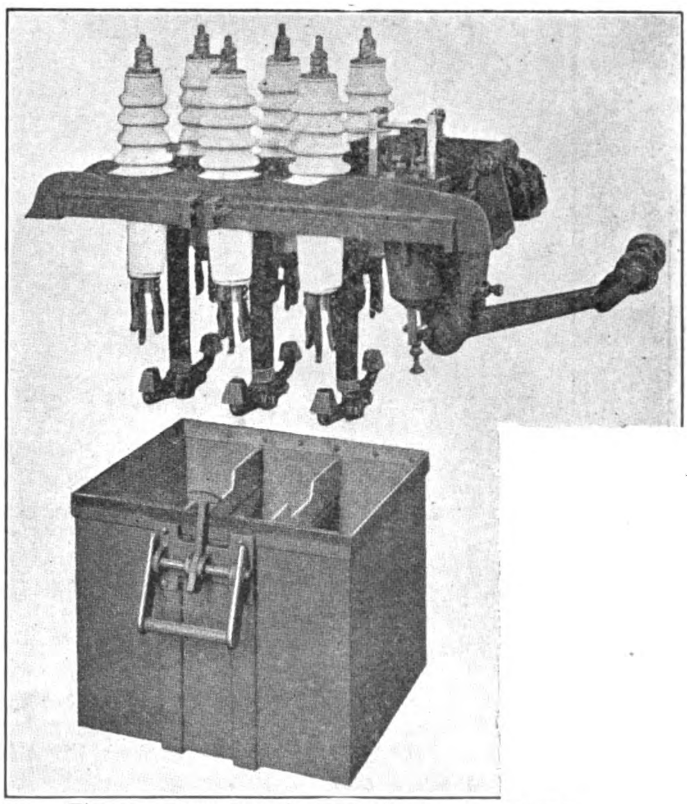


Fig. 15.—EUROPEAN (OERLIKON) CIRCUIT-BREAKER, OBERMATT PLANT

panel. This cut also shows the oil-immersed series transformers in the high-tension and low-tension circuits, as well as the double spiral choke coils and disconnecting switch in the 44,-000-volt circuit.

Fig. 15 shows a three-pole, 6000-volt oil breaker of the type supplied by the Oerlikon Company to the Obermatt station of the Lucerne Engelberg transmission in Switzerland, the actual breakers used being arranged for distant control by means of levers located at a pedestal on the operating gallery. All of the wedge-shaped contacts are placed in a single tank of sheet metal with barriers between the poles.

Fig. 16 shows the type of oil-breaker supplied by the Oerlikon Company for the 27,000-volt circuits of the Engelberg Lucerne plant. The actual breakers used in this installation were operated by a rope transmission, while in some other installations solenoids located on the top frame operate the mechanism. This breaker has

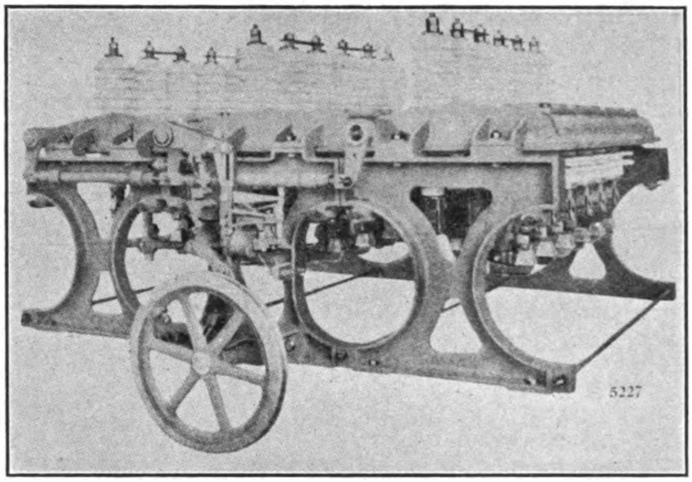


Fig. 17

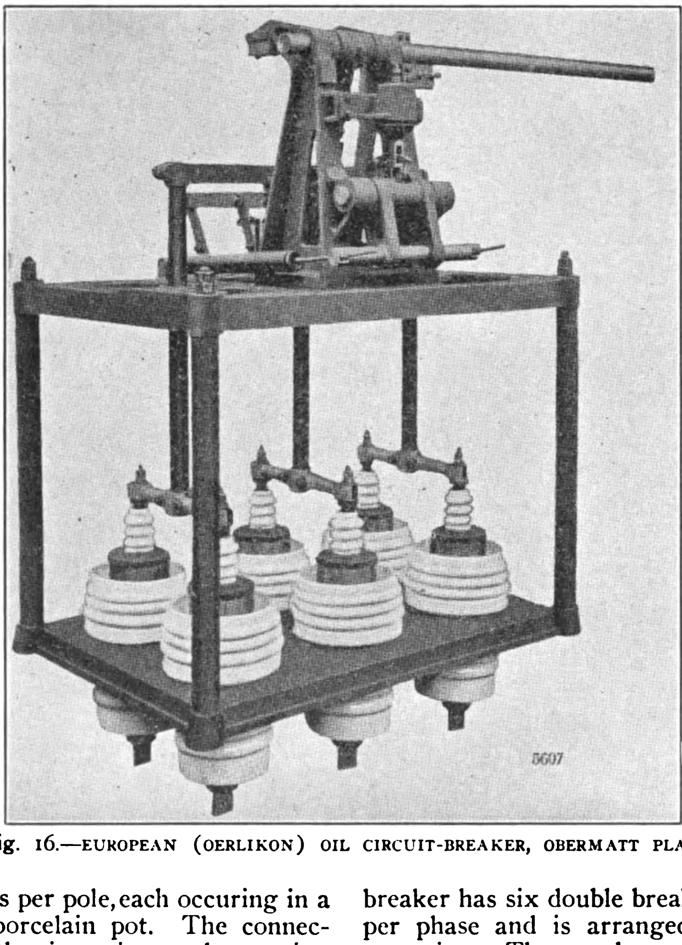


Fig. 16.—EUROPEAN (OERLIKON) OIL CIRCUIT-BREAKER, OBERMATT PLANT

two breaks per pole, each occuring in a separate porcelain pot. The connections of the incoming and outgoing leads are made at the bottom of the pots, while the plunger rods enter the top and are attached to cross-arms operated from the mechanism on the upper frame-work. This breaker, like all bottom-connected ones, with vertical break, has the disadvantage that gravity tends to open it rather than close it, and sediment is apt to settle on the contacts at the bottom of the oil pots.

Fig. 17 shows one of the 47,000-volt, three-pole oil-breakers supplied by the Oerlikon Co. for the Caffaro-Brescia transmission in Italy. This breaker has six double breaks in series per phase and is arranged for rope operation. The number of points to be insulated and the apparent complication of the mechanism should be compared with the few parts and the simple mechanism required for the American breaker of practically the same voltage shown later in Figs. 30 and 31.

[To be continued.]

A Generous Gift

The Commonwealth Edison Company of Chicago and the General Electric Company of Schenectady have jointly presented to the Department of Electrical Engineering of the University of Illinois a 125-kw., stem turbo-generator. The turbine of this unit is to be non-condensing. The generator is to be designed for three-phase, 60-cycle currents, to be delivered at 2300 volts. With the addition of this machine the electrical laboratory will be prepared to deal extensively with problems involving single-phase, quarter-phase and three-phase currents. The significance of this announcement is increased by the fact that this turbo-generator, which is secured for the University through the interest of the Commonwealth Edison Company, constitutes the first large gift which thus far has ever been received by the College of Engineering. This gift following closely as it does after coming to the university of Dr. E. J. Berg as professor of electrical engineering, may be accepted as marking a new era in the activities of the Department of Electrical Engineering at the University of Illinois.

American Exposition in Berlin

An American exposition will be held in Berlin, Germany, from May to July, 1910. At the head of this exposition is a committee consisting of representative business men of the United States. A committee has also been formed in Berlin, whose honorary president is Prince Henry of Prussia. The conditions governing the exposition have been examined by the Bureau of Manufacturers, Washington, D. C., and appear to offer a great opportunity to American enterprise.

An English Single-Phase Electrification

By JAMES DALZIEL and JOSIAH SAYERS*

PART I—THE INSTALLATION

In the summer of 1906, acting on the recommendation of Mr. R. M. Deeley, M. Inst. C. E., then locomotive superintendent of the Midland Railway, the Midland Board ordered the section of main line between Lancaster, Morecambe and Heysham to be electrically equipped with the single-phase system, and the work was put in hand and generally carried out by the respective staffs of Mr. Deeley and Mr. W. B. Worthington, M. Inst. C. E., the chief engineer. The authors under them were respectively responsible, one for the power-house and cars and their equipment, and the other for the overhead equipment, rail-return, etc.

The authors made a preliminary investigation of some of the lines being electrified on the Continent in the autumn of 1906. The work was then put in hand, and in December, 1907, current was first put on to the section from Heysham to Torrisholme (about three miles) and trial runs of electric trains were made in January, 1908. Passenger trains were first run on April 13, 1908.

The chief reasons for choosing this section for the experiment were: first, the existence at Heysham of a power-station which was capable of enlargement and could accommodate the necessary single-phase machinery with a small expense both in construction and maintenance, and which in particular had installed as part of it a large battery that could be drawn upon for the peak demands, in addition to doing its ordinary work in connection with the harbor for which the station primarily existed; secondly, that the local traffic was light in the winter, but bridged about 17 hr. of the day, taking up five engines, the cost of which could be entirely saved. The summer traffic was heavy and liable to congestion, particularly in connection with the departure and arrival of steamers, and it was considered that electric trains could clear, say, Heysham rapidly of passengers for Morecambe and Lancaster, while the main-line trains for the south were filling.

In the event, during the two summers of working, there has been work on most days sufficient to keep two trains running incessantly from morning till night, and on the busiest days a third train frequently has to be run. In dealing with the local traffic, which on bank holidays and Saturday nights is very heavy between Morecambe and Lancaster, particularly from 10.30 P. M. to 11 P. M., it is found that Morecambe platform is cleared about 40 minutes earlier than in the days of steam locomotives; that the use of the electric trains has enabled nearly the whole of the main-line trains, both ordinary and excursion, to be run through Lancaster without stopping; and that an electric train, notwithstanding that the only crossover road at Lancaster is about 300 yd. beyond the station, necessitating frequently three, and always two, stops instead of one, returns to Morecambe in 20 min., against the 40 required by the shuttle steam trains. The frequent service has also effected a much-needed improvement in relieving the congestion of the platforms. The platforms at Lancaster in particular, where exit facilities are rather restricted, used to become badly overcrowded when discharging a long heavily-loaded train, and many minutes were lost before carriage doors could be shut and the train drawn out of the station.

The installation, therefore, while partly experimental, was designed to perform practical work in, and be of benefit to, traffic operations, and a saving in working expenses was also anticipated.

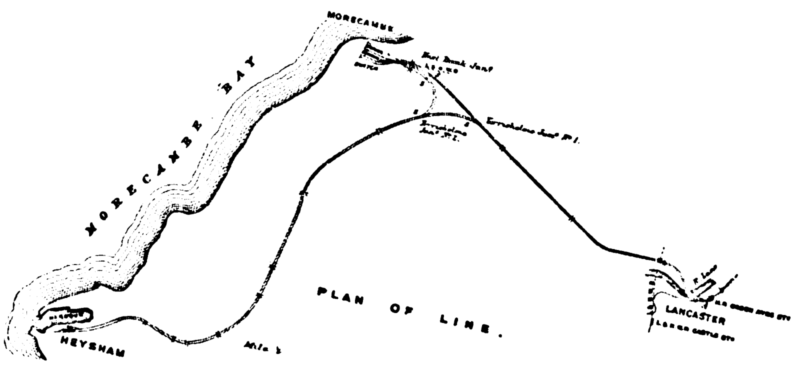


Fig. 1.—MAP OF ELECTRIFIED SECTION

The particular section electrified (shown in Fig. 1) is probably the most difficult that could have been selected for equipment, as with the single exception that it does not possess a tunnel, it offers every possible difficulty to the erection and maintenance of a high-pressure overhead line. It is very exposed, and in spray gales the air is heavily laden with salt. At a time of the year when continuous traffic would be of use in assisting to free the line from snow, etc., the traffic is lightest, but at holiday times in summer the train service is very heavy indeed. The authors consider that an equipment which will work satisfactorily on this section will do so anywhere on the Midland system.

OVERHEAD WORK

Contact Wire.—The method of suspension adopted was largely adapted from that used on the Hamburg-Altona line by the Siemens-Schuckert Werke, who courteously permitted the authors to inspect it.

Such method fulfils in a remarkable manner the chief essential for high-speed running with a light bow pressure, namely, great evenness of inertia. This results in the absence of mechanical waves in the contact wire at whatever speed the car is running; and there is, in addition, an entire absence of points held more or less rigidly, which in most systems provide points for reflection of mechanical waves and vibration.

It will be seen from Fig. 2 that the contact wire lies evenly in the loops along its length. The importance of keeping the inertia of the contact wire to vertical motion as even as possible is very great, owing to the comparatively low upward pressure allowable for the contact bows. The pressure of the bows was kept as low as possible, first, because the clearness under certain structures are very small, and the lower the upward pressure of the bow the less chance there is of the contact wire being raised foul of the structure; and secondly, because it was desired to reduce to a minimum the wear and tear due to the high speeds at which it was intended to work the line. This result has been attained with a pressure which varies between 10 and 12 lb.

The authors believe the following features of the suspension to be novel:

First, the catenary wire, instead of being taken over the top of the insulator and secured by a clamp, consists of two similar steel cables which are clipped together through the greater part of the span, but divide on either side of the insulator to enable them to pass through two grooves of a malleable cast-iron ring. The wires are not

* Institute Civil Engineers

secured in any way on this ring, and the ring itself is below the highest point of the steel bolt inside the insulator. It is considered that this affords better mechanical connection between the catenary wire and the steel bolt than with the usual top-clip arrangement, and that great flexibility is given to the catenary system, the strains from one span to another being automatically adjusted by slight movement of the catenary wire through the grooves. In case of severance of the catenary cables on one side, the run back could only be as far as the first clip, say 2 ft., thus preventing the suspension as a whole from falling; and this particular action has been tested in practice with success.

Secondly, the contact wire is anchored at one end only. Messrs. Siemens in their Continental work leave both ends unanchored and weighted to produce proper tension of the contact wire, but the Midland Railway Company decided to anchor one end and weight the other. The trains enter at the anchored end and leave at the weighted end, the result being that the bow pressure has a beneficial tendency in continually straightening out the wire. The authors believe that on the Continent it has been found that the two free ends result in a gradual movement of the wire in the direction of the motion of the train, as was perhaps to be expected, and that this difficulty has been overcome there by putting more weight on the end at which the train normally enters. Each section of contact wire is approximately 1000 yd. long, and the sections do not join mechanically, the bow passing from one section to the other in the course of three spans, as shown in Figs. 2. The idea in this was, of course, to carry out the principle of evenness of motion in the transfer of the bow from one wire to the next.

The normal stagger of the contact wire from the center of the track was originally designed to be 2 ft. on each side, but the first trial runs on the Heysham branch showed that this was too much for the widest bow that could be constructed to get through the structures, and it was reduced to 18 in. on each side. On about one-half of the line, however, from Morecambe to Lancaster, and up the Castle branch, the stagger was made 1 ft. on each side of the center, as consideration of all the factors that produce the movement of the bow across the wire made it clear that with this 2-ft. stagger the bow would still be fairly evenly worn all over.

The maximum vertical gradient adopted for the contact wire is 1 in 100, and with this the bow seems to have no difficulty in following the plane of the contact wire at high speeds.

The catenary and auxiliary cables, which are of galvanized steel, were made up by first coating each separate strand with warm red-oxide paint, and then stranding the whole together immediately after passing through a bath of the same paint, the object being to prevent moisture from penetrating to the inside strands as long as possible. Some of the cables have now been up nearly two years, and examination shows that they are still solid with paint. Two years' trial under the climatic conditions prevailing here is a very severe test.

Switch Sections. — Disconnecting switch sections are provided at the points S S in the general plan of the line as shown in Fig. 2, indicate the manner in which these sections have been laid out. By the adoption of an idle wire bridging three spans (this wire being connected normally when the switches are in), the center span is dead when the switches are out. The object of this was to provide against a car running from an electrified to a non-electrified section with the bows up, which, if the sections overlapped, would serve to connect them together. If the car under the authors' arrangement runs past the open switch, it has to go across one span of dead wire before reaching the next section, and contact is thus prevented between the "switched in" and the "switched out" section.

Gantries.—The gantries spanning the lines are of two kinds. The great majority consist of two steel angle-bars, erected parallel with 1-in. distance pieces between them, bolted together, and supported by creosoted timber poles specially selected for straightness and uniformity of taper. The remaining gantries are of steel lattice construction throughout, and

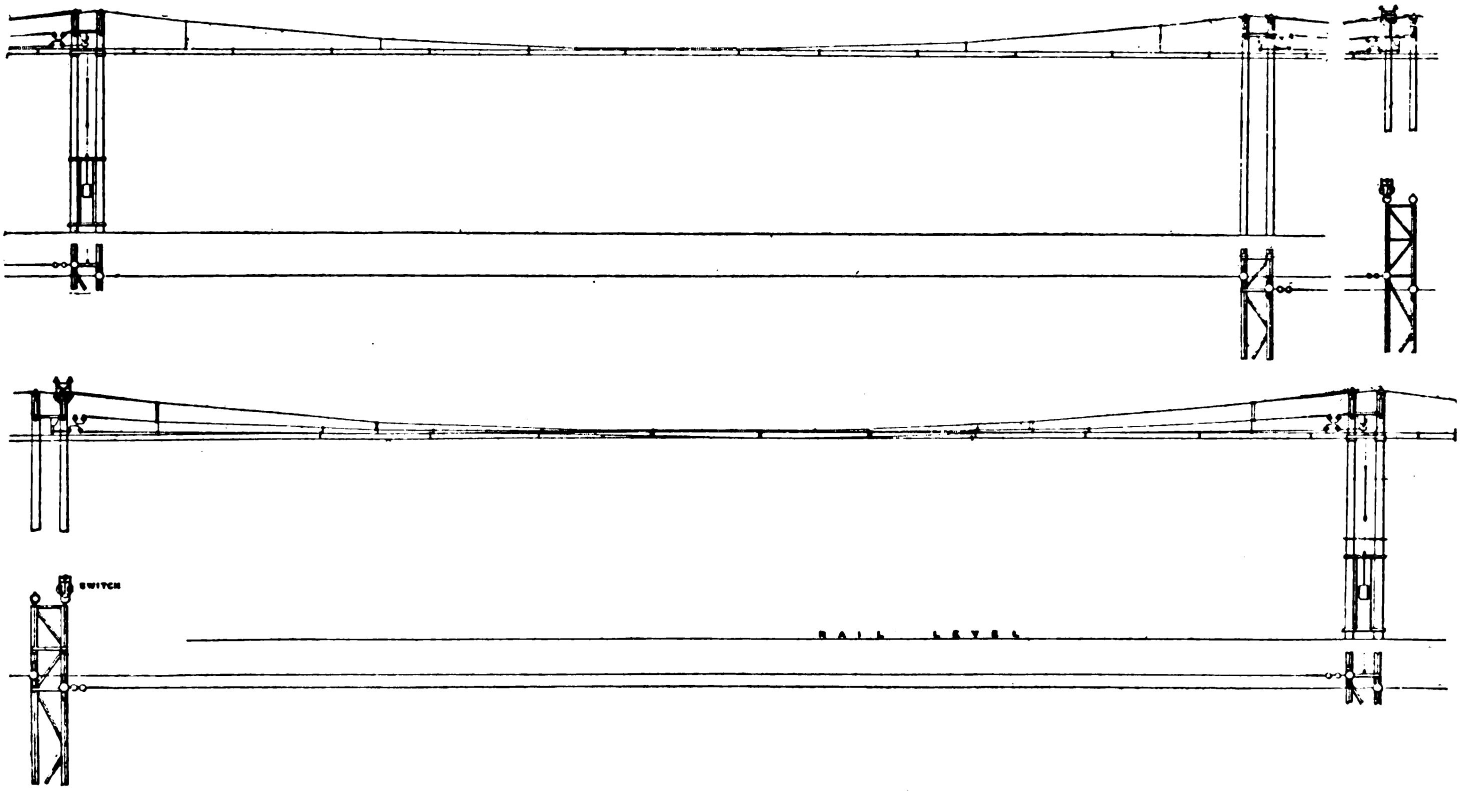


Fig. 2.—GENERAL VIEW OF SUSPENSION

this type has been used at places such as Morecambe Station, where several lines have to be spanned and the obstruction of a large number of timber poles could not be permitted. The design and erection of these gantries was carried out by the staff of the northern divisional engineer (Mr. J. Argyle, M. Inst. C. E.) and under his supervision.

The question of earthing these gantries, and so preventing the timber poles from being charged to a dangerous pressure from small leakage of the insulators, was the subject of careful

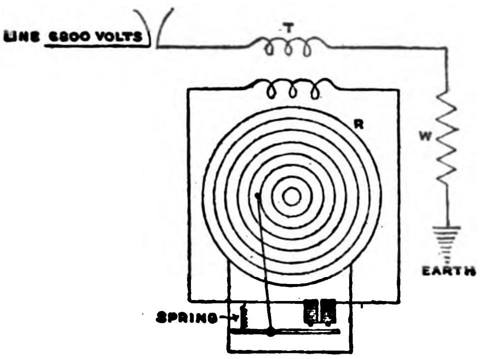


Fig. 3.—OVER-VOLTAGE RECORDER

thought. The obvious method was to run earth wires down the poles to their bases, but it did not seem to be altogether a safe method, as the earth wire would be necessarily embedded in concrete, in itself a partial insulator; it would also be, where it entered the ground, out of sight, and liable to become disconnected in course of time, and in order to be safe it would require to be insulated where it passed down the pole. It was decided, therefore, to connect up all the gantries with a steel cable clipped to each and run in half-mile sections, each end of a section being connected to an earth plate which is easily inspected. Instead, therefore, of having, say, 2000 doubtful and inefficient earth wires and plates to look after, there are on the whole 19 miles of single line about forty efficient, easily-inspected earth plates.

The line is protected from injurious lightning effects as far as possible by the provision of horn-type lightning-arresters, which are placed at the end of each section of the contact wire. In addition, the sections of contact wire, which overlap as already described, are connected across by large spirals of copper wire, with the object of introducing a certain amount of self-induction into the contact wire at these points, so as to confine high-frequency oscillation currents as far as possible to one section. This small amount of self-induction would, of course, be comparatively inoperative at 25 alt. per sec.

Observations at the radio-telegraph station which the company have experimented with at this point show that even at times when apparently there is no lightning in the neighborhood there may exist very high potentials a few feet above the ground. Sparks 3/4 in. long have been obtained from the antennæ continuously for 1/2 hr. at such a time, and it must be expected, therefore, that, quite apart from lightning, an extensive overhead system will be frequently charged to a high potential from the atmosphere. A diagram of the apparatus used for recording these discharges is shown in Fig. 3.

RAIL-RETURN

The return current from the cars is taken back through one rail of each track. These rails are bonded with copper bonds, which were specially designed to suit the clearance between the fishplate and the rail, and which allow for the normal wear of the fishplates before the latter are scrapped. The rails are cross-bonded about every 1/2 mile, and at junctions every rail and every angle is bonded.

By the use of a double-screw bond-compressor very great pressure is put upon the internal copper as distinct from compression of the external head of the copper stud, and an extremely good electrical joint is thereby made.

It is fairly well known that such bonds should be made only when the weather is good, or when the bond can be protected, so that between the time of drilling the hole in the rail and compressing the bond, say 1 min., there can be no deposition of moisture on the internal surface. While the bonding was in progress on this line, complete notes were made of the weather prevailing at the time of each bond, and when the bonds were tested afterwards for ohmic resistance, it was found that there was unmistakable evidence as to whether a bond had been made in dry or in damp weather; the resistance of the bonds made under the latter conditions being of course higher. The actual resistance of each bond was very low in all cases, 0.00005 ohm being the mean reading of a large number of tests in which the highest reading was 0.000075 ohm and the lowest 0.000007 ohm.

The experiments which the authors have been able to make on the impedance of the steel rails employed on this line, which weighed at that time about 85 lb. per yard, show that while their resistance to direct current would be 0.085 ohm per mile, their impedance at 25 cycles with about 25 amperes of current is 0.37 ohm per mile.

The rails are earthed at three points: at Heysham by duplicate earth plates into the harbor, at Morecambe by earth-plates sunk in a cast-iron caisson at the end of the old Midland pier below low water, and at Lancaster by connection with the four iron columns supporting the bridge over the River Lune; these columns were selected after being tested for their earth resistance, and are the only ones that stand always in water. With these exceptions the rails are not earthed at any point, as it was intended to find out how the return current distributed itself, which could not be conveniently done if a large number of earths were put in. The result has been somewhat surprising, as from the very beginning the pressure between the rails and earth at any point with two cars accelerating has been very small indeed, not exceeding 5 volts, and all the results clearly indicate that the return current leaves the rail and enters the ballast at a very small distance from the power-house. Recording ammeters in the sea earth-plates mentioned have recorded absolutely no current from the day they were put in, a result which the authors think could hardly have been apprehended.

A series of experiments were carried out to ascertain the distribution of return current under normal conditions by putting in insulated joints at various points in the line, inserting an ammeter and taking continuous observations of the current passing the joint. The net result was to show clearly enough that the current did not continue along the rails for any considerable length, but within a very few hundred yards of the car sank gradually into the earth.

PROTECTION OF LEVEL CROSSINGS

At all level crossing loading gauges have been provided on each side as a protection against anything being carted over the crossing of such a height as would be likely to bring it into contact with the overhead wires.

SIGNALS

The erection of the overhead gear considerably altered the sighting of some of the main-line signals, and these had consequently to be rearranged.

As the Morecambe passenger station was being reconstructed at the time the electrification commenced, and the line was being doubled from Morecambe to Hest Bank, advantage was taken of the necessity for new signals to erect a special high signal gantry for the large and complicated junction outside the station, and arrangements were made to prevent any possible danger of contact with the overhead equipment.

As an extra precaution, all rods and signal wires in the electrification area are insulated before entering the boxes or going up the signal posts, and the frames in the boxes are earthed.

TELEGRAPHS AND TELEPHONES

Part of the reason for the equipment of this line was to ascertain what trouble was to be expected from electrostatic and electromagnetic induction between the contact and open telegraph and telephone wires, and partly for this reason no open wires were removed from the side of the line. The ordinary telegraph line is partly screened from interference by the earth wire which runs from gantry to gantry, and on the other side of the line, for about 2½ miles, a separate pole line has been put up upon which two revolved copper telephone circuits and one ordinary telegraph circuit have been erected.

The telegraph wire having been well insulated and connected by an electrostatic voltmeter to earth at various points, numerous observations were taken of the pressure between the wire and earth when trains were running upon the different routes. The normal pressure with no train running, when the wire was tested with a shunted voltmeter, was about 250 volts, but this pressure invariably fell when trains were taking current, and to a considerably greater degree than any fall in the pressure between the contact wire and earth due to the fact of load being on. This is apparently the result of the electrostatic and electromagnetic interferences not being in phase, as of course they would not be unless the power factor were equal to unity.

The above-mentioned pressures must not be taken as absolute, as owing to the small capacity of the wire the use of an electrostatic voltmeter shunted with a resistance at once artificially lowers the effective voltage; by testing the absolute pressure of the telegraph line with a different unshunted voltmeter it was found to be more of the order of 1000 volts.

Experiments were also made with the telegraph wire earthed at both ends, and the electromagnetically induced electromotive force in it, by inserting a Duddell thermo-ammeter, and the results were plotted as curves. Although these only reached small values, they were ample to completely upset most telegraph circuits. Experiments were made to test the efficacy of the method suggested by the engineer of the New York, New Haven and Hartford line to prevent interference, in which a pilot wire on the telegraph poles is put through the primary of a one-to-one transformer and the secondary put in the disturbed telegraph circuit in a reverse direction, and by this means interference with actual telegraph circuits was at once obviated. This method has the strong objection that apparently a separate transformer is required for each circuit, as if one primary and several secondaries are used there is interlinking of the magnetic circuits of the secondaries, and therefore further interference. It is possible that one pilot wire may be introduced in series with several transformer primaries for dealing with various circuits, and as a matter of fact, on this line two circuits on two transformers are now being compensated for by one pilot wire.

The difficulty with regard to telephone circuits is, however, very much greater, owing entirely to the great sensitiveness of the telephone. A twisted telephone circuit is, if equally insulated on each wire, theoretically balanced and noiseless, whatever electrical disturbances are in the neighborhood, but practically it is impossible to twist a telephone circuit symmetrically and maintain its insulation perfectly symmetrical, the result being that from one cause or the other inductive disturbances pass unequally through the telephones at either end.

No difficulty has been experienced in making the experimental telephone circuits silent by putting adjustable leaks from each wire to earth, but adjustment of the leak is required from time to time. This points to the fact that telephone trunk-lines erected near overhead power-lines will require to be maintained at a higher pitch of efficiency and symmetry of position and alignment than is necessary at present. The audible note on the telephones in the Heysham district is of about 175 periods per second.

COST OF CONSTRUCTION

The cost of construction of the overhead equipment of a comparatively short section of railway must vary with some factors which cannot be controlled, particularly the weather, and the traffic which has to be passed while the line is being equipped.

One method of erection that has been considered to avoid this difficulty is to put the overhead wires, droppers, etc., complete, by the side of the line away from the rails in long lengths, such lengths to be pulled over on Sundays; but it will be found that this requires a good deal more space on the side of the line that is usually available, and it is for obvious reasons particularly difficult on a line where there are a large number of level crossings or overbridges.

The Siemens-Schuckert Werke, when erecting the equipment on the Rotterdam-Hague-Scheveningen Railway, adopted the expedient of constructing the overhead equipment complete away from the line, and then bringing it on to the ground in a long train of trucks and hoisting it in position, cutting and re-terminating the catenary wire, of course, to pass over the insulator; but the authors do not gather that this method could be considered to be either very cheap or very satisfactory from the point of view of the final condition of the contact wire.

The Midland equipment was erected unfortunately during the very wet year of 1907. Considerable expense was also entailed due to the fact that the wires had to be erected while the traffic was being run.

POWER-STATION

The existing station supplies power for the machinery and lighting of the harbor at Heysham. The motive plant consists of gas engines using gas from two Mond producers of about 750 h.p. each. These gas-engine sets supply direct current at 460 volts pressure, and all the single-phase current is obtained through two motor generators.

The engine-room originally contained three 250-h.p. three-cylinder Westinghouse engines, driving 150-kw. generators, and a battery having a capacity of 100 kw. for 5 hr. A 350-h.p. 235-kw. Westinghouse set has been added.

The "peak" demands on the station amount for traction to about 1000 kw. direct current on the busiest summer days. The engines are arranged so that whatever the actual load they may be working on previous to peak loads coming on, before the battery is called on to discharge heavily they work up to their full overload capacity, which is about 20 to 25 per cent. The battery is worked through one of two boosters, and during the peaks is called on to work up to its full 1-hr. rate of 750 to 1000 amperes.

In order to make the generators thus take their full share of the peak loads it was found necessary to flatten their characteristics, there being a drop in pressure of about 20 per cent. between half- and full-load currents. To put series coils over the existing shunt coils, which already contained sufficient copper to give with hand rheostatic regulation more than the full pressure at full load, would have been a matter of considerable expense, and one involving also complete dismantling of the machines. An effective alternative at one-fourth of the cost was found in providing each machine with an exciter on which the series coils are connected from an qualizer bar exactly as if they were direct on the generators. These gave precisely similar results to ordinary compound windings, and involved no dismantling; in fact, the whole four machines were fitted in little over a week.

All the peak working and load-equalization is effected on the direct-current bus bars, off which the traction motor generators work, as part of the power load of the station. It is obvious, of course, that this method of working involves some avoidable transformation and light-load running losses, but it has to be remembered that the largest traction peaks require the whole capacity of this very small station to be put at their disposal, and that in this case it was necessary to make the best job possible of adapting existing machines to a new purpose without detriment to their usefulness for the original purpose.

The motor generators were specified to be capable of a continuous output of 150-200 kw. with a temperature rise of 80° F., but they were also called on to be capable of safely carrying output overloads of 900 kw. instantaneous, 600 kw. for $\frac{1}{2}$ min., 500 kw. for $\frac{3}{4}$ min., and 300 kw. for $1\frac{1}{2}$ min., and were required to be tested under a regular cycle of these overloads, with underloads of 75 kw. in between, for 8 hr. The internal driving losses were also required to be kept down, and on the alternating-current side the machines were required to be self-regulating within 6 per cent. on throwing off a non-inductive load equal to the full continuous load, and within 20 per cent. on throwing off a similar but inductive load of 0.8 power factor. Further, they were required, with the assistance of an external regulator if necessary, to restore the pressure to normal within 7 sec. of the coming-on or throwing-off of loads up to 600 kw. at power factors down to 0.3.

The maker's specification of the machines was 175 kw. on continuous rating, and the machines on test were well within the specified temperature rise, but not excessively so. During the running of the trains at Heysham the sets are frequently each subjected to loads up to 900 kw. and smaller overloads of 600, 500 kw., etc., are very frequent. These are carried without any commutator trouble. As regards the alternating-current regulation, on an average, after the switching-on or throwing-off of a heavy load, the voltage is restored to its normal 6600 volts within 5 to 7 sec., with a maximum voltage variation of about 500 to 750 volts each way. Considering the small size of the machines and of the station itself, and the heavy and sudden loads to which they are subjected, this regulation is satisfactory, and it is good enough for the normal traffic conditions of the section. The drop is, however, obviously sufficient to affect for the worse the conditions under which the cars accelerate, particularly during any special tests, such as those of which particulars are given later.

The alternator has a three-phase star winding, so that if one winding breaks down the other two may be used for the single-phase supply; otherwise no use is made of the three-phase connections. It is questionable if the extra winding is really of use.

The exciter has laminated fields and is compound wound, its series winding carrying a portion of the main motor current, so that (so far at least as varying loads of equal power factor are concerned) the tendency of the alternator to drops in volts is thus compensated for.

The external regulator, which compensates for varying power factors, is of a type which inserts or extracts resistance from the circuit of the shunt field of the exciters by the action of solenoids which are respectively excited as the voltage exceeds, or is less than, the normal. The direct-current motor armature and the revolving field magnet of the alternator are carried on the same shaft without any intermediate bearing. There are only two main bearings on the machines, and these are ball-bearings. Some difficulty has been experienced with these bearings owing to expansion caused by the heat generated in the machines. This has been overcome by allowing a small amount of clearance for the balls in the race. Breakage of the balls still takes place occasionally, but is generally attributed to a defect in the material.

The starting current of the machine at 460 volts is only about 75 amperes, and the no-load loss is about 23 kw., with the exciter and alternator fully excited.

ROLLING STOCK

The rolling stock consists of three trains, there being three motor cars, two with equipments by Messrs. Siemens Brothers, and one equipped by the Westinghouse Company. There are also four new trailer cars, and two old bogie compartment coaches have been adapted as trailers.

From the outset it was resolved, in order to make the experiment as complete as possible, to divide the rolling-stock order, but the railway company, for various reasons, the chief of which perhaps was that its standard brake is the vacuum brake, preferred all-electric to electro-pneumatic control gear, hence the major portion of the order was given for Siemens equipments which embodied the former. As the master controllers have to be interchangeable on both motor cars and trailers, these are all of Siemens construction.

The passenger entrance is through the driver's vestibule compartment in all the coaches except the two old ones. Their construction with four entrance doors down each side was considered, but while this would have been useful on several of the busiest days of the year, and particularly on bank holidays, it was not thought that the gain on these few days would justify the extra weight and expense that this construction would have involved. It is noteworthy, however, that the old compartment trailers appear to be the most popular of the coaches with passengers, and that on busy days the time taken to unload and reload the vestibule coaches is very noticeably long. Of course, all three stations are terminal stations, and it must also be remembered that the passengers are more than ordinarily casual and not regular travelers, so that drilling them into habits is practically impossible. Also, at periods of heavy traffic, the flow is nearly always in one direction only.

Lighting is effected from power current, with six lamps in series of 150 volts. There is no objectionable result from the low periodicity, which is imperceptible. The variation of pressure, when trains are started and current is shut off, is seen, but practically no more than on some of the London underground lines. Electric heaters are provided in the motor cars only.

The motor bogies were constructed by the company's locomotive department, and were specially built of rolled

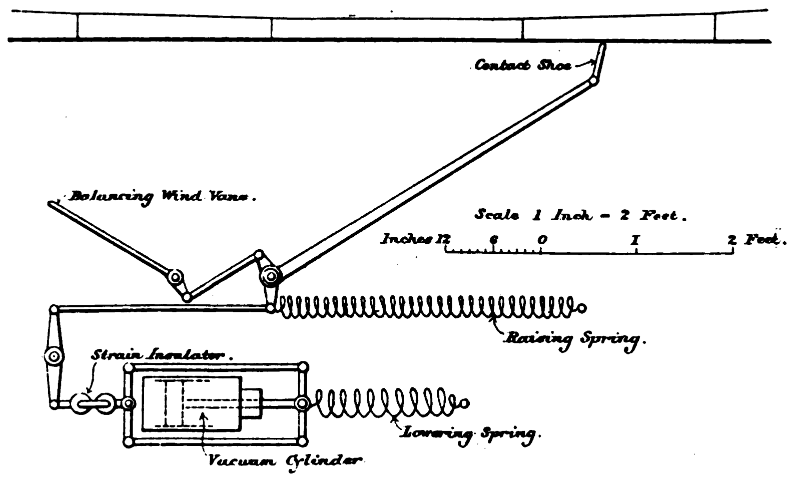


Fig. 4.—SIEMENS BOW

sections and plates. The axles are of forced steel 6¼ in. in diameter, parallel between the wheels and reduced to 4¾ in. in the axle bearing, the length of the journal being 9 in. The wheel-base is 8 ft. 6 in. and the driving wheels are 3 ft. 7½ in. in diameter on the tread when new. As only a few cast-steel wheels were required, an existing tender-wheel pattern was made use of for the wheel-center, and consequently the wheels are heavier than is really necessary, which, however, gives longer life to the tires. The weight of the whole bogie is 6½ tons, the extra weight of the wheels accounting for about 1 ton of this.

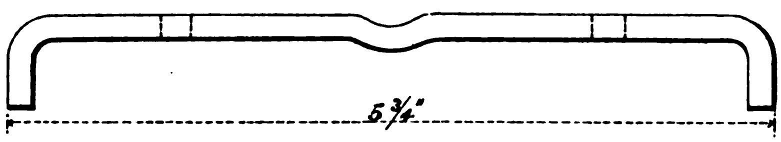


Fig. 5.—WESTINGHOUSE SHOE

Brake Equipment.—As is usual in electric motor trucks, the brakes act only on one side of the wheels, lack of space making it complicated to adopt the standard railway practice of two brake-blocks per wheel. The brakes are vacuum brakes, and it was decided to follow the company's steam practice closely, using no electric valves or electric train line, but simply the usual single train pipe. The brake cylinders are of the piston type with rolling rubber-ring packing and the standard vertical ball valve between train pipe and reservoir side. There are in each case auxiliary reservoirs increasing the cylinder reservoir capacity, as there is an extra long stroke on the piston.

The vacuum is obtained from a pump motor driven with a worm speed-reduction gear running in an oil bath. A single brake pump is used on each motor car. The control gear for the pumps is arranged so as to give a high speed and a low speed, the latter being one-quarter of the higher. The pump runs at the low speed throughout the running of the train, and whether the brakes are being applied or not, except when it is put on to the high speed in order to take off the brakes rapidly. The action thus corresponds exactly with the operation of the large and small ejectors on a locomotive. The driver's brake valve is combined with a switch which operates the contactors controlling the vacuum pump. The two transformer tappings giving the high and low speeds are connected to two contactors between which is a choking coil, so that both may be up at the same time, without any damage resulting. There is thus no dead position on the brake-valve switch, the contact making on the high-speed switch sector before breaking on the low.

There is a driver's brake valve in every driving compartment. Only the valve and switch in that compartment which is being used for driving, and in which the driving feed-plug, which will be referred to again late, is inserted, is operative for starting and varying the speed of the pump; but th brake can be applied by the guard at either end of every coach.

There is fitted to each motor car a switch operated by the vacuum, which will trip all the motor contactors in the event of the vacuum falling below about 15 in. The guard is thus given full control over the train, which is an advantage, seeing that there is only one motorman; and this switch also ensures that motormen cannot start the train before taking off their brakes.

Bows.—The Siemens cars are provided with two collector bows in order to ensure continuous contact as far as possible. It was found impossible to get the firm's standard bow into the restricted space at disposal between the coach roof and overbridges, and a bow has been adopted which is somewhat similar to the Continental tramway type of bow, but has a small auxiliary bow with an aluminium wearing strip at the end, controlled by parallel motion, as shown in Fig. 4. This bow, while appearing to be somewhat simpler than the standard bow, requiring less room, and being fairly satisfactory in working, has the disadvantage that it requires balancing by a wind screen.

The Westinghouse bow is of that firm's standard pantograph type, a single bow only being used, and this goes into the available space fairly well. The wearing shoe is of galvanized sheet iron, of the section shown in Fig. 5, being maintained in position by springs fixed to the pantograph arms.

The authors' experience tends to show that from the point of view of the car equipment one bow is sufficient, and as regards frictional wear on the overhead wire, one is obviously better than two. It is also simpler and cheaper.

In both bows the frame carrying the contact strip is extended at the ends in a line approximately parallel to the structure gauge. This construction was adopted to allow of any excessive rolling on the coaches, especially under low bridges, where the wire usually has to be at the limiting distance from the center of the track horizontally. The actual contact strips are, of course, themselves long enough to remain in contact with the overhead wire in all normal circumstances. The construction of the bow-ends to the structure gauge curve obviously makes the bow move to the structure gauge at the side on which the wire is placed during the rolling of the coach. In fact, the provision of a second wire at the other side would, in many instances, so fend the wire off as to enable many low bridges to be got through without any danger of the bows coming too near the structure.

In both makers' bows the whole bow frame is "alive," that of the Siemens bow being mounted on ordinary vertical insulators, while the Westinghouse one is mounted in barrel insulators forming the bearings for the cross-shafts of the pantograph.

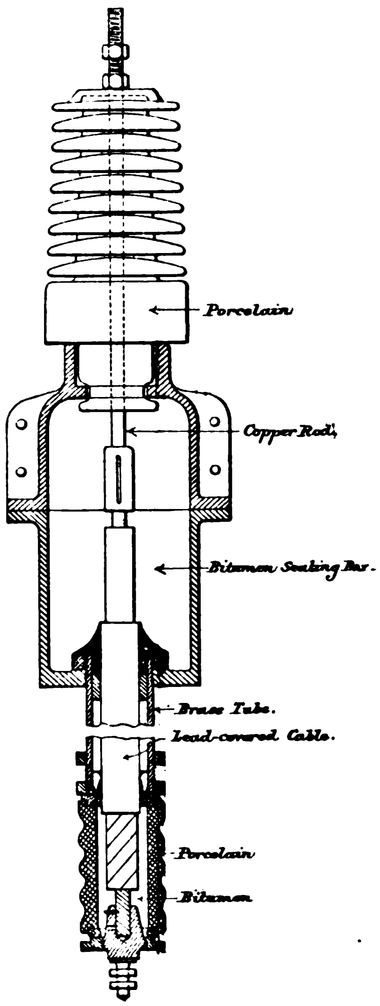


Fig. 6.—HIGH-TENSION CABLE-HEAD

Both bows are purely spring controlled. The Siemens bow, however, is lowered by a master spring, which can be thrown out of action by a vacuum cylinder, whereas the Westinghouse actuating spring is controlled and the bow is lowered by compressed air, there being on this car a special compressor installed for use in connection with this and the control gear. Thus the normal position of the Siemens bow is down, and that of the Westinghouse is up. The former is preferable.

A small hand-pump is used in each case for raising the bows when first starting out in the morning or at similar times when no compressed air or vacuum is available.

The two Siemens bows can be raised or lowered separately, and the vacuum for holding them up is obtained from the train pipe through a ball valve, so that when the brakes are operated the vacuum remains on the bows.

For protection in the event of an accident bringing down the overhead line, the roofs of all the vehicles are covered with stout wire-netting, thoroughly earthed with heavy copper wire running the whole length of the roof. This, it is considered, is better than the sheet-metal sheathing adopted in some other cases, as it obviates the necessity for the laborious and somewhat unreliable soldering of the joints between the sheets, and leaves the canvas of the roof free for the ordinary inspection. If sheet metal be used, any pin-holes that may be unnoticed leave room for the entrance and lodgment of moisture, which will not readily evaporate, but will remain to rot the wood and canvas of the roof. This netting has been tested under actual conditions of accident several times and has proved adequate, never having failed to bring out the station circuit-breakers immediately. Although on one occasion one strand of the netting was burned away for about ¼ in. of its length, the canvas roof-covering below was quite unharmed. The authors consider that this result shows conclusively that the use of overhead conductors at high pressure does not involve any fire risk such as exists (and has more than once been exemplified) when the conductor is fixed on the ground.

Connections. — The high-tension wiring on the cars was originally carried in lead-covered cable, protected on the roof with a further metal covering. It was carried down about the center of the car through a brass tube of heavy section, the lead covering of the cable being sweated at the top on to this tube, which was substantially earthed.

The further high-tension wiring to the two transformers was also in lead-covered cable, which again in its turn was protected in metal tubing, both heavily earthed. The cables are rubber-insulated.

Except for the short length down

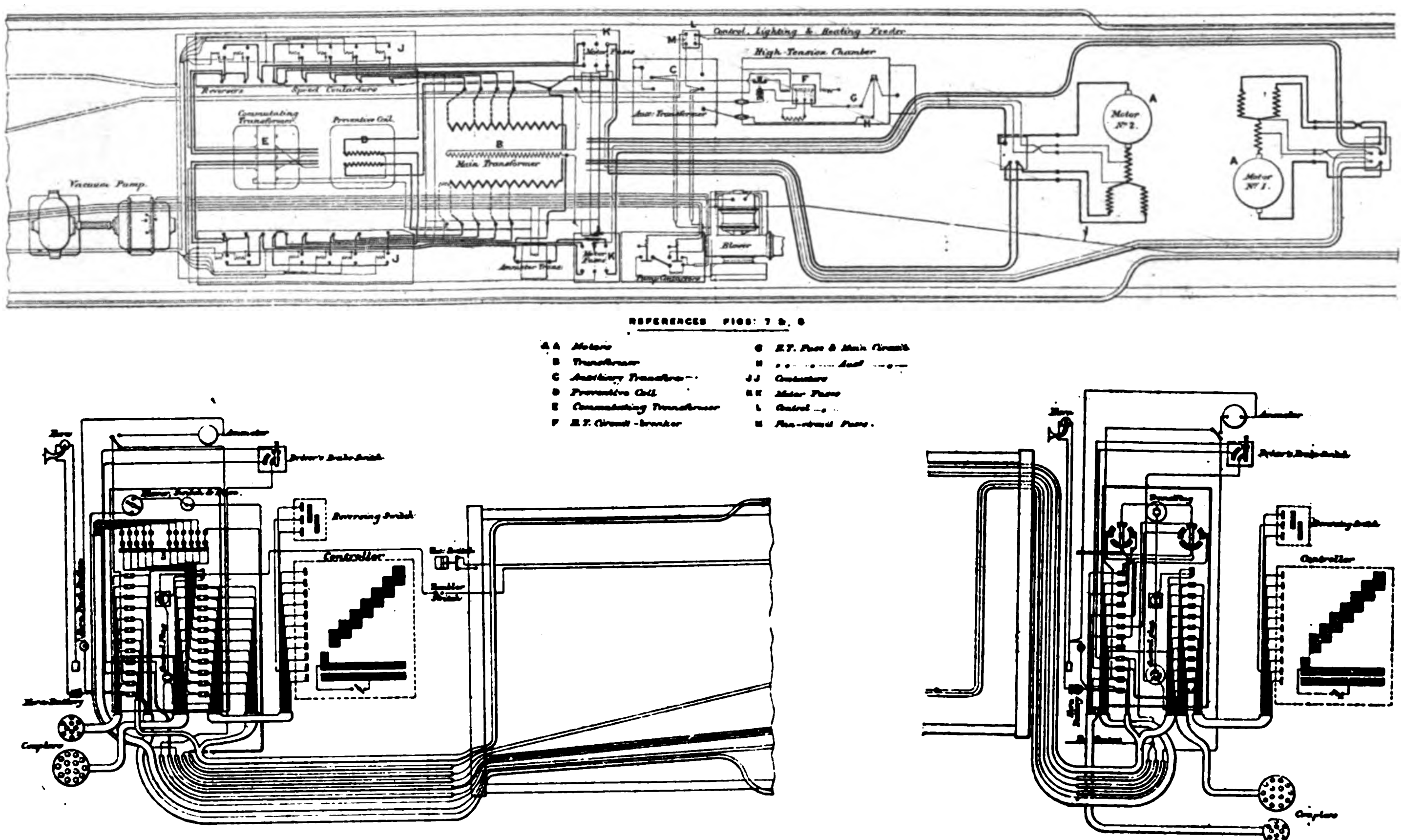


Fig. 7.—DIAGRAM OF CONNECTIONS OF SIEMENS CAR

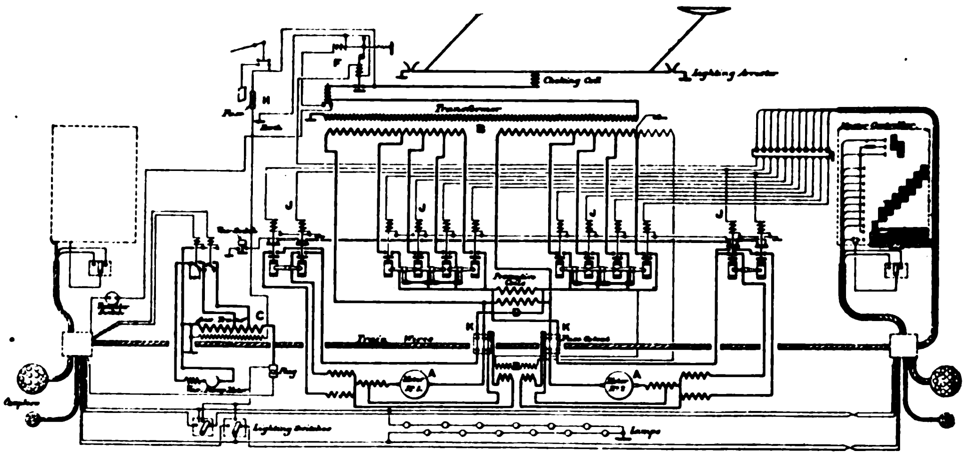


Fig. 8.—WIRING DIAGRAM FOR SIEMENS CAR

through the coach, the high-tension wiring is, from the bow down through the high-tension chamber to the main transformer, now changed to all bare wire, carried on porcelain insulators on the coach roof and underneath the coach. The vertical tube through the coach itself is of brass, and is removable, being practically part of the wiring. The cable is paper-insulated and lead-covered, terminating above and below in bitumen sealing chambers with porcelain insulator terminations. Fig. 6 shows a section of the tube complete. There is about 3/16 in. air space between the lead covering and the inside of the tube. The reasons for this change will be stated later; it may be pointed out here, however, that there is now no portion of the high-tension circuit which cannot be removed and repaired within a few minutes, and though no trouble has been experienced on the Westinghouse car with the rubber cable, except one slight failure at a termination due to damp, the high-tension wiring of this car has also been altered.

On the Siemens cars the door of the high-tension chamber is mechanically interlocked with the bows, so that it cannot be opened unless the bows are down.

The low-tension wiring of both types of car is carried longitudinally between the two girders forming the center members of the underframe, and it is supported between these two members in wooden frames spaced about 18 in. apart. The low-tension cables themselves are not carried in metal tubing, as probably eddy-current troubles would arise if they were; but they are substantially surrounded with metal, and the coach body and its frames are all covered with sheet iron and asbestos wherever cables are run underneath. Where these cables require to go crosswise they are carried between the tops of the girders and the floor and spread out fanwise. The train cable is carried along the outside of the coach alongside the sole-bar, in a metal tube, being carried round the bends in flexible metallic tubing.

Figs. 7 and 9 show, respectively, the Siemens and Westinghouse equipments.

The contactors of the latter equipment are electro-pneumatically operated, as are also the raising, lowering and locking gear of the bow, and to supply these parts a small compressor L is installed in addition to the vacuum pump. In any future similar case no doubt this compressor could be embodied with the vacuum pump.

As already indicated, the two equipments were specified to be worked from the same master controllers, and, though some obstacles had to be overcome, this has been done successfully.

Beyond the bow collecting gear, the disposal of the high-tension wiring, which has already been described, and the disposal of the transformers, there is no substantial difference between the construction and operation of single-phase rolling stock and the better-known direct-current apparatus. Tracing the course of the circuits,

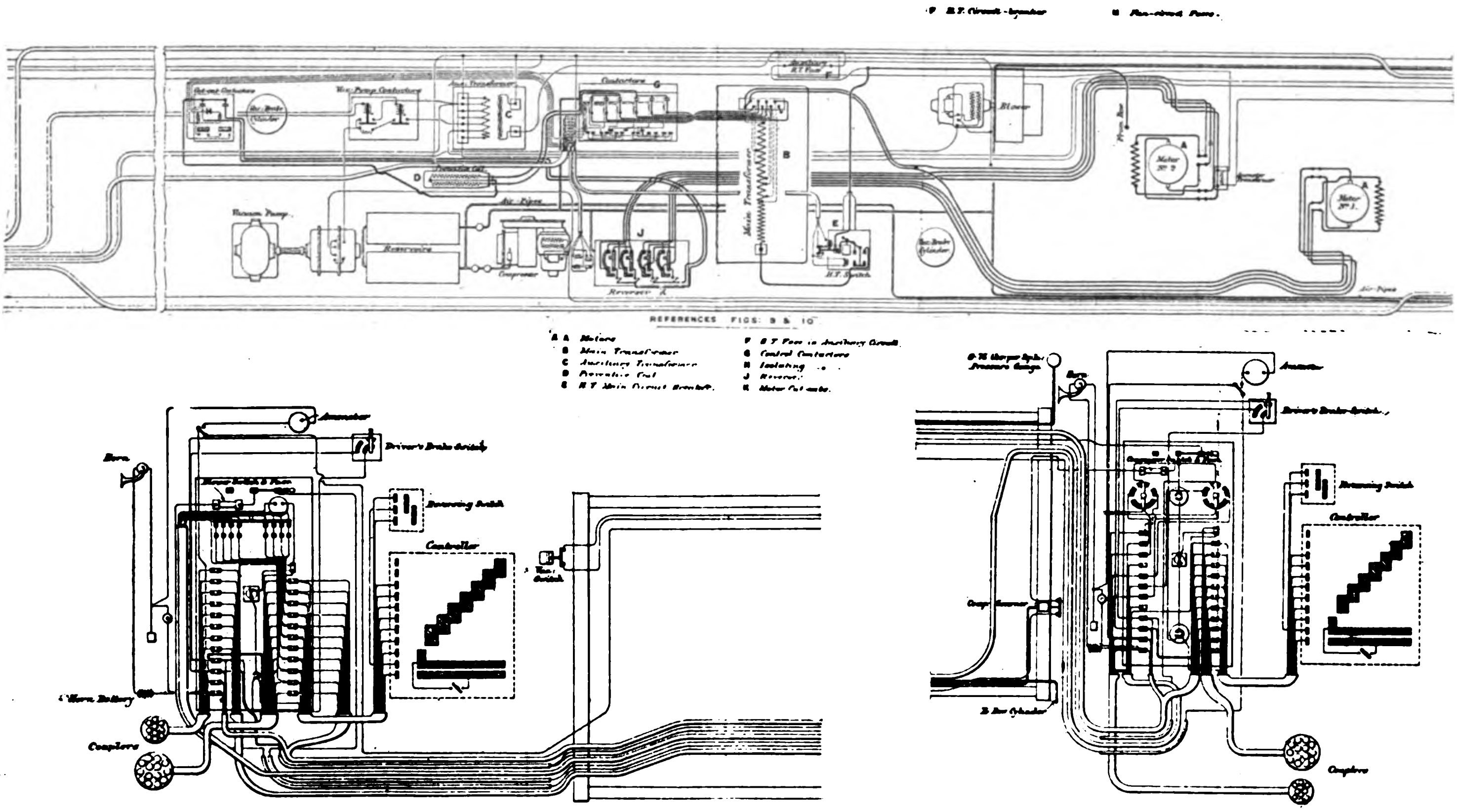


Fig. 9.—DIAGRAM OF CONNECTIONS OF WESTINGHOUSE CAR

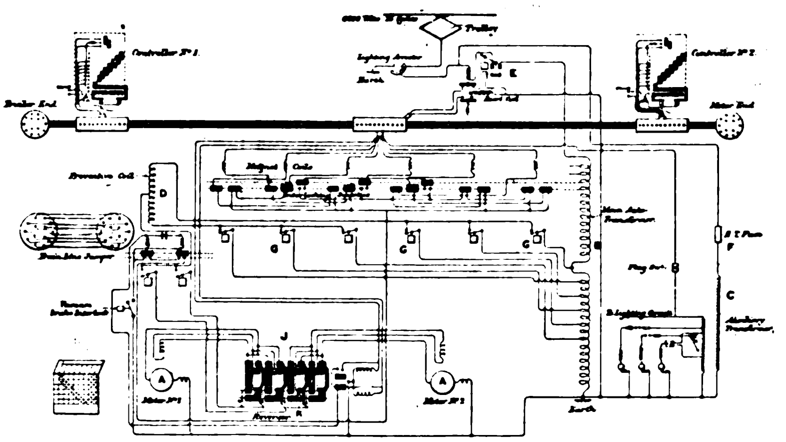


Fig. 10.—WIRING DIAGRAM FOR WESTINGHOUSE CAR

however, it will be seen that the current proceeds from the collector on the roof through the lightning-arrester coil and through the high-tension circuit-breaker to the main transformer, a loop being taken off on the live side of the latter to the auxiliary transformer. This last feeds current at 150 volts to the main train wire from which all the contactors are worked.

The high-tension circuit-breaker is in each case an oil-switch, the Westinghouse being a standard switch similar to that used on the switchboard. The Siemens switch is a three-prong one, which in closing makes first of all, for an instant, the circuit to the main transformer through a resistance, this being intended to "charge" the transformer and obviate surge currents. Relying on this device as a means of obviating surges, the Siemens car was originally arranged so that the main transformer was

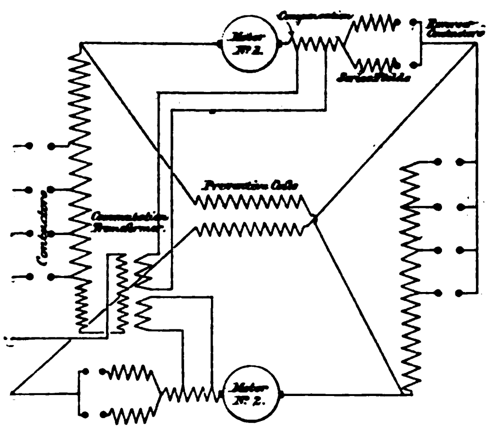


Fig. 12.—CONNECTION OF SIEMENS CONTACTORS

switched off at each interruption of driving current, which to some little extent saves magnetizing current losses and keeps down the temperature of the transformer. This arrangement was abandoned for reasons given later.

The Westinghouse high-tension main circuit has always been arranged to be closed so long as the car was in service, and it is opened and closed by means of a small switch, as is now the Siemens one. Both switches are actuated from the 150-volt current obtained from the auxiliary transformer, and they have both overload devices, which for reclosing necessitate the motorman returning his controller to the zero position and again notching up.

The Siemens transformers are all oil-cooled, as are also the Westinghouse main and auxiliary transformers. The Westinghouse preventive coil transformer is, however, air-cooled.

Passing from the main transformer, the Westinghouse reverser is shown at J. It is a standard throw-over reverser without an "off" position so far as the train line is concerned. The switches shown at H have been inserted so as to provide a second circuit-breaking point in the motor circuits additional to the contactors, as a safeguard in the event of one of the latter sticking up, which, however, has never happened on this car. These switches also obviate the possibility of the motors generating when the car is being hauled. Until their insertion this sometimes happened if the reverser was not thrown over or the cut-outs removed, and was a source of some perplexity to engine-drivers once or twice.

The contactors on this car are shown at G and are in two groups, one of each of which goes up alternately, their connection being as shown in Figs. 10 and 12. The driving current passes from the two tappings of the transformer through the two halves to the middle point of the preventive coil, shown at D, and thence to the motors. The contactors in each of the two groups are electrically interlocked, so that no two of a group can be up together, the preventive coil choking any current tending to pass between the two that are up. There are five running notches, and consequently six contactors, on this car.

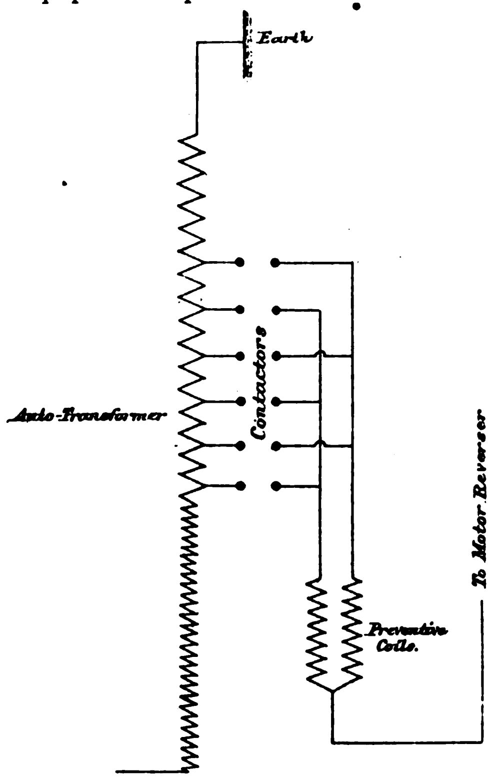
In the Siemens cars the reversers are of the contactor type, and the transformer secondary is in two halves, each giving the full motor voltage, the connections being as shown in Fig. 8. As in the Westinghouse case, the speed contactors are divided into two groups, the individual members of each group being so interlocked that no two can be up together. The interlocking in this case is mechanical.

As will be best seen from Fig. 11, the two transformer secondaries and the two motors are all in series, being alternated with each other, however, so that the potential on similar portions of the motors is approximately the same.

Reversal is effected in the Siemens motors not by reversing the direction of the field current, but by connecting to different portions of the field winding; hence only simple switch-type contactors, two in number per motor, are required.

Current passes from one of the transformer secondaries to the common bar of one group of contactors, through one of the latter, thence through one of the reversers to the motor; it then passes through the second secondary, and through a contactor of the other group to its common bar, thence through the reverser of the second motor to the latter, and back to the first secondary.

The tappings on the two groups of secondary windings are different in pressure, and, as will be seen from Fig. 11, the two windings of the preventive coil are connected across points of the motors which should be equipotential points. Hence the two



CONNECTION OF WESTINGHOUSE CONTACTORS

preventive coil windings equalize the voltage on the two motors by their mutual inductance, the one giving half the difference of potential in a direction to reduce the potential of the higher tapping, and the other having induced in it similarly half the difference in the direction to increase the pressure of the lower tapping. Hence the preventive coil in this case does not carry the whole current, except when one motor is not in action.

The purpose of the extension at one end of one of the secondary windings and of the tapping into the motor compensating winding, shown on the full diagram, Fig. 8, will be dealt with in describing the motor.

It will be seen that though the two methods of control are radically different, they are operated by the same master controller, except that there are seven running notches on the Siemens cars as against the five of the Westinghouse. In running the two types of car together in one train the fifth notch is not passed.

The Westinghouse motors work in parallel, and in order to disconnect one, the links shown at K, Fig. 9, are thrown out. The disconnection of a motor of the Siemens car is accomplished by throwing out its fuses, shown at K, Fig. 7.

The auxiliary transformers have

three tappings, namely, 150 volts for the control circuits, lighting and heating, 100 volts for the high speed of the vacuum pump motor, and 50 volts for the low speed of the latter.

The auxiliary transformers were adopted chiefly in connection with the intended working of the Siemens main transformer, which has now been modified, and with a view to keep the lights independent of the working of the latter, particularly should the overload circuit-breaker be thrown out, or should any other trouble occur affecting it.

Experience of the working of the cars, however, shows, in the authors' opinion, that the arrangement of the transformers and of the circuit-breakers is capable of being revised for the better and simpler, and that the auxiliary transformer could be dispensed with, leading the high-tension wiring into the main transformer, and from its low-tension side taking off all necessary tappings, with resulting simplification and lightening of the equipments.

The forced ventilation for the motors of both sets of cars has been fairly simple to arrange, and the taking of the air from the outside is quite satisfactory. The power required by the fan motor for this particular service is 1.1 kw. in the Westinghouse and ¾ kw. in the Siemens car. For a heavier service more air would be provided, particularly on Siemens cars.

[*To be continued.*]

The Three-Voltage Rating of Mazda Lamps

The Mazda incandescent lamp, when operated at an efficiency of 1.25 watts per c-p., has proven itself far more economical than either carbon, gem or tantalum lamps on all cost of energy above a few cents per kw-hr. There are some cases, however, in which the cost of energy per kw-hr. is very low, perhaps a small fraction of a cent, and where a cheaper and less efficient lamp may show greater economy in operating expense than the Mazda lamp operated at 1.25 watts per c-p. The somewhat higher renewal expense of the latter lamp at this efficiency may not be counterbalanced by even a great reduction in the amount of current used where the current is cheap, and since the Mazda incandescent lamp is inherently of higher efficiency and quality, the question of its economical application to any particular case merely depends upon its operation at the correct efficiency.

In the case just cited a small sacrifice in efficiency of the Mazda lamp could be made in order to reduce the renewal expense and thus secure greater economy than could be obtained with the other types of lamps even on very cheap power. Also, besides the actual saving in current made possible through the use of the Mazda lamp, there is the very important possibility of releasing generating capacity, which even where the operating cost is low, may often be of great value. This point should not be overlooked in deciding the relative economy of high efficiency versus low efficiency lamps.

The incandescent lamp manufacturers have recently made a radical change in their methods of rating these lamps, in order that they could be used with greater economy under those certain conditions, where heretofore their cost of operating exceeded that of a less efficient type of lamp which is valuable in cases where the cost of electrical energy is low. The

TABLE NO. I

TABLE SHOWING TOTAL COST OF PRODUCING LIGHT WITH TUNGSTEN LAMPS AT TOP, MIDDLE AND BOTTOM VOLTAGES OR VARIOUS COSTS OF POWER

Nominal watts	25			40			60		
Nominal c. p.	20			32			48		
Voltage	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Watts per candle	1.33	1.39	1.45	1.25	1.30	1.35	1.20	1.25	1.30
Actual watts	25.0	24.2	23.3	40.0	38.9	37.8	60.0	58.0	56.5
Actual c. p.	18.8	17.4	16.1	32.0	29.9	28.0	50.0	46.5	43.5
Total lumens	184.2	170.5	157.8	309.8	289.4	271.0	490.0	455.7	426.3
Lumens per watt	736	7.05	6.77	7.74	7.44	7.17	8.16	7.86	7.54
Hours life	1000	1300	1700	1000	1300	1700	1000	1300	1700
Kwhs. cons. per 1000 hr	25.0	24.2	23.3	40.0	58.9	37.8	60.0	58.0	56.5
Cost of Frosted Lamp	$0.75	$0.75	$0.75	$0.85	$0.85	$0.85	$1.17	$1.17	$1.17
Lamp renewals p. 1000 hrs.	.75	.58	.44	.85	.65	.50	1.17	.90	.69
Nominal watts	100			150			250		
Nominal c. p.	80			120			200		
Voltage	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Watts per candle	1.20	1.25	1.30	1.20	1.25	1.30	1.15	1.20	1.25
Actual watts	100	98.0	92.4	150	145.5	141.2	250	242.5	235
Actual c. p.	83.3	77.6	72.4	125	116.4	108.6	217.3	202.0	188.0
Total lumens	816	760	710	1225	1141	1064	2104	1954	1819
Lumens per watt	8.16	7.76	7.54	8.17	7.84	7.54	8.41	8.05	7.74
Hours life	1000	1300	1700	1000	1300	1700	1000	1300	1700
Kwh. cons. per 1000 hrs	100	98.0	94.2	150	145.5	141.2	250	242.5	235
Cost of Frosted Lamp	$1.55	$1.55	$1.55	$2.25	$2.25	$2.25	$3.20	$3.20	$3.20
Lamp renewals p. 1000 hrs.	1.55	1.19	.91	2.25	1.73	1.32	3.20	2.46	1.88

COMBINED COST OF POWER AND LAMP RENEWALS PER 100,000 LUMEN HOURS IN DOLLARS

VARIABLE COST OF	1	$ .54	$ .48	$ .43	$ .40	$ .36	$ .32	$ .36	$ .32	$ .29
POWER CENTS PER	2	.68	.62	.57	.53	.49	.46	.48	.45	.43
K. W. H.	3	.81	.76	.72	.66	.63	.60	.61	.58	.56
	4	.95	.90	.87	.79	.76	.74	.73	.71	.69
	5	1.09	1.04	1.02	.92	.90	.88	.85	.83	.82
	6	1.22	1.18	1.17	1.05	1.03	1.02	.97	.96	.96
	8	1.49	1.47	1.46	1.31	1.30	1.30	1.22	1.22	1.22
	10	1.75	1.75	1.76	1.57	1.57	1.58	1.46	1.47	1.49
	12	2.03	2.04	2.05	1.82	1.84	1.86	1.71	1.72	1.75
	16	2.57	2.59	2.64	2.34	2.37	2.42	2.20	2.23	2.28
	20	3.12	3.16	3.28	2.86	2.91	2.97	2.69	2.74	2.81
VARIABLE COST OF	1	$ .31	$ .29	$ .26	$ .31	$ .28	$ .26	$ .27	$ .25	$ .23
POWER CENTS PER	2	.44	.41	.39	.43	.41	.39	.39	.37	.36
K. W. H.	3	.56	.54	.52	.55	.53	.52	.51	.50	.49
	4	.68	.67	.66	.67	.66	.65	.63	.62	.62
	5	.80	.80	.79	.80	.79	.79	.76	.75	.75
	6	.93	.93	.92	.91	.92	.92	.86	.87	.88
	8	1.17	1.19	1.19	1.16	1.17	1.19	1.10	1.12	1.14
	10	1.42	1.45	1.46	1.41	1.43	1.45	1.34	1.36	1.40
	12	1.66	1.70	1.72	1.65	1.68	1.72	1.58	1.62	1.65
	16	2.15	2.22	2.25	2.14	2.19	2.25	2.05	2.11	2.17
	20	2.64	2.73	2.78	2.63	2.70	2.88	2.53	2.67	2.69

REDUCTION FACTOR: 25-60-100-150 WATT LAMPS = 78%.
40-250 " " = 77%

new method of rating called the "three-voltage plan" is based upon the fact that for any given set of conditions, depending upon the cost of energy and cost of lamp, there is one particular efficiency and life at which it is most economical to operate a given lamp. Each Mazda lamp is labeled with three voltages two volts apart, as for example:

114
112
110

called top, middle, and bottom voltage respectively. This method of rating makes it possible for a customer to select the particular efficiency of lamp he wishes to use by specifying that either the top, middle, or bottom voltage, as the case may be, should be the same as that of his lighting circuits.

When burned at top voltage the Mazda lamp has the highest efficiency or consumes the least energy for the light produced, and gives life of 1000 hr. At middle voltage more energy is consumed per candle-power produced and the life is lengthened (due to operation at a lower temperature) to 1300 hr. At bottom voltage the lamp is operated at lowest efficiency and gives a life of 1700 hr. It is obvious that the relative cost of lamp and energy will determine the most economical life and efficiency, since if energy is cheap the saving in energy obtained by operating the lamp at high efficiency is not sufficient to counterbalance the higher resulting renewal expense. On the other hand, if energy is relatively expensive, then it will be desirable to operate the lamp at a high efficiency, since the saving in current at the higher rate will more than pay for the increase in renewal expense.

The efficiency of the different sizes of lamps at top voltage is not the same, since the larger lamps are relatively longer lived than the smaller ones, and, in order to give all sizes a uniform life of 1000 hr. at the top voltage, it was necessary to operate the 25-watt lamp at 1.33 watts per c-p., the 40-watt lamp at 1.25 watts per c-p., the 60, 100, and 150-watt lamps at 120 watts per c-p., and the 250-watt lamp at 1.15 watts per c-p. The advantage of the new plan will be apparent by referring to the table No. 1 showing the cost of producing light with Mazda lamps. This table is based on list price of bowl-frosted Mazdas, and shows the total cost of operating the several sizes at top, middle, and bottom voltage with costs of energy from one cent to 20 cents per kw-hr. The total cost given in the table includes the cost of the energy consumed and the renewal expense involved in the production of a quantity of light equivalent to 100,000 lumen hours (which is equal to about 10,200 mean horizontal candle hours in the case of the Mazda lamp).

In order to see how the most economical efficiency varies with the cost of energy refer to table No. 1 and consider, for example, the cost of producing 100,000 lumen hours with a 60-watt Mazda at the top, middle, and bottom voltage with energy varying from one cent to 20 cents per kw-hr. With the 60-watt lamp, and with energy at one cent per kw-hr., 100,000 lumen hours can be produced most cheaply if the lamp is operated at the bottom voltage. The difference between the cost at top and bottom voltage with this cost of energy being about 19 per cent. At 5-cent energy the bottom voltage is still the cheapest, but is now only about 3 per cent. cheaper than at top voltage. At 8 cents per kw-hr. the top and middle voltages are as cheap as the bottom voltage, and above 8 cents the top voltage is the most economical.

When the per cent. saving possible to obtain by operation at bottom voltage is slight, as, for example, is the case just considered with energy above 5 cents per kw-hr., it is far better to use the lamps at top voltage and thus secure not only a better quality of light, but more light from a lamp of a given size as well. The greatest benefit can be derived from the three-voltage plan, however, on the low costs of energy, where operation at bottom voltage will then show economy for the Mazda lamps over either carbon, gem, or tantalum down to energy costs as low as 0.2 kw-hr.

Table No. 2 shows the comparative cost of producing 100,000 lumen hours with carbon, gem, tantalum and Mazda lamps with costs of energy from 0.2 cents to one cent per kw-hr. This table is based on conservative total life values of the carbon and gem lamps in place of the usual useful life, since practically all lamps are left in service until ultimately burned out, rather than till they drop to 80 per cent. of initial candle-power. The Mazda lamps have all been taken at bottom voltage, and the gem lamp has been figured in the same way, as this is the most economical voltage for such low costs of energy. The average candle-power and watts during the life values shown have been taken in every case rather than the initial values. This has been done because the Mazda lamp maintains its candle-power much better than the other types, which is a distinct advantage in its favor and should be considered in comparing it with other types of lamps. The costs of lamps taken in this table are those for clear lamps in standard package quantity.

For energy costs above 5 or 6 cents any percentage saving that it is possible to obtain by operating the Mazda lamps at other than top voltage becomes so small as to be negligible in comparison with the better quality of light obtained at the higher voltage. Only in those cases where energy is very cheap should anything but top voltage be seriously considered. For ordinary use on central-station circuits on the usual central-station rates, top voltage should always be used. The prime object of the three-voltage plan, as applied to Mazda lamps, was to widen the field of its commercial application by making it competitive with the cheaper and less efficient lamps on low cost of energy.

TABLE NO. 2

COMPARATIVE COST OF 100,000 LUMEN HOURS, CARBON, GEM, TANTALUM, TUNGSTEN LAMPS, WITH ENERGY BELOW 1c. PER K. W. H.

Rating		Carbon 16 cp. 3.1 w.p.c.	Carbon 16 cp. 3.5 w.p.c.	Gem 20 cp. Btm. Vltge	Tantalum 20 cp. 2 wpc d. c.	Tungsten 25 w. Bottom Voltage	Tungsten 40 w. Bottom Voltage	Tungsten 60 w. Bottom Voltage	Tungsten 100 w. Bottom Voltage	Tungsten 150 w. Bottom Voltage	Tungsten 250 w. Bottom Voltage
Actual initial c.p.		16	16	16.7	20	16.1	28.0	43.5	72.4	108.6	188.0
Actual initial watts		49.6	56	47.3	40.0	23.3	37.8	56.5	94.2	141.2	235.0
Nominal w.p.c.		3.1	3.5	2.83	2.00	1.45	1.35	1.30	1.30	1.30	1.25
Hours life		800	1700	1450	1200	1700	1700	1700	1700	1700	1700
Ave. c.p. during life		13.20	13.06	14.00	21.66	16.46	28.30	42.60	71.50	107.2	179.7
Ave. watts during life		48.6	54.9	40.2	41.0	23.9	38.6	55.6	92.6	138.8	241.3
Reduction factor		82.5	82.5	82.5	79.0	78	77	78	78	78	77
Lumens		138	135	145	215	161	274	417	701	1051	1739
Cost of lamp std. pkg.		$.18	$.18	$.225	$.405	$.567	$.648	$.891	$1.175	$1.701	$2.430
Cost of Power Cents Per K. W. H.	.2c.	$.233	$.160	$.162	$.195	$.237	$.167	$.152	$.125	$.122	$.110
	.3	.269	.200	.190	.214	.252	.181	.166	.138	.135	.124
	.4	.303	.241	.218	.233	.266	.196	.179	.151	.148	.138
	.5	.339	.282	.246	.253	.281	.210	.192	.165	.161	.152
	.6	.374	.323	.273	.272	.296	.224	.206	.178	.175	.166
	.8	.445	.404	.329	.310	.326	.252	.232	.204	.201	.193
	1.0	.515	.485	.384	.348	.355	.280	.259	.231	.207	.221

The Non-Condensing Steam Turbine Plant of the Milwaukee Electric Railway and Light Co.

By C. J. DAVIDSON

Chief Engineer of Power Plants, the Milwaukee Electric Railway and Light Co

It is seldom that a non-condensing turbo-generator plant of 4500 kw. capacity is designed to operate against the back pressure of 7 lb. gauge or 22 lb. absolute resulting from an exhaust steam heating plant. Such a plant is in operation in Milwaukee, and aside from the unusual facts mentioned above, there are operating features, and conditions under which it was installed, that add to its interest.

The Milwaukee Electric Railway and Light Company built what is known as the Public Service Building in the heart of the business district of the city. This building is used as a terminal station and waiting-room for the various interurban street railway systems entering the city and for the general offices of the company. After complete plans of the building had been made and work on the structure itself far advanced, a contract was entered into to furnish exhaust steam to the Milwaukee Central Heating Company for its steam-heating system, and it became necessary to provide for a large and varying supply of exhaust steam. The company had two power plants, one of which it was not deemed practicable or desirable to use at all, and it did not seem wise to rely entirely upon the other. If this latter plant had been used for the entire supply, it would have been necessary to install additional non-condensing equipment or to decrease the efficiency of the plant by operating more of the condensing apparatus non-condensing.

Under these conditions, the president and general manager, John I. Beggs, conceived the idea of the equipment which is here described. So, instead of dividing the additional load between the two existing plants, an entirely new plant was designed and installed in the basement of the Public Service building, which would handle the peak electrical load and at the same time carry the heating load. The details of the electrical equipment and switchboard were worked out by Mr. O. M. Rau, while the writer had charge of the steam apparatus installation.

It would not ordinarily seem advisable to have so large an investment in non-condensing machinery which must necessarily be idle for a portion of the year, and which could be used in an emergency during this time only at a great sacrifice in the economy of the plant operation. In every lighting system, however, there is some portion of the generating capacity which stands idle for a large part of every day. At certain seasons of the year the hours of use are very short; but the plant must be maintained to meet the peak load of the year in the winter season. This plant contains the extra equipment necessary to provide for that peak load and is installed where the exhaust steam can be used to the best advantage. With these considerations in mind, it can be seen that the selection of this type of plant was justified.

Due to the fact that the building was nearly completed before the advisability of the installation of the plant was determined upon, no provision had been made for bringing in heavy machinery; therefore, it was necessary to lower all apparatus through an elevator shaft at the rear of the building. Once in the basement it had to be moved about 200 ft. and erected without cranes.

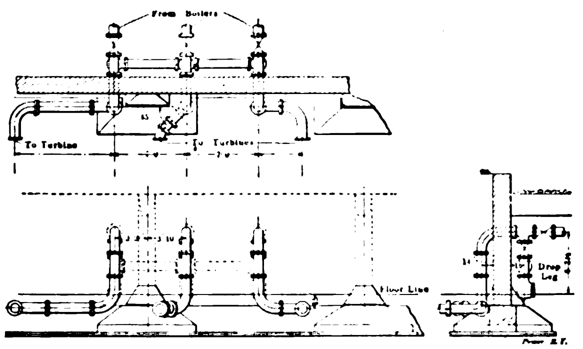
The installation is a simple non-condensing steam plant consisting of boilers, heaters, feed pumps, generating units and the switchboard. Practically all the auxiliary apparatus is used in connection with the office building rather than with the generating plant.

BOILER ROOM

The fuel generally used is Youghiogheny screenings, which is delivered to the plant by wagons and dumped through chutes to the storage bins immediately beneath the sidewalk, having a capacity of about 2000 tons. As the coal bunkers are directly in front of the boiler and very close to the firing aisle, no coal conveyors are required. Ashes are wheeled to a motor-driven hoist which delivers them to the street level and deposits them in cars.

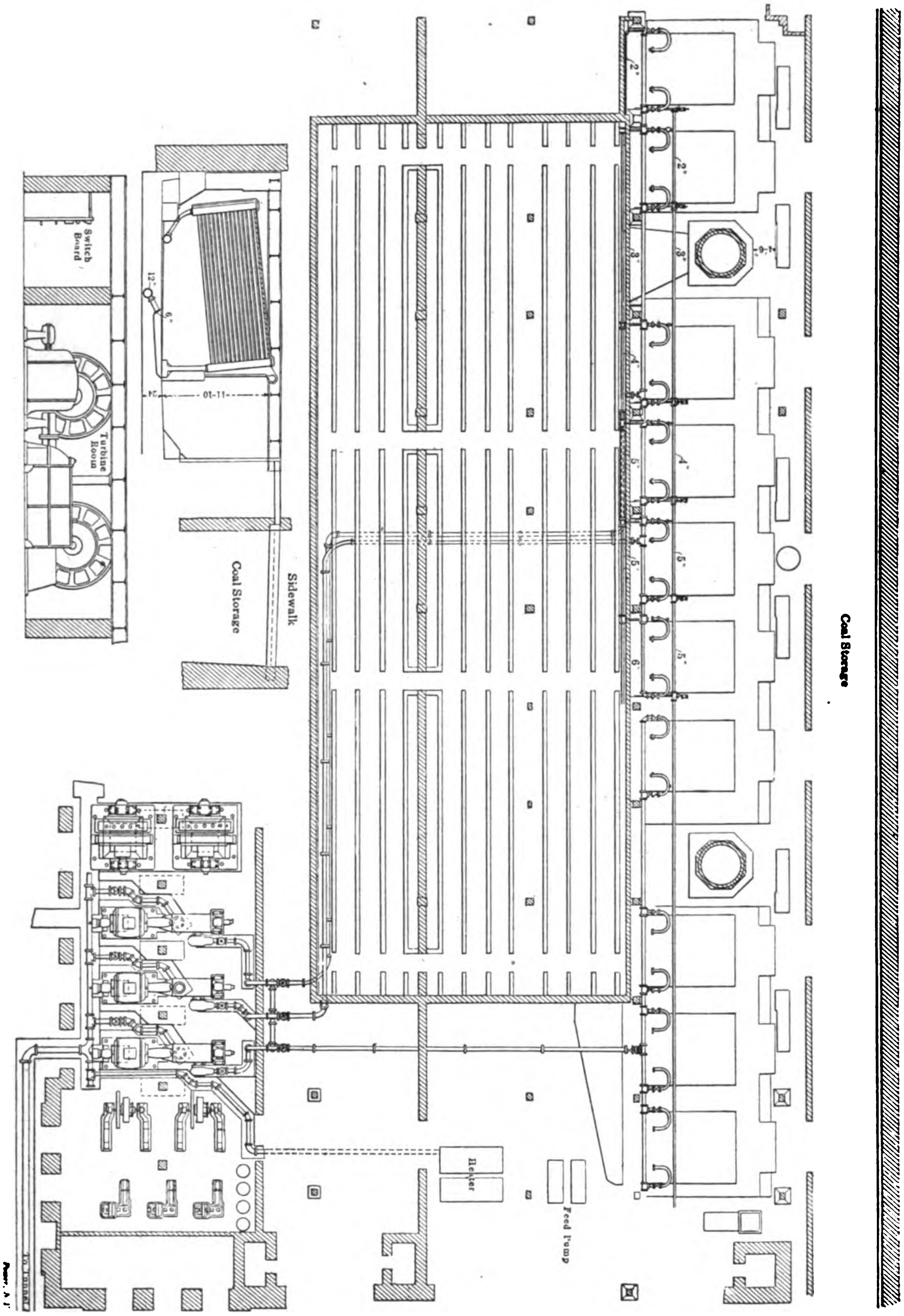
Due to the fact that the foundations of the walls and columns of the building were of such a character that little excavating could be done, only 11 ft. 10 in. head room could be obtained between the floor of the boiler-room and the I-beams of the ceiling. By arranging the highest points of the boilers between the I-beams it was possible to install the equipment.

The steam-generating equipment consists of 10 special EdgeMoor water-tube boilers, each rated at 400 h.p. on a basis of 10 sq. ft. of heating surface per horse power when neglecting 1500 sq. ft. of superheating surface in the tubes above the water line. Under actual operating conditions these boilers have shown a capacity of 530 h.p. Due to existing conditions it was necessary to make some modification in the boilers to fit them for the building. No steam drums are used. The handhole plates are made up with asbestos gaskets above the water line, as a superheat of some 30 to 50 degrees is obtained in the upper tubes, and with lead gaskets below. Because of the interference of the foundations it was necessary to carry the mud drums forward from the rear header. These are fitted with two 2-in. Chapman gate valves in series on each end. The feed water enters each end of the mud drum through Squires feed-water regulators.



STEAM LEADER MANIFOLD BETWEEN BOILERS AND TURBINES

One of the most interesting features of the boiler setting is an arrangement whereby much of the heat ordinarily radiated from the furnace walls is saved, and at the same time a thinner wall is possible. The walls are made of specially fashioned hollow tile through which pipes are carried. These are connected to headers at each end of the boilers, which are in turn connected to the boiler proper



PLAN OF POWER PLANT, WITH SECTIONAL ELEVATIONS OF BOILER AND TURBINE ROOMS

and thus allow free circulation of water.

Steam is taken from the top of the rear header on each side and passes through two 5-in. short-radius bends and Chapman stop valves to a 10-in. steam main immediately behind the boilers. The front header is provided with hollow staybolts for blowing the tubes. The boilers are divided into three groups, one of four and the others of three each, each with its independent 10-in. header. While these headers are not connected, the feeders to the turbine room are so arranged that any group of boilers can furnish steam for any turbine unit. A 10-in. line extends from each header to the outside of the turbine room wall, where they all connect to a 10-in. manifold. This gives extreme pliability to the steam supply. The lines going from the manifold to the turbines drop below the floor level just inside the turbine room wall and are carried at that level to the inlet valves. A drop leg is provided under each steam line to collect condensation, if there should be any.

Feed water is supplied from the city

mains to either of two 1500-h.p. Hoppes open feed-water heaters. The feed to the boilers is by two 14 by 8¼ by 15-in. Worthington outside center-packed pot-valve pumps which are controlled by Mason regulating valves used in the feed-water regulating system. It was necessary to excavate in order to get the suction of the pumps sufficiently low.

Two stacks, each 9 ft. in diameter and 150 ft. high, serve five boilers each. The flue gases are collected in rectangular flues and uptakes built of blast-furnace slag concrete.

TURBINE ROOM

Three non-condensing turbo-generators, as shown in the illustration, are installed in the turbine room. These are of 1500 kw. capacity when running at 1800 r.p.m., and develop 60-cycle, three-phase current at 2300-4000 volts. The primary reason for installing turbines was the desire to avoid the vibration which, it was thought, might result from the installation of reciprocating engines, and which might prove injurious to the building and annoying to the occupants. But aside from this fact, it is extremely doubtful if the head room and floor space would have permitted the desired engine capacity. Even with the present arrangement, some difficulty was experienced in making connections because of the broad footings, and a special rectangular casting was necessary to connect each turbine with the exhaust main.

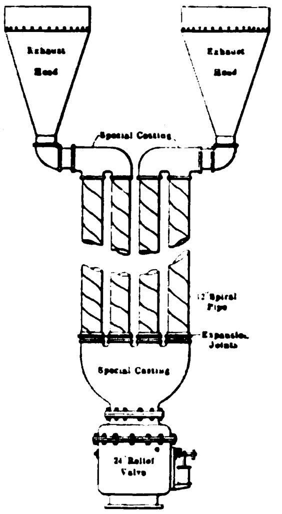
Each turbine unit has an oil-circulating system driven directly by worm gearing, by which the bearings are lubricated and which also is used in the operation of the inlet valve under control of the governor. An independent motor-driven oil pump is provided for use when starting the machines or in case of emergency.

The principal point in which these turbines differ from the standard condensing turbine is in the length of the rotor, a shorter machine being required for non-condensing service. The total velocity and terminal volume of the steam expanded to the high back pressure is considerably less than if expanded to a low back pressure (that is, into a condenser). Consequently, fewer steps or rows of blades are required to absorb the velocity, and the long low-pressure blading on a large diameter is not required.

The exhaust from the turbines discharges into a 24-in. main leading to the tunnels of the Central Heating Company. A 24-in. Crane relief valve is connected in this main. As there was not room to install a 24-in. outlet, it was found necessary to use a small space adjacent to one of the elevator shafts. As shown on page 695, a special casting with four connections was made to fit the relief valve. From this casting four sections of 12-in. spiral pipe were run to the roof, where other special castings connected them to two 16-in. Crane exhaust heads. These are intended simply as emergency or safety devices which will protect the turbines in times of sudden increase in load, when the exhaust is not entirely used on the heating system.

ELECTRICAL EQUIPMENT

All the electrical output of the station is used on lighting service, either



DETAILS OF EXHAUST RISER

as 2300 volts three-phase current, or on the three-wire 220-volt system. Alternating and direct-current bus bars and chables connect with the other two power plants, and the several plants operate in multiple both on the alternating-current and direct-current sides, using for the latter service two motor-generator sets, as illustrated on page 692, and a storage battery of 320 Type G-39 chloride cells. Each motor generator set consists of a 2250-h.p. 50-cycle three-phase synchronous motor driving a 1500-kw. direct-current generator at 300 r.p.m. and delivering current at 220-250 volts. The sets are started from the direct-current bus bars. The generator sets have proven so satisfactory that two other have been ordered for other plants of the company.

The panel for each generator set carries an edgewise ammeter, voltmeter, double-throw main switch, a Thompson recording wattmeter, alternating-current voltmeter, a direct-current field meter and power factor indicator. There is installed a 150-kw. 1200-ampere booster for charging the storage battery, together with its corresponding control panel. Two battery panels are provided with edgewise Weston ammeters, end cell switch indicators and controlling apparatus.

For the three-wire direct-current feeders, 24 feeder panels are used. These are provided with Weston ammeters on each wire. No circuit-breakers are used between the load and the direct-current side of the motor generators, but six automatic circuit-breakers are used on the alternating-current side. The lighting circuits in the building are controlled by six lighting panels provided with a double set of bus bars. By means of a double-throw switch the lighting circuits can be thrown on either the alternating- or direct-current side of the system.

The storage battery consists of 320 G-39 chloride cells of 1500 ampere-hr. capacity. These are divided into two sets having twenty end cells each. It is charged during the day and discharged at the peak load, which comes between five and six o'clock in the afternoon.

The motor generators are intended primarily to furnish direct current, but they also serve to tie the alternating- and direct-current systems together in such a way that either may assist the other when necessary, even to the extent of transforming the storage-battery current into three-phase high-tension current.

This description will give some idea of the novelty of the installation. So far it has been satisfactorily meeting the requirements placed on it, and demonstrates that turbines can operate under as difficult conditions as reciprocating engines.

Alternating-Current Elevator Controller]

Alternating-current elevator controllers are now made in many different styles for the various purposes for which elevators are used. One of the latest of these is shown in the accompanying illustration, and consists of a self-starter with primary solenoid switch and a separate belt switch, which is used as a pilot switch to control the self-starter. The belt switch is designed to be connected to the belt-shifting mechanism of the elevator, so that the water will be started and stopped whenever the operator moves the cable to shift the belts.

The primary circuit to the motor is controlled by a two-pole solenoid switch, and acceleration is accomplished by a multiple solenoid self-starter of the series relay type.

These controllers, which are one of the regular lines made by the Cutler-Hammer Company, of Milwaukee, are suitable for use on two-phase or three-phase, 25- to 60-cycle, slip-ring induction motors whose rated full-load rotor current does not exceed 100 amperes per phase.

Gas-Electric Motor Car—Self-Contained Type

By A. W. JONES

The immediate and gratifying success of the larger type of gas-electric motor car manufactured by the General Electric Company for steam railroads, and the successful application of this form of drive on trucks and passenger vehicles operated on streets without rails has naturally suggested the use of the gas-electric drive for cars of medium size for which there has already been manifested a marked demand. This demand will increase and new uses will be found for this type of equipment when its reliability and ease of operation become better known.

The General Electric Company has just completed the first car of this type, which has been placed in commercial service with excellent results. The car is shown in Fig. 1. The car body and trucks are especially designed for strength and lightness, and the equipment, briefly described, consists of a direct-coupled gas engine and generator with exciter on the same shaft, all completely enclosed and mounted between the axles of the truck and below the car floor. This arrangement permits low and convenient platforms, and leaves the interior of the car entirely unobstructed. The car is heated in cold weather by hot-water pipes under the seats, through which the circulating water is passed. A railway motor, of the standard type, is mounted on each axle, and the current for these motors is transmitted from the generator through a controller at either end of the car designed to vary the resistance in the shunt field of the generator and place the motors progressively in series and parallel. The car is illuminated by tungsten incandescent electric lights, deriving their current from the exciter circuit.

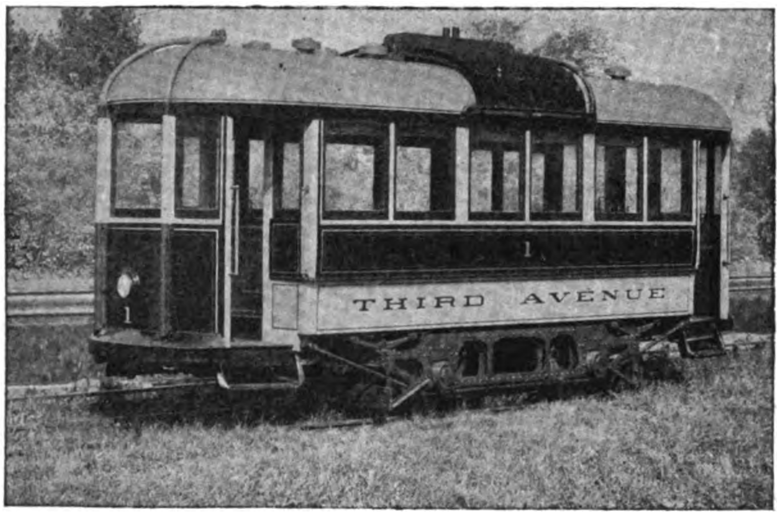


Fig. 1.—GENERAL VIEW OF CAR

The operation is like that of an ordinary electric trolley car, and, due to the characteristics of the gas engine and generator, there is less liability of abusing or overloading the apparatus by improper use of the controller. The car is reversed by a reversing handle on the controller, without affecting the gas engine, and can be equally well operated in either direction, a controller being provided on each platform.

THE GAS ENGINE

The gas engine is of the 4-cylinder, 4-cycle type, the cylinders being 5¾ in. diameter by 5 in. stroke, and cast *en bloc* (Fig. 2). The inlet and exhaust valves are of large size, located on opposite sides and actuated by separate cam shafts. The crank shaft is of high-grade steel, hand forged, and oil treated. Fig. 2 shows a side view of the engine and generator. The crank shaft is supported by three babbitt-lined bearings. Both the crank shaft and the bearings have been made of extra large size, and much greater strength and bearing surface are provided than would ordinarily be used on an engine of this size. The crank case is arranged so as to provide a constant level system of splash lubrication for the engine, oil being kept in circulation and the level maintained by a centrifugal pump with adjustable overflow.

The pistons are of the trunk type and made of the same material as the cylinders. They are provided with four cast-iron snap rings. The wrist pins are of steel, hardened and ground, and are fastened in the connecting rod in a special manner.

The connecting rod is of drop-forged machinery steel and oil treated. The cylinders are water-jacketed, circulation being secured on the thermo-siphon principle, the circulating water being cooled by a radiator located on the roof of the car, which can be seen in Fig. 1. This radiator has a cooling surface of approximately 900 sq. ft, and a capacity, including water jackets and piping, of about 65 gal.

A centrifugal type of governor gear driven from the inlet cam shaft is furnished, which acts directly on a balanced valve controlling the quantity of the mixture admitted to the cylinders, and maintains the speed of the engine and generator with small variations at about 800 r.p.m. Ignition is provided by a gear-driven Bosch low-tension magneto and magnetic plugs.

The entire engine is so designed that when it is assembled, together with the governor, magneto and spark plugs, it is completely enclosed, thus being protected against dust, dirt and water. This construction is clearly shown in Fig. 2.

The carburetor is of the Venturi type, with float feed, the gasolene being admitted by gravity from the gasolene tanks located under the car seats. Two of these tanks are provided, each of 35 gal. capacity.

The engine exhausts into a muffler, the exhaust gases thence being carried to the roof of the car, thus avoiding all odor of burned gases and eliminating noise.

GENERATOR AND EXCITERS

The generator and exciter, Figs. 3 and 4 are direct coupled to the gas engine and are completely enclosed. The armatures of these two machines are assembled on the shaft so that the commutators are adjacent. This arrangement permits of using but one inspection cover for both machines. The generator is shunt wound, and the exciter, in addition to the shunt winding, has a series field.

MOTORS

Two standard GE-60 250-volt railway motors are used. Each motor will develop 22 h.p., the output being based on standard rating.

The magnet frame is made of two castings bolted together, the suspension side bolts are hinged, and the lower frame is arranged to swing down so as to permit of inspection of fields and armature. The axle and armature bearings are of bronze, lined

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with babbitt, and are designed for use with oil and waste lubrication.

The pinions and gears are of steel, and entirely protected by a gear casing. The number of teeth in the gear and pinion, that is to say, the gear ratio, may be varied to suit different conditions of service.

CONTROLLERS

Two controllers (Type P-15-A) are furnished, one for each end of the car. These controllers are provided with the usual reversing cylinder, fingers, and connections for placing the motors progressively in series and parallel. Magnetic blow-out coils for main contacts and cut-out switches for the motor circuits are also provided. In addition there are provided 14 steps, introducing resistances in the generator shunt field for varying the voltage impressed upon the motors, thus securing a smooth and even rate of acceleration.

A separate reversing handle is provided, so designed that the controller is locked in the off position when the reverse handle is removed

TRUCK

The truck is of a special light construction of riveted plate frame, and is supported on the journal boxes by helical springs.

The car body is carried on the truck by means of helical springs, in addition to four half-elliptic springs which prevent excessive longitudinal rocking of the car body. The truck is 7ft. 6in. wheel base with 31 in. wheels.

The generating unit is swung centrally in the truck and bolted directly to cross-ties which are riveted to the side frames.

The motors are outside hung on the truck, with the suspension side supported on the main truck frame. An extension shaft is brought out from the engine to the end of the car for purpose of cranking.

TABLE OF SCHEDULE SPEEDS IN FREQUENT STOP SERVICE AND ON GRADES

AVERAGE LENGTH OF RUNS IN MILES

	Duration of Stops 5 Secs.					Duration of Stops 30 Secs.							
Per Cent. Grade	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	2.0	4.0	Fre Running Speed
0.	6.7	9.0	10.5	11.5	12.4	11.3	11.9	12.4	12.9	13.3	15.9	17.4	25.0
.25	6.5	8.5	9.8	10.7	11.5	10.5	11.0	11.4	11.9	12.3	14.4	15.6	20.0
.50	6.3	8.1	9.2	9.9	10.6	9.7	10.1	10.5	10.9	11.3	12.9	13.9	17.0
.75	6.1	7.6	8.6	9.2	9.7	9.0	9.4	9.7	10.0	10.3	11.5	12.3	14.5
1.00	5.9	7.2	8.0	8.5	8.9	8.3	8.7	8.9	9.1	9.3	10.3	10.8	13.0
1.25	5.7	6.8	7.6	7.9	8.2	7.8	8.1	8.3	8.5	8.7	9.5	9.9	11.5
1.50	5.5	6.5	7.2	7.4	7.6	7.3	7.5	7.7	7.9	8.0	8.7	9.1	10.0
1.75	5.3	6.2	6.8	7.0	7.2	6.8	7.0	7.2	7.3	7.4	7.9	8.3	9.0
2.00	5.2	5.9	6.4	6.6	6.8	6.4	6.5	6.6	6.7	6.8	7.2	7.4	8.5

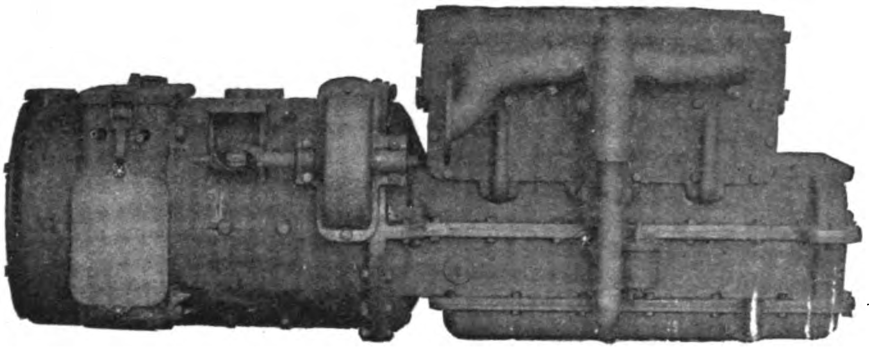


Fig. 2.—ENGINE AND GENERATOR

CAR BODY

The car body, which is clearly shown in Fig. 1, is designed with especial reference to strength and lightness. The platforms are semi-vestibuled.

The roof has no monitor, it being dome shaped and provided with suction ventilators. The radiator is placed on the roof over the center of the car, and is connected to the water jackets of the cylinders by pipes enclosed within the center posts of the car. The seats are longitudinal, finished in rattan, and have a capacity of 26 passengers. Trap doors are provided on the bottom of the car floor, giving ready access to engine, generator and motors. The controllers, hand brakes, auxiliary switches, etc., are carried on the platforms. The accompanying table gives principal dimensions:

DIMENSIONS

Length over bumpers	28 ft. 0 in.
Length of car body (inside)	19 ft. 0 in.
Length of each platform	4 ft. 0 in.
Width over body	7 ft. 4 in.
Width over radiator	8 ft. 0 in.
Height from rail to top of roof	11 ft. 1 in.
Height from rail to top of radiator	12 ft. 4 in.

An obvious usefulness for this type of car on trolley systems lies in its adaptation to "owl" trips, thus permitting the power station to be entirely shut down, say, between midnight and morning, when otherwise one generating unit would have to be kept in operation.

The type of car body which may be used with this equipment is, of course, not restricted to that shown in the illustrations and described above. Many other designs suggest themselves. A baggage space can be provided. An open type of car with transverse seats will be useful in warm climates.

The performance of this car for the week of Dec. 1st to Dec. 7th, inclusive, is stated to show the following results:

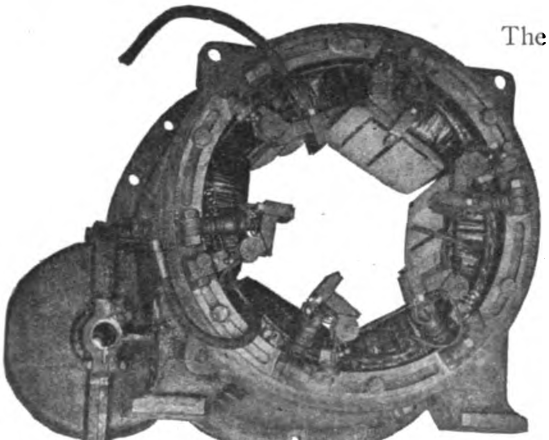


Fig. 3.—GENERATOR FRAME

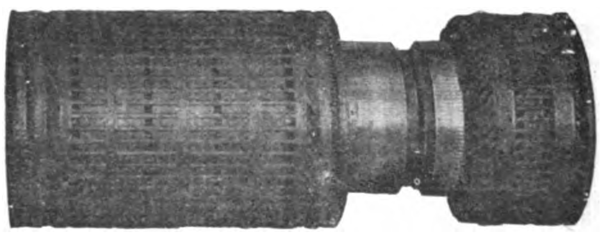


Fig. 4.—GENERATOR AND EXCITER ARMATURES

Fare passengers carried		3.345
Transfer passengers carried		800
Revenue mileage		540
Gross mileage		554
Gasolene requ red, gal		222
Cylinder oil required, gal		575
Cost of Operation per revenue car mile:		
Platform costs, same as electric car	7.7	cents.
Gasolene	4.83	"
Cylinder oil	.48	"
Miscellaneous	.707	"
Total expenses per revenue car mile		13,717
Total earning per revenue car mile		30.97

Questions and Answers

Question.—*Will a wattmeter measure the true watts in an alternating-current circuit in which the power factor is below 50? If so, why?*

Answer.—Surely! We do not just see why you select 50 as the critical value. At 50 per cent. power factor, or any other power factor above zero, there is energy in the circuit, and a properly designed wattmeter will measure it. It does so by reason of the reaction of the two or more coils with which it is provided. One of these coils registers voltage, and the other current. Now, if at a certain instant the voltage is at its maximum value and the current, owing to the low power factor, at something less, the combined effect of the two will be that of the maximum voltage plus that of the current whatever it may be at that instant. This is proportional to the true watts at that instant, and the same holds true for any other instant. So that the result over any given length of time will be accurate, and will measure the true watts in the circuit during that time quite independent of the power factor.

Question.—*Is there any difference between the terms "water rate" and "steam rate" as used in connection with steam engines and turbines? If not, which is preferable?*

Answer.—The two terms are identical. Perhaps the latter is preferable as being more accurate.

Question.—In changing over an old compound-wound dynamo to run as a motor, should the series coils be left in use? If so, would it not be well to connect the coils in series with the shunt coils?

Answer.—The leaving of the series coils in use connected in the usual way is preferable, especially if the motor has to start under some load, as the series coils tend to improve the torque at starting. For a constant speed service, starting under a light load, the machine should do just as well with these coils out as in. Your second suggestion is one that would hardly be worth the trouble of carrying out. The comparatively few series turns, in series with the higher resistance shunt field coils, would get so little current through them that their effect on the total field strength of the motor would be scarcely appreciable.

Question.—*How many horse power will be required to get full load out of a 25-h.p. motor, run as a dynamo, at the rated speed?*

Answer.—This depends on the efficiency of the machine. The horse power put into the motor running as a dynamo at full load will be equal to that load plus the losses in the machine. As a rule the efficiency of a motor run as a generator is not quite so great as would be that of a generator of the same size and weight of active iron and copper. What this difference in efficiency is depends on the design of the machine. If the motor efficiency at full load is 85 per cent., and running as a generator would be only 80 per cent., the amount of power required to get 25 h.p. out of it would be $25 \times 100/80 — 31.25$ h.p. The best way to determine the actual power is to measure it. It would be difficult to predict it beforehand.

Question.—*How can one determine the proper output of a small 110-volt dynamo whose rating is unknown?*

Answer.—This can be done approximately by finding the size of the armature wire and assuming about 5 amperes for each 1000 cir. mils. For instance, if the wire proves to be No. 10 B. & S., and it is wound singly, the area is 10,380 cir. mils and the rated amperage may be taken as about 50. To prove this, load up the machine to that extent, run it at that load for an hour, and then measure the rise in temperature with a thermometer. If it proves to be more than 75° F. above the temperature of the surrounding air, the machine is overloaded. By a series of such tests, running for an hour until the rise in temperature is from 70 to 75 deg. above the surrounding air, you can determine just what is the normal load of the machine.

Question.—*Please explain the advantage of using a reactance coil rather than a resistance in series with an alternating current arc lamp?*

Answer.—The advantage is that the loss of energy in the coil is much less than it would be for an ohmic resistance with the same drop in voltage across the terminals. For example, a resistance which would produce 22 volts drop in a lamp circuit carrying 5.5 amperes would have a value of 4 ohms and would dissipate 121 watts. Now, a reactance coil, whose impedance would be 4 ohms, could readily be designed with a resistance of not more than 0.05 ohm. The watts lost in such a coil would be $(5.5)^2 \times .05 =$ 1.5 watts. So in the latter case the loss is less than 1/80 of the loss in the former.

Question.—*What is the relative cost of wood ties laid in concrete and steel ties laid the same way? How long should each last?*

Answer.—Steel ties cost from $1.50 apiece up, according to weight. Wood ties can still be got for about half that price in some localities. The former can be placed further apart than is usual with the latter, so that only about three-quarters as many steel ties are necessary for any given length of track. Moreover, the scrap value of steel ties after they are worn out would be many times that of the wood tie. The life of each tie would probably be about the same if both are properly laid in concrete, probably 20 years at least. It is somewhat cheaper to lay the steel ties than the wood, so that in most localities the first cost of a steel tie track will run lower than that of one with wood ties. Prices for both articles vary so much in different places that each case must be figured out by itself.

Question.—*What is the best way to locate a short-circuited coil in the stator winding of an induction motor?*

Answer.—Take out the rotor and send some alternating current through the stator winding. The short-circuited coil will then become heated and can be detected. An alternating-current magnet held close to the successive coils will heat up the short-circuited one more than the other. Various forms of this magnet are in use, and some are made for finding short-circuited coils in direct-current armatures, which is a similar problem. Anyone can make up such magnets, and they are good things to have around the power-plant.

Question.—*In counting up the expenses of operating electric properties, certain allowances are always made for depreciation. They seem to be figured as percentages on the first cost of the parts of the properties. How are they determined?*

Answer.—They are supposed to be the combined result of experience and foresight. But just as these qualities vary, so do the allowances vary. There is no hard and fast rule.

Good general practice is indicated in the following table, which covers the ordinary plant:

AVERAGE DEPRECIATION ALLOWANCES

Item	Per cent.
Real Estate	0
Brick, stone or concrete buildings	1.5
Boilers and accessories	8
Engines and accessories	3 to 8
Generators	5
Transformers	7
Pole line and outside wiring	6
Meters	7
Arc lamps	7

These percentages are separate from maintenance and are simply estimates of the cost of keeping the property in shape.

"Wireless" Light for Everywhere

Mr. Nicolo Tesla is being quoted in a recent newspaper interview as saying that as the result of many years' effort his "wireless electric light" has practically been brought to a state of perfection, and a plant for its production is now nearing completion at his laboratory.

"It would be possible by my powerful wireless transmitter," said Mr. Tesla, according to this account, "to light the entire United States. The current would pass into the air and, spreading in all directions, produce the effect of a strong aurora borealis. It would be a soft light, but sufficient to distinguish objects.

"My present plan is to distribute this light from a central station, which is the most economical and also the best method of obtaining light of highest quality. My lamps will last forever, there being nothing in them to burn out. They are simple tubes or bulbs of glass hermetically sealed and containing nothing but rarefied gas.

"One advantage is the economy of production, which is greater than in any other light so far obtained. A great saving will be effected by wireless distribution. I am intending chiefly to supply isolated dwellings which cannot be conveniently reached by wires, and in this system of distribution there is absolutely no difference where the dwelling is located. The force of the current is the same whether the house is 12,000 miles from the plant or 12 ft."

The Benjamin Tungsten Lamp Shock Absorber

The Benjamin shock absorber, made by the Benjamin Electric Manufacturing Company, Chicago, consists primarily of a strap iron stirrup and a loose bushing, centrally located, supported by a coil spring and tapped to receive the fixture stem. The compression spring forms a resilient connection between the supporting element (iron stirrup) and the fixture. The stirrup has two feet, provided with screw-holes for attaching to the supporting surface, and, when so attached, takes the place of an ordinary crowfoot. An additional strap, centrally threaded to fit a ⅜-in. insulating joint, is attached to the stirrup by means of two screws. This strap may be omitted for attaching to a wooden ceiling or block. In one case the device thus becomes a shock-absorbing hickey; in the other, a shock-absorbing crowfoot.

Where it is desired to use a brass casing and canopy, a canopy support, consisting of ⅞-in. brass tubing with the upper end flanged outwardly, passes through the opening in the bottom of the stirrup and surrounds the bushing. This permits the canopy to be attached by means of a ⅞-in. slip ring to the supporting element, thus leaving the fixture freely suspended, and overcomes the difficulty of providing a means for preventing the transmission of shocks from the support to the fixture through the canopy and stem. There is also enough play between the movable parts to allow the fixture to hang plumb, even though the support be uneven.

In addition to other good features, this shock absorber incorporates what is claimed to be an essential for successful devices of this character in that provision is made for locating it

SHOCK ABSORBER

at the ceiling or the point of fixture support rather than above the individual lamp sockets.

The initial shock of a sharp or sudden jar from the ceiling or point of support is intercepted before it reaches the fixture proper, while any subsequent vibration which might be transmitted is dissipated by the weight and consequent inertia of the fixture before it reaches the lamps themselves.

News Notes

It is stated in an English newspaper that an Italian engineer has invented a reversible steam turbine, which, it is claimed, "has no blades or vanes to get out of order, and will work with equal power or speed in both directions, forward or reverse." It can be built in all sizes from 5 to 50 h.p. The making good of these claims will be looked for with interest by everyone interested in prime movers.

Mr. Geo. H. Cone, of Burlington, Vt., has a sun-operated thermopile device for converting the energy of that body into electricity and charging storage batteries. Details are not yet published.

The ratepayers of Toronto, at the municipal elections on Jan. 1st, by a vote of 19,268 as against 10,697, decided in favor of the city corporation making application to the Ontario Legislature for the necessary authority to construct and operate a system of municipal subway and surface railway lines in order to furnish rapid transportation to and from the downtown district to the citizens residing in the outlying portions of the city.

It is proposed to rebuild the famous Colorado River dam at Austin, Tex., which, after costing that city a million dollars, collapsed in 1900, entailing a loss of $1,600,000. Private capital offers to rebuild the dam in return for a 15-yr. lease of the water power and hydroelectric plant which it proposes to develop. It also asks the city to make a contract for power with the company at the rate of two cents a kilowatt-hour, and to install motors at its pumping plant. At the end of the lease the dam and plant pass to the city. It is likely that the proposal will be put to a vote.

A Public Utilities Bill providing for the creation of a public utilities commission for Maryland has been proposed, but the sentiment of the Legislature at Annapolis is thought to be such that it has but small chance of passing. The estimated annual expenses of running such a commission are $92,200.

The production of steel railroad ties and fasteners in Germany increased from 123,000 tons in 1888 and 356,000 tons in 1906 to 494,000 tons in 1907.

The highest dam ever constructed has just been completed on the Shoshone River in Wyoming. Its total height from the base to the parapet is 328.4 ft. It is located in the canyon of the river, where the walls are nearly perpendicular and rise almost 2000 ft. above the stream. At its base the dam is 70 ft. across; on the top its length is 175 ft., while at the bottom the width is 108 ft. The dam has been constructed to control the floods of the Shoshone and to provide a water supply for the irrigation of more than 100,000 acres of land.

Montevideo, the capital of Uruguay, is now supplied with street railway service by two companies, one called the Transatlantica and the other the Sociedad Comercial. The first system is about 75 miles long, has 160 motor-cars and 25 trailers, and has 1028 employees, receiving a total annual wages of $350,000. It is capitalized at $2,500,000 and carried 20,000,000 passengers in 1908. The second system operated 215 motor-cars and 50 trailers for 6,022,100 car-miles, and carried 25,900,000 passengers. This Company is capitalized at $6,000,000, of which $2,000,000 is in stock. Its gross earnings were $1,093,870.

Reproduction Costs of a Great Street Railway System

At a hearing before the Public Service Commission, first district, in New York, of an application for issuing new securities, Mr. Henry Floy estimated the actual cost of reproduction of the entire physical properties of Third Avenue proper, Forty-second Street, Dry Dock, Union, Southern Boulevard, Bronx Traction, Kingsbridge, Yonkers and Westchester Railroad Companies on basis of present-day prices, as follows:

Building-structures	$7,205,315
Tracks	10,331,894
Paving	3,542,644
Distributing System	2,838,246
Overhead Construction	1,200,500
Duct Lines	2,116,538
Power Equipment	3,495,219
Rolling Stock	7,650,934
Removal of Obstructions	1,479,049
Paving over Obstructions	1,389,035
Real Estate	4,524,570
Tools, Supplies, Fixtures	553,165
Horses, Wagons, etc	56,874
Salvage on Materials and Apparatus	5,822
Total	$46,389,805
Purchase price Mamaroneck & Larchmont Road	110,000
Grand Total	$46,499,805

In addition to this reproduction, he estimated that to really reproduce the system, incidental and contingent expenses amounting to 25 per cent. of a cost of $46,500,000 would be necessary, which would be $11,625,000, making the total cost of reproduction by a new company amount to at least $58,125,000.

These incidental expenses include legal expenses, ½ of 1 per cent.; technical expenses, ½ of 1 per cent.; preliminary running expenses, 8½ per cent.; taxes, ½ of 1 per cent.; discounts on promotion, 10 per cent., and promotion expenses at 5 per cent.—25 per cent. in all.

Many of these values would apply only to New York traction projects for reasons on which the general public is pretty well informed.

110-Volt Circuit-Breakers for the Southern Power Company

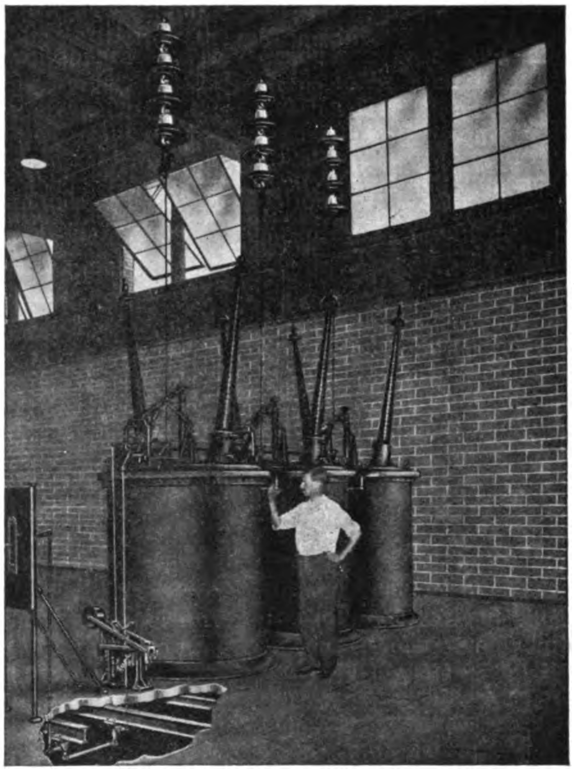
Four groups of 110,000-volt oil circuit-breakers were recently put in service by the Southern Power Company on its high-tension transmission lines in the vicinity of Charlotte, N. C. This installation is unique as being the first in which switching apparatus is called upon to break currents of this extreme potential, although several similar plants are now under construction and will shortly be in operation.

In the case of the Southern Power Company's lines not only is the voltage interrupted remarkable, but the magnitude of the currents being successfully handled under these severe conditions, marks a far step in the design of high-tension control apparatus. In this connection it is interesting to note the rated limit of operation of these 110,000-volt circuit-breakers; viz., that they shall successfully interrupt any short circuit that may occur on a transmission system of 120,000 kw. capacity.

As shown in the accompanying illustration, a feature of the construction of these circuit-breakers is the isolation of each pole in a separate tank. Each pole is thus entirely independent of the others except for the pull rod which operates the contacts. This rod is released by the tripping mechanism shown at the left of the tanks, allowing the contacts to open by gravity. The 47-in. break thus interposed into each phase occurs in the center of the tank, in oil free from any possible sediment or moisture. By the arrangement of the operating mechanism, gravity assists in making a quick break during normal operation, while in case of any injury to the circuit-breaker parts the circuits naturally tend to fall open.

A double break is made at each pole, spring-seated butt contacts assuring a firm closure. A small double-pole, double-throw switch operated by the contact mechanism provides a simple tell-tale, indicating the position of the breaker contacts, by lighting a red or green lamp. The tanks are of welded-seam boiler steel, filled with oil and fitted with a thick lining of specially treated insulation which encloses the contacts. The terminals are of the condenser type, and allow the line wires to be brought in directly from overhead.

The 110,000-volt breakers for the Southern Power Company are of both the hand- and electrically-operated types. They are normally closed by energizing the operating solenoid from a low voltage local circuit, but may also be hand-operated by a lever handle through a simple mechanical connection. Series relays, mounted on suspension insulators and inserted directly in the line, are provided for automatically tripping the circuit-breakers in case of overload. A wooden rod transmits the movement of the relay armature on the suspension insulator to the latch mechanism, providing a simple and quick-acting mechanical release effected directly by the line current.



CIRCUIT-BREAKERS INSTALLED

The 110,000-volt circuit-breakers described in the foregoing are of the type "GA" design, developed and manufactured by the Westinghouse Electric & Manufacturing Company. Elsewhere than the Southern Power Company, these breakers are now in use, controlling lines aggregating 200,000 kw. capacity, and ranking in potential from 44,000 to 88,000 volts, in the plants of the Idaho-Oregon Power Company, Boise, Idaho; Spokane & Inland Empire Railroad, Spokane, Wash.; Niagara, Lockport & Ontaria Power Company, Niagara Falls, Ont., and Societa Industriale Italiana, Milan, Italy, besides a number of installations yet incomplete.

The January Technical Press

Leading Articles of General Technical Interest

Commercial

"From Generator to Consumer," L. J. Auerbacher. A graphic study of the path of a current unit from the coils of the generator to those of the consuming device. The case selected is from the Thirty-eighth Street plant of the New York Edison Company to some point on Riverside Drive. That this is one of the most complex service circuits in the world may be gathered from the fact that a unit of current here passes through no less than 39 separate devices.—*Elec. Rec.*

"Hydro-Electrical Development in Southern Asia," H. P. Gibbs. An account of the harnessing of the Cauvery River, in India. The work was done for the government of the native State of Mysore. Nearly 10,000 kw. capacity were installed, the principal market being at the Kolar gold mines, 92 miles away. Transmission is at 35,000 volts, steel tower and pole being used. The power is sold on a flat rate based on the normal full-load consumption of the mining companies' motors. The agreement covers 10 yr., as follows:

1st year	$145 per h. p.-year
3 following years	91 " " "
5th year up to	120 " " "
5 following years	50 " " "

—*Gen. Elec. Rev.*

"The Engineering Aspects of Large Power Contracts," H. S. Knowlton. The writer continues an original analysis and discussion of the principles governing the manufacture and sale of power. Having treated "Definition of Service" and "Payment for Service," he takes up "Establishment of Service," "Operation of Service" and "General Considerations." This paper is of special interest to transmission companies and to their customers.—*Eng. Mag.*

Detail Apparatus

"Line Shaft Drive and Individual Motor Drive," A. G. Popcke. An article giving a lot of data on the relative economies of line shaft drive *vs.* the individual motor, especially in machine shops. In the cases worked out, the advantage is, as usual, with the latter; but as the author justly remarks, each case should be studied by itself to insure accurate results.—*Elec. Jour.*

Electric Railways

"A Gas-Electric Motor Car," A. W. Jones. A description of a self-contained gasolene-electric motor car now being built by the General Electric Company. An extended description of this car will be found elsewhere in this issue.—*Gen. Elec. Rev.*

"Central Repair Shop of London County Council Tramways," W. E. Ireland. An interesting description of the above corporation's repair and maintenance plant.—*Elec. Tract. Wkly.*

"Lewiston, Augusta & Waterville Street Railway." Gives an extended description of a Maine interurban road that operates partly from a power-house on the Androscoggin River, and partly from steam plants.—*Elec. Ry. Jour.*

"New Work of Illinois Traction System." A description of important improvements and extensions of the Illinois Traction System operating in the region east of St. Louis, including a new bridge over the Mississippi at St. Louis, and a new generating station at Venice, Ill., whose ultimate capacity will be 28,000 h.p.—*Elec. Ry. Jour.*

Management

"Motor Loads and Incomes," A. D. Adams. A careful analysis of the motor business of some 16 different central stations. The figures given, which are principally for cities of the second class, show a wide variation in the amount of power used and in the prices obtained. The former range from 7.7 h.p. to 65 h.p. per 1000 inhabitants; the latter from 1.88 to 8.29 cents per kw. hr. As would be expected, the cities enjoying the lowest rates have the largest proportion of power-users, other things being equal. —*Elec. Wld.*

Measurements and Tests

"Efficiency Test of an Otto Gas Engine," C. C. Winn. A complete account of the measurements of the efficiency of a 10 h.p. 270-r.p.m. Otto gas engine, with the accompanying tables, curves and diagrams. The best thermal efficiency obtained was 18.4, carrying a little over the rated load at somewhat less than 240 r.p.m. —*Power.*

"Magnet Steel and Permanent Magnetism," G. Mars. An inquiry into the magnetic properties of various steels made by the author, who is engineer for the well-known "Böhler Bros." steel works at Kaffenberg, Germany. Carbon, tungsten and chromium steel, as well as combinations of these alloys, were tested and the results tabulated. From these experiments the following conclusions are drawn:

(1) Steel for permanent magnets has the opposite properties to soft dynamo steel material.

(2) The greatest retentivity of the ordinary carbon steels is shown with about 0.97 per cent. carbon, corresponding to the entectoid carbon percentage. The smaller retentivity of steels with less carbon is due to their lesser hardness; with more carbon because of there being less free iron.

(3) The greater strength of the special steel magnets compared with carbon steel is due to the existence of more free iron in them with equal hardness.

(4) The constituents of magnet steels do not influence directly the strength of the magnetism, but with equal hardness, because of the displacement of a greater or less amount of the efficacious iron.

(5) For great retentivity it is necessary that the steel be glass-hard, of very small structure, and contain as much free iron as possible. With steels of equal hardness the amount of permanent magnetism is the greater, the more the percentage of free iron.

(6) The magnet steel, with about 0.6 per cent. carbon and 5.0 per cent. tungsten, shows the highest retentivity when quenched from a temperature of 930° C. to 950° C.—*Elec. Wld.*

"The Magnetic and Electric Properties of Iron-Nickel Alloys," C. F. Burges and J. Aston. A series of measurements and tests of the magnetic and electrical behavior of various iron-nickel alloys made in the engineering laboratories of the University of Wisconsin under a grant from the Carnegie Institute. Full tables and curves are given.—*Metal and Chem. Eng.*

Power Plants

"An Alaskan Hydroelectric Development," M. Adler. An illustrated account of the power plant and transmission system of the New England Fish Company at Ketchikan, Alaska. The power from two 800-h.p. turbines is transmitted six miles to be used in freezing halibut.—*Elec. Wld.*

"Hampton Power Plant, D. L. & W. Railroad." An illustrated description of the plant recently finished by the Delaware, Lackawanna & Western for supplying power to the car shops at Scranton. This plant is operated from very fine "rice-size" coal, which is obtained by washing the culm banks, familiar to all those who have traveled in the coal regions. The commercial value of this fuel is said to be practically nothing, yet this plant is getting an evaporation of about 8.3 lb. of water per pound of coal from it.—*Ry. Age Gaz.*

"Juniata Water and Water Power Company." A well-illustrated description of the combined water- and steam-power plant of the above-named corporation, near Huntingdon, Pa. Four 500-kw. 2300-volt water-driven alternators, operating under 27 ft. head, are helped out in the dry season by two 500-kw. steam turbines. Transmission lines at 45,000 and lower voltages supply half a dozen important cities of central Pennsylvania with light and power.—*Elec. Wld.*

Prime Mover

"The Melville-MacAlpine Reduction Gear." Describing the new reduction gear for steam turbines that has recently been constructed at the Westinghouse Machine Company's works at East Pittsburg. This device promises to be of great importance in marine work, and not improbably may come into use for other high-speed motor reduction purposes. It consists essentially of a helical gear flexibly mounted in an oil bath, and in a test in which it was attached to a 6000-h.p. 1500-r.p.m. turbine, an efficiency at full load of more than 98.5 per cent. was developed. It would be interesting to know how well the gear efficiency would stand up under a prolonged usage.—*Elec. Jour.*

Theory

"Transmission Line Calculations," M. W. Franklin. The fourth of these series is devoted to the calculation of line capacities. This subject is clearly stated, and tables giving the charging current in amperes on three-phase lines for 25, 60 and 100 cycles are appended.—*Gen. Elec. Rev.*

"Calculation of Lines Between Steel Railway Power Stations," R. H. Rice. A convenient method of calculating the sizes of the lines in a net-work of city railway feeders running from separate stations.—*Elec. Ry. Jour.*

"Transmission Lines of Central Colorado Power Company." An illustrated description of the high-voltage transmission system of this well-known company, who are operating lines at from 80,000 to 100,000 volts under difficult conditions, both as to topography and climate. By the use of the very best material in both insulators and towers an exceptional operating record has been established. The present is the first winter for 100,000-volt operations, and is said to be an extremely severe one, ice forming on the line conductors to a diameter of 6 in. in some places without having caused breakdowns. The results so far are very encouraging to the advocate of higher voltages in transmission work.—*Elec. Wld.*

Transmission

"Transmission System of the Southern Power Company," J. Liston. An interesting description of the enormous high-tension net-work of the Southern Power Company in North and South Carolina. There are some significant figures given showing that this company, which sells 80 per cent. of its output to the cotton mills of the Piedmont district, maintains some 639 miles of high-tension circuits, which supply nearly 200,000 kw. capacity of connected transformers, of which 130,000 kw. are arranged for 100,000-volt transmission. A good many miles of this transmission are still on wooden poles. Where towers are used the standard spans are 500 to 600 ft., according to the type. Electrolytic aluminum cell lightning-arresters have become the standard.—*Gen. Elec. Rev.*

Utilization

"Electrical Applications to Mining Work," C. V. Allen. An account of the latest applications of electricity to mining, particularly to the mining of precious metals. Many illustrations showing hoisting, pumping, haulage, air compression, conveying and stamp and tube mill and other details of mining work are shown. It is to be remembered that all the illustrations show direct-connected operation, and it may be taken for granted that the belt nuisance has forever disappeared from this field, except where belting is absolutely necessary.—*Elec. Jour.*

"Electricity in the Boiler Shop." A copiously illustrated article on the applications of electricity to various machines used in the manufacture of boilers, shears, bending rolls, riveting machines, reamers, punchers, planers, drills, saws, presses, hoists, turntables, and air compressors, all with individual motor drive.—*Elec. Rec.*

"The Electric Motor in Printing Work," S. H. Sharpsteen. A discussion of the proper arrangement of motors for operating printing machinery. This service is one for which electricity is the ideal motive power, if the installation is properly designed, and the article gives information as to the best way of getting the desired result of a maximum of speed and convenience coupled with a minimum of operating cost.—*Elec. Wld.*

Miscellaneous

"Concrete in Electrical Construction," H. N. Muller. A timely and well-illustrated article on the use of reinforced concrete and cement in power-plant and distribution construction. Concrete is shown as applied to switchboard and bus-bar structures, manholes and cable armoring, transformer houses and pole-line construction. An especially ingenious, but seldom advisable, application is the replacing of rotted wood pole butts by reinforced concrete stubs.—*Elec. Jour.*

"The Wireless Telephone," J. L. Hogan, Jr. A description of the work being done in wireless telephony and an attempt to forecast the future development. Distances covered in isolated cases range up to 300 miles, but the conclusion is that until some type of transmitter far superior to those in use to-day is developed, and improvements are made in the oscillator, commercial wireless telephony cannot succeed.—*Elec. Wld.*

"Installation Costs of a Modern Steam Turbine Plant." A detailed list of the cost of a recently completed 2500-kw. central station in a building designed to contain ultimately 10,000 kw. capacity. This station is stated to be along the waterfront of an eastern city, and to be equipped with six 400-h.p. mechanically staked boilers costing $28,000, and one 2500-kw., 5600-volt, 60-cycle, two-phase Westinghouse - Parsons turbo - alternator whose cost is given at $52,000. Other principal items are:

Concrete foundations	$26,838
Brick and carpenter work	14,045
Coal conveyor	9,800
Condensing machinery	8,435

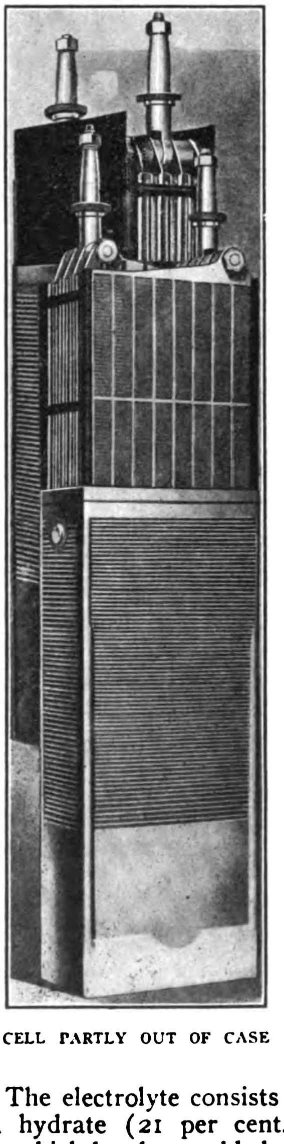
Unit costs per kilowatt capacity are summarized as follows:

Boilers	$11.52
Furnaces	4.15
Turbine set	20.80
Building and foundations	30.33
Condensing equipment	3.37
Other items	20.81
Total cost per kilowatt of initial equipment	91.98

These results are somewhat modified by the fact that the building was designed for a much larger capacity. —*Elec. Wld.*

The New Edison Storage Battery

The Edison Storage Battery Company, of Orange, N. J., announces the completion of the new Edison cell, which is now being placed on the market for traction service. In outward appearance it does not differ except in minor details from the original cell brought out in 1901, but the structure of the positive plate has been radically modified and other improvements embodied to increase the capacity and durability. At present the battery is made in two sizes; one size having four positive and five negative plates, and the other possessing six positive and seven negative plates. The active material in the positive plate consists of nickel oxide, and iron oxide is used in the negative electrode. The electrolyte consists of potassium hydrate (21 per cent. solution) to which has been added a small amount of lithium hydrate. The function of the lithium hydrate is not clearly defined, but it has been found to improve the working of the positive electrode. The normal specific gravity of the solution is 1.210, which does not change during charge or discharge.



CELL PARTLY OUT OF CASE

The efficiency and capacity of the cell, however, are not affected to any extent if the specific gravity of the solution is as low as 1.160. Below this a temporary effect is noticeable in the output of the cell.

The retaining cans are made of electroplated steel welded at the seams by the autogenous method—that is, by the application of the oxyacetylenic blow-pipe. The walls of the can are corrugated so as to obtain the greatest amount of strength with minimum weight. The iron element has an excess capacity over the nickel element. Much time has been spent in perfecting the latter. The original positive plate was made up of flat rectangular pockets containing nickel oxide and graphite. It was found that the graphite oxidized and that mechanically the structure could not resist the swelling action of the nickel oxide. In the new plate round tubes 4 in. long and about the diameter of an ordinary pencil are used to retain the nickel oxide. The tube is made of thin perforated steel, which when filled with the active material and properly bound by eight steel rings, makes expansion of the active material impossible and insures perfect internal contact. Instead of the graphite formerly employed, electrochemically prepared flakes of pure nickel are interspersed in the oxide to increase the conductivity of the active mass, because nickel oxide of itself is a poor conductor. Each positive plate consists of a grid of nickel-plated steel holding 30 of these tubes. The negative plate comprises 24 flat rectangular pockets supported in three horizontal rows in a nickel-plated grid. The pockets are made of thin nickel-plated steel perforated with fine holes, each pocket being filled with an oxide of iron and afterward subjected to very heavy pressure.

The plates of each group are hung on a connecting rod perpendicular to, but integral with, the pole. They are held apart by nickel-plated steel washers and held in contact by nuts screwed on both ends. The two outside plates are negative and are insulated from the retaining can by sheets of hard rubber. Hard-rubber pieces are also fixed between the can and the side and bottom edges of the plates, and these, together with the hard-rubber rods inserted between the plates, maintain correct spacing and insure permanent insulation.

The cover of the cell, which is also welded in place, has four mountings. Two of these are for stuffing boxes through which the positive and negative poles extend; one is a separator which prevents the loss of electrolyte while allowing the gases to escape, and the other is an opening for water and electrolyte.

This opening is fitted with a water-tight cap held in place by a catch. Fastened to the cap is a spring so arranged that the cap will fly open unless properly fastened. In an assembled battery each individual cell is held securely in place and from contact with adjacent cells by a small hard-rubber button which extends through the slat on each side of the tray and fits over an emboss pressed out on the side of the can. The bottoms of the cells are held in position by small buttons protruding from a conveniently arranged wooden block fastened to the bottom slats of the tray. The indentations in the bottom of the cell fit over these buttons. A rubber apron insulates the cell from the block.

The separator through which the gases escape while the battery is charging is designed in such a way

TOP VIEW OF CELL

that these escape in a substantially dry condition, the globules of liquid coalescing with a liquid film which forms at the base of the casing and the seat of the ball valve with which the battery is fitted, and in this way falling back into the cell. The electrolyte, therefore, need only be replenished with distilled water until completely changed in every eight or 10 months.

Electrical connections between the cells are made by heavy copper connectors, well plated with nickel. The lugs at the end fit over taper-joint binding posts and are held in place with a nut. A socket wrench for removing the nuts which hold down the connectors and a specilly designed jack for lifting the lugs from the binding pots when disconnecting the cells are sent with each battery. The trays in which the cells are assembled are very light, and where formerly the ends and the bottom were dovetailed together, the trays are now made of continuous strips, the corners being bent. The data of the cells are given herewith:

	Type A-4	Type A-6
Normal ampere-hour output....	150	225
Average discharge voltage per cell........	1.2	1.2
Normal rates of charge and discharge in amperes........	30	45
Weights (in pounds) of cell complete........	13.5	19.2
Width of can........	2 9/16	3 1/4
Breadth of can........	5	5
Height of can........	13 1/8	12 3/8
Height of cell to top of pole (not assembled)........	13 1/8	13 1/8
Required height of battery compartment........	15	15

While the normal rate of charge of the smaller cell, for instance, is 30 amperes, charging may be done at double this rate for a one-hour boost if the temperature is kept from rising much above 100° F. It is also permissible, though not recommended, to discharge a battery continuously at rates up to 25 per cent. above normal, and for occasional short intervals of time, as in hill climbing or starting on heavy roads, no harm is said to result if the rate be increased to three or four times normal. The capacity of the Edison battery increases after being in service, so that when working some time the efficiency is increased and greater output obtains also. This process of self-forming continues over a period of from one to three months of regular service, and it is partly to assist in this forming up that the overcharges are recommended at intervals.

The battery possesses reserve capacity. The highest practical limit of output is reached when a battery is charged 10 hours at the normal rate, and its value will be, for a fully formed battery, perhaps 30 per cent. more than the rated output. A seven-hour charge at normal rate is considered a normal charge. With a rated discharge three times normal the voltage drops 0.03 volt for every 10-ampere increase. On returning to normal discharge the voltage comes up to a value a trifle higher than normal owing to the heat generated at the heavy discharge rate. Heat on discharge increases the output, while heat on charge diminishes it; but excessive heating at all times impairs the life of the battery. The watt-hour efficiency ranges from 60 per cent. to 65 per cent. The smaller battery gives about 14 watt-hr. per pound of cell, and the larger cell 16 watt-hr. According to the makers, the battery cannot be injured by overcharging; it does not deteriorate when left discharged; any cell can be removed simply by detaching the connections from the poles, and the battery has nearly twice the output or mileage of other batteries weight for weight.

To test the performance of this battery in traction service a set consisting of 200 of the smaller cells, with 10 separate cells for lighting, was mounted on a new type of light-weight car, designed especially to minimize "dead weight" and get a maximum of useful service, was tried out on the lines of different railways in and around New York.

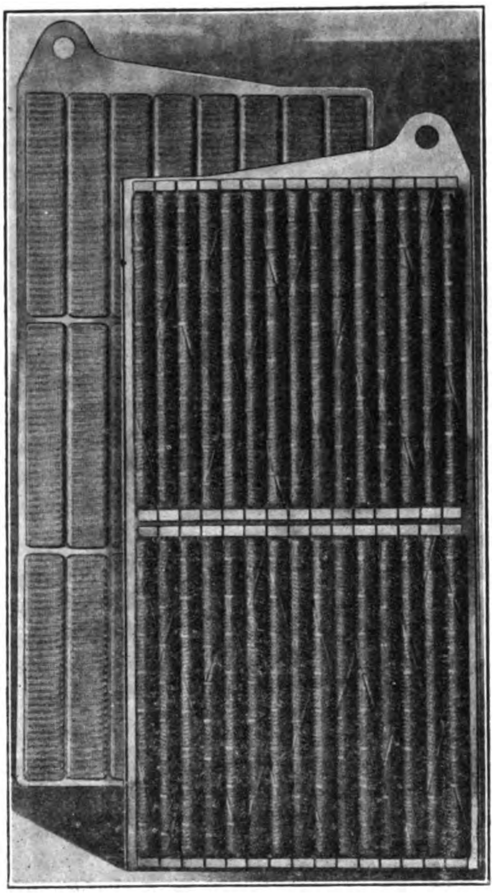
The car is capable of seating 26 passengers, and is 18 ft. between corner post and 26 ft. over all.

The various weights are as follows:

Carbody........	3,500 lbs
Truck and electrical equipment........	3,500 "
Batteries........	3,000 "
26 passenger load........	3,750 "
Total weight of loaded car........	13,750 lbs

The motors are wound for 110 volts and rated at 5 h.p. each at a speed corresponding to a maximum of 15 miles per hr.

The batteries are placed under the



POSITIVE AND NEGATIVE PLATES

seats, and lighting is by means of eight 10-c-p. 12-volt tungsten lamps.

The control arrangement is as follows:

1st step; batteries in multiple at 50 volts, motors in series.
2d step; batteries in multiple at 100 volts, motors in series.
3d step; batteries in series at 100 volts, motors in multiple.

No fixed resistances are used, the control being entirely as shown.

The power consumption of this car when accelerating at 1 mile per h.p. is said to be about 3½ kw., and when running about 1½ kw.

The tests have been satisfactory in every way, and cars so equipped would have a field of their own in operating long-branch lines of infrequent service, as well as in many other ways.

Among the Associations

The executive committee of the Ohio Electric Light Association has fixed the place and date of the sixteenth annual convention of that body at Cedar Point, Ohio, July 26th, 27th and 28th. A comprehensive program has been arranged.

The American Institute of Electrical Engineers has decided to hold a meeting at Charlotte, N. C., March 30th, 31st and April 1st. The following papers will be read:

"Economies of Hydraulic Plants," by U. S. Lee.

"Electric Drive in Textile Mills," by A. Milmow.

"Calcium Cyanamid and Its Relation to Water Powers," by Chas. H. Baker.

"Gas Engines in City Railway and Light Service," by E. D. Latto, Jr.

"Protective Devices for High-Tension Transmission Lines," by L. C. Nicholson.

The Southern Power Company has offered to place a special train at the disposal of the members in attendance, to enable them to visit its plant at Great Falls, S. C., and to inspect a 100,000-volt substation.

The Wisconsin Electrical Association held its first annual meeting at the Hotel Pfister in Milwaukee. This association, it will be recalled, is the child of the union of the Northwestern Electrical Association and the Wisconsin Electric and Interurban Railway Association which took place last June. More than 150 members were present. The following officers were elected: Clement C. Smith, Milwaukee, president; G. B. Wheeler, Eau Claire, first vice-president; Irving P. Lord, Waupaca, second vice-president; W. H. Winslow, Superior, third vice-president; J. S. Allen, Lake Geneva, secretary and treasurer.

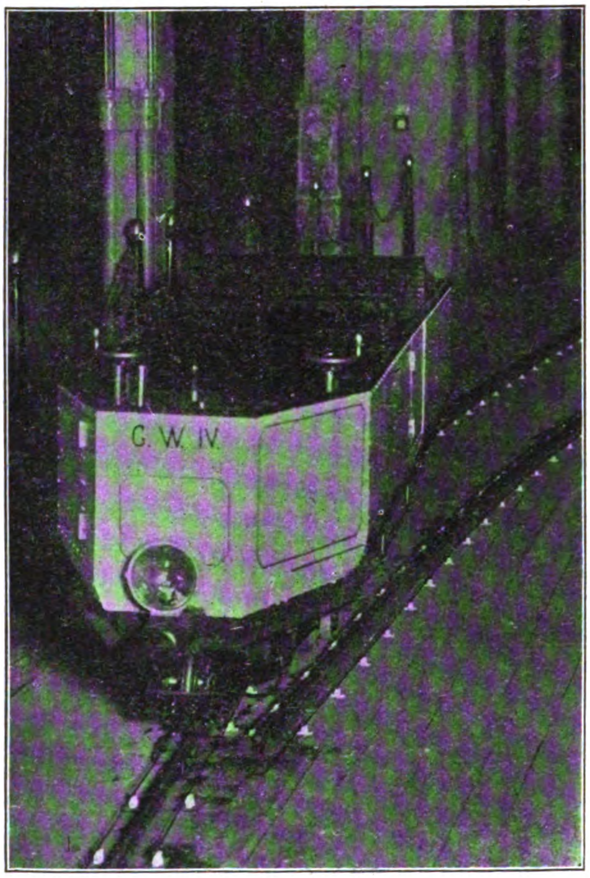
The fourth annual meeting of the Illuminating Engineering Society was held on Friday evening, Jan. 14th, at the Machinery Club, New York.

The following gentlemen were elected to office for the year 1910: Dr. Edw. P. Hyde, president; Mr. V. R. Lansingh, vice-president; Mr. W. Cullen Morris, treasurer; Mr. Preston S. Millar, general secretary; Mr. L. B. Marks, Dr. E. B. Rosa and Mr. F. W. Lloyd, directors.

A Gyrostatic Monorail Car

The German type of gyrostatically balanced monorail car was exhibited in January at the Clermont Rink in Brooklyn. This car is about 18 ft. long and 4 ft. wide at the widest part. It is shaped like a boat and weighs 5500 lb., of which about 300 lb. is taken up by the gyrostat.

The body of the car is mounted on two double-axle trucks, which are spaced on 15-ft. centers and have wheels 16 in. in diameter with a 1.2-in. flange. One wheel of each truck is driven through a double reduction gear by a 2-h.p. 110-volt direct-current series motor. Both motors can be operated from controller at each end of the car. The current is collected through truck contact shoes from a wire carried on insulator near the running rail. This car holds six passengers, counting the motorman.



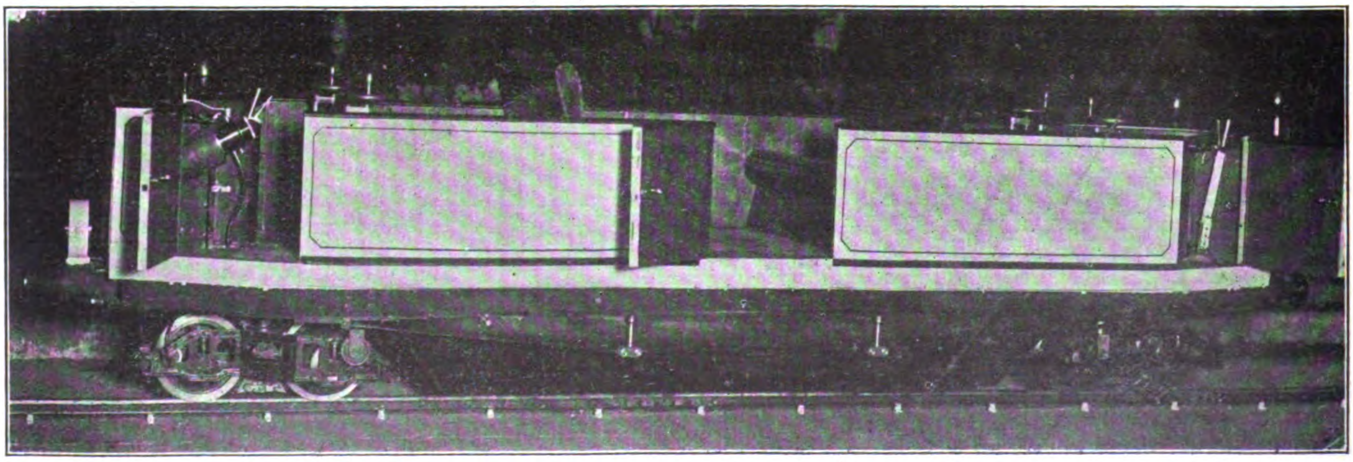
CAR RUNNING ON CURVE

The balancing mechanism comprises two gyroscopes revolving in opposite directions. Each gyroscope consists of a 110-lb. steel wheel rotating at 8000 r.p.m. in an air-tight chamber in which the pressure has been lowered almost to a vacuum. Each wheel is driven directly by a ½-h.p., 110-volt, direct-current shunt motor. To obtain the balancing effort, their precission is artificially influenced by means of an apparatus operated by oil under pressure. Should the motors which drive the gyroscopes fail from any cause, the high-speed wheels operating in the partial vacuum would easily permit the car to run safely for an hour or more. However, before the revolutions of the gyroscopes sink below a certain amount, the motorman can apply an emergency brake, which consists of four vertical props, which are dropped to the ground to bring the car into stable equilibrium. The gyroscopes are carried underneath the car body.

The test track at the Brooklyn rink was in the form of an oval, whose largest diameter was about 150 ft. The track was laid with a rail weighing about 20 lb. per yard of special section, having a rounded head of about 1 in. wide. In addition to the oval track there was a spur running into one of the anterooms, in which the car was kept when not in use.

Perfect stability was maintained even when a passenger was carried seated upon the side of the car, running at about four miles per hour on straight track and three and one-half miles per hour on curves. On meeting curves, the car would, of course, incline toward the center, but this movement would not take place until the actual curve was reached. When standing still it remains in perfect equilibrium, though with a slightly swaying motion. It was also run backward on the track. When the passengers boarded the car on one side, the effect of the gyroscopes was to give the car an inclination in the other direction, but the car righted itself after the passengers were seated.

The English type of gyrostatic car has a slightly different arrangement of the balancing mechanism. The car exhibited over there in November is much larger and heavier than this car, which, however, is the first to be exhibited in this country.



SIDE VIEW OF CAR

Chicago Electrical Show

The fifth annual Electrical Show, held at the Coliseum under the auspices of the Chicago Electrical Trades Exposition from the 15th to the 29th of January, was a record-breaker in point of public interest and attendance. The huge amphitheater was, as usual, a beautiful sight, with its myriads of colored incandescent lights flashing reflections from the polished surfaces of glass and metal, and the canopied dome of incandescent gold and silver tinsel. The booths were lighted by tungsten clusters with Holophane reflectors, partially shaded by an imitation art glass dome. Loops of bunting were gathered up from the corner posts of the booths to form an apex over the clusters. About the hall ran a frieze bearing escutcheons made of imitation art glass, illuminated by incandescent lamps and spaced every 22 ft.

A special feature of exhibition was the Wright aeroplane purchased from the famous brothers by the United States Government for use in the army.

The increasing interest of the small specialty manufacturer in these shows was manifested in the increased number of such exhibits. Industrial power and domestic appliances, together with illustrations of arc and incandescent lighting, and glassware and art glass fixtures were the predominant features. There was also a fine line of telephone apparatus for all kinds of service, and a very complete representation of electric vehicles with their necessary charging appliances. Storage batteries of all sizes and kinds were well represented.

The largest exhibitor was the Commonwealth Edison Company of Chicargo, whose model gargage and complete industrial power and domestic appliance exhibit extended clear across an end of the hall.

Other prominent exhibitors were: The Allis-Chalmers Company, Milwaukee, Wis.; The Acme Wire Company, New Haven, Conn.; The American School of Correspondence, Chicago, Ill.; The American Steel & Wire Company, Chicago, Ill.; The Appleton Electric Company, Chicago, Ill.; The Como Electrical Company, Spring Lake, N. J.; The Chicago Fuse Wire and Manufacturing Company, Chicago, Ill.; The Chicago Pneumatic Tool Company, Chicago, Ill.; The Crane Company, Chicago, Ill.; The Cutler-Hammer Mfg. Co., Chicago, Ill.; The Duntley Manufacturing Company, Chicago, Ill.; The E-Z Vacuum Cleaner Company, Chicago, Ill.; The Electric Cleaner Company, Chicago, Ill.; The Electro-Magnetic Tool Company, Chicago, Ill.; The Empire Vacuum Company, New York, N. Y.; The Electric Storage Battery Company, Philadelphia, Pa.; The Electrical Testing Laboratories, New York, N. Y.; The Excello Arc Lamp Company, New York, N. Y.; The Fairbanks Morse Company, Chicago, Ill.; The Federal Electric Company, Chicago, Ill.; The Fort Wayne Electric Works, Ft. Wayne, Ind.; The General Vehicle Company, Long Island City, N. Y.; The Hamler-Eddy Smoke Recorder Company, Chicago, Ill.; The Electric Heating Garment Company, Chicago, Ill.; The Kimble Electric Company, Chicago, Ill.; The Keller Manufacturing Company, Philadelphia, Pa.; The Neville Illuminating Sign Company, Chicago, Ill.; The Pacific Electric Heating Company, Ontario, Cal.; The Pelouze Electric Heater Company, Chicago, Ill.; The Stromberg Electric Manufacturing Company, Chicago, Ill.; The Shelton Electric Company, Chicago, Ill.; The Simplex Electric Heating Company, Chicago, Ill.; The Perfection Vacuum Cleaner Company, Chicago, Ill.; The Vulcan Electric Heating Company, Chicago, Ill.; The Western Electric Company, Chicago, ill.; The Westinghouse Electric & Manufacturing Company, East Pittsburg, Pa.

STATISTICS OF NEW YORK CENTRAL-STATION SERVICE

The lighting and power service supplied on the Island of Manhattan, New York City, from central stations, was as follows on December 1, 1909:

Service connections	51,933	
Customers	92,093	
Meters	111,434	
Incandescent lamps	4,057,170	
Arc lamps	40,477	
Vapor arc lamps	1,279	
Heating appliances	1,158	kilowatts
Storage batteries	5,096	"
Electric motors	233,834	"
Kilowatt hours sold	249,677,504	
Increase of last year	14,406,392	
Percentage increase	5.77	

Business Notes

The Lord Electric Company, of New York, reports a very satisfactory business during the past year, and cites one from a large number of cases of which it justly feels proud. Among other customers supplied with the company's lightning arresters during 1909, a single customer purchased 1,500, not one of which has proven defective.

The Wire & Telephone Company of America, who manufacture all kinds of bare and insulated wire for electric purposes, at Rome, N. Y., have changed their corporate name to "The Rome Wire Company."

The Protective Electric Supply Manufacturing Company, of Fort Wayne, Ind., has increased its capital stock from $10,000 to $25,000, the proceeds to be used for enlarging its business. Milton B. Lorimer is president of the company, and E. M. Popp, secretary.

The contract for the construction of the power development of the Etowah River, near Creighton, Ga., for the Blue Ridge Power Company, has been secured by Frank B. Gilbreth, Inc., 60 Broadway, New York.

This work will include the construction of a Ransom hollow dam 42 ft. high and 600 ft. long, and a reinforced concrete power house sufficient for 4000 h.p. installed.

The Le Valley Vitae Carbon Brush Company, New York, recently moved int oits new factory at 4123 Park Avenue, New York. The company's rapidly increasing business made necessary a large increase of manufacturing facilities. It had outgrown its old plant on Tremont Avenue and was compelled to seek larger quarters.

The Brooks Electric Company, electrical contractors and supply dealers, has opened an elaborate establishment in Baltimore, Md. The store is located on North Eutaw Street, right in the heart of the business district. Mr. Brooks, the proprietor of the new house, is well known in local business circles. He was employed with the Viaduct Telephone Company for many years and was more recently with the electrical contracting firm of Eugene Rosenfeld & Company, who took over the affairs of the viaduct people.

Plans are being developed by J. R. Carper, of Denver, Colo., for the construction of a large hydroelectric plant near Boulder, Colo., to furnish electrical energy to supply water for the irrigation of several thousand acres of land in the eastern part of Weld County, Colo. The project will involve an expenditure of several million dollars. It is said that the proposed plant, when completed, will develop 10,000 h.p.

The Edison Electric Illuminating Company of Boston, on Jan. 1st, reduced the basic price of its energy for lamps from 12 cents to 11 cents per kw-hr.

Plans are being considered by the Belknap Power Company, of Marysvale, Utah, for the construction of a hydroelectric power plant in the Sevier River, to supply energy for lamps and motors for the towns in the Gold Mountain and Marysvale districts. The cost of this plant is estimated at $3,000,000, and it is said that it will develop from 6000 to 7000 h.p.

An order has been placed with the Allis-Chalmers Co. for two 6500-kw., 1200-volt, 25-cycle, hydraulically-driven generators by the Niagara Falls Hydraulic Power & Manufacturing Company. These machines will be duplicates of the two already installed by the Allis-Chalmers Co. in the same plant.

The Hart Manufacturing Company, Hartford, Conn., has taken over the electrical specialties heretofore manufactured by the Price-McKinlock Company, and hereafter will manufacture in Hartford the specialties consisting of meter connection blocks, remote control switches, O. K. fuse block connections, O. K. ground clamps and kindred devices. Mr. Granville E. Palmer, formerly with the Pettingell-Andrews Co., is taking charge of the former Price-McKinlock specialty business for the Hart Manufacturing Company.

The Moore Electrical Company, Newark, N. J., reports that installations of the white Moore light for color matching in textile mills near New York during the past four months have enabled 10,000 employees to work full time, regardless of daylight or weather conditions. Heretofore on dark days they were compelled to remain idle, and it was impossible to operate several departments of the mills at night. The newest product of the Moore Electrical Company is the Moore light window, which is factory-built and semi-portable, and can be installed very rapidly.

The General Electric Company has plans prepared for the big pattern storage building it is to erect at the Stanley plant, and the contract will soon be awarded. The building will cost between $60,000 and $100,000. It is estimated that the company will expend about $600,000 in new buildings at the Stanley plant this year, which will surpass the amount expended in any previous year on buildings. The amount of business done at the plant amounts to $1,000,000 a month.

The widely-known engineering and constructing firm of J. G. White & Company, Inc., with branches in many parts of the world, announce the opening of a branch in Chicago, Ill. It will be in charge of Mr. Charles T. Mordock, with offices in the First National Bank building.

TO MR. EDISON

The way that your inventions
Have brightened up the nights,
We see you've done the best you could
"According to your lights."

Legal Notes

The Westinghouse Electric & Manufacturing Company has secured a preliminary injunction in the United State Circuit Court at Cincinnati restraining the Bullock Electric Manufacturing Company from infringing certain sections of Patent No. 518,693 covering parts of a controller for electric cars.

The General Electric Company has secured a preliminary injunction against J. W. Poole in the litigation over safety fuse covered by Patent No. 502,541.

The Johns-Manville Company announces a decision from the United States Court of Appeals holding that the flat-strip fuses of the Sachs Company are infringements of the Johns-Pratt Company's Patent No. 660,341.

In an opinion rendered on Jan. 3d by Justice Day, the Supreme Court of the United States held to be invalid an ordinance adopted by the City Council of the city of Minneapolis, Minn., in 1907, requiring the Minneapolis Street Railway Company to sell six tickets for 25 cents. The company fought the ordinance on the ground that it was a violation of the contract implied in its charter, which, issued in 1873, was to run for 50 yr., and which authorized a charge of five cents for each ride. The United States Circuit Court for the District of Minnesota declared against the ordinance, and Justice Day's decision sustained that finding.

Some Pending Legislation

A bill prepared by United States Senator Thomas Carter, of Montana, provides for the ceding of all water-power sites now owned by the Government to the States in whose boundaries they are located. The bill will further provide that the title to the sites shall remain in the States, which shall proceed to lease the sites, under proper regulation, to individuals and corporations for development. The bill conforms in large measure with some of the conclusions reached at the recent conference of governors, and it is said that President Taft has given his tentative approval to the bill, although he is not understood to have endorsed its provisions in detail.

Bills have been introduced into the Massachusetts legislature to prohibit a charge for the use of gas or electric meters, and also to provide for uniform telephone rates within the city limits of Boston, to permit savings banks to invest in the bonds of certain electric lighting and gas companies, corresponding to the statute which permits investment in certain street-railway bonds.

The latest State to consider the expediency of establishing a public utilities commission is Ohio. A bill is pending in that State, which is understood to be modeled on the one drawn up for New York.

The Traveler's Iron

This little 3-lb. iron is particularly attractive and very useful. It comes in a handsome, durable, leatheret case lined with velvet, and is especially intended for a woman when traveling. It is light weight, and with it she can do her light ironing; lace collars, fine handkerchiefs and such things as she does not care to send to the ordinary laundry.

The case contains iron, cord and stand in compact shape and is easy to pack in a suit-case or trunk, and it is always ready for immediate use by attachment to the ordinary lamp socket.

This is one of the numerous handsome and handy household articles made by the American Electrical & Heating Company of Detroit.

To Electrify Boston's Steam Railroads

At a recent meeting of the United Improvement Association, of Boston, Mass., it was decided to introduce a bill in the Legislature for the electrification of the railroads within ten miles of Boston. Co-operation with other organizations is planned to arouse general interest in the proposition.

A Consolidation

The Engineering Digest and *Industrial Engineering* have been consolidated under their combined titles, and Mr. R. T. Kent, the founder and editor of the latter, will be managing editor of the united periodical. Mr. Harwood, who founded and edited the *Digest*, has retired from the management.

Personals

Dr. Louis Duncan and Mr. Lamar Lyndon announce that their partnership as consulting engineers was dissolved, by mutual consent, Jan. 1st.

The board of directors of the Westinghouse Electric & Manufacturing Company has voted a six months' leave of absence to George Westinghouse, president of the company. Mr. Westinghouse will spend this vacation abroad. He was entertained in Boston on Jan. 22d at a dinner given by the Boston branches of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers, at which he delivered an address.

Mr. H. I. Millard, recently with the Westinghouse Company at Pittsburg, has become connected with the sales department of the Toronto Electric Light Company, Limited.

Mr. A. H. Boyd, electrical engineer in charge of the motor sales department of the Fort Wayne Electric Works, has been appointed manager of the Philadelphia branch office of the Fort Wayne Company.

Dr. Frederick Bedell, professor of applied electricity at Cornell University, sailed with his family for Algiers on Jan. 29th and will proceed later to France and Germany, returning to the university in September.

Mr. E. C. Foster has resigned as first vice-president of the New Orleans Railway & Light Company, of New Orleans, La., the resignation becoming effective on Feb. 1st. Mr. Foster will continue as a director of the company.

Mr. Robert Mather, chairman of the board of directors of the Westinghouse Electric & Manufacturing Company, will be placed in charge of the executive end of the company's business during the absence of Mr. George Westinghouse, who has been voted a six months' leave.

Mr. Hjalmar Hertz, until recently assistant chief engineer of the Western Electric Company at the Hawthorne works, Chicago, has resigned to accept the position of advisory engineer for the General Electric Company, with headquarters at Lynn. Mr. Hertz is a graduate of the University of Zurich, Switzerland, and an associate member of the American Institute of Electrical Engineers. He was the recipient of several dinners and farewell entertainments before his departure from Chicago last week.

Mr. James Wolff, Chicago manager of the New York Insulated Wire Company, has been made chairman of subdivision No. 31 of the new ways and means committee of the Chicago Association of Commerce. This subdivision represents electrical goods, fixtures and wire, and the other members are Mr. James J. Heaney, of E. Baggot Company, and Mr. F. A. Ketcham, of the Western Electric Company.

Mr. F. L. Dame, formerly engineer of the Electrical Securities Corporation, New York City, has been elected vice-president of the Electric Bond & Share Company. Mr. Dame has also been elected vice-president and a director of the American Power & Light Company.

Mr. Walter M. McFarland, acting vice-president Westinghouse Electric & Manufacturing Company, will deliver a lecture at Columbia University, New York, on April 7th, on commercial engineering.

Mr. T. E. Spence, formerly with the Lucerne County Gas & Electric Company, of Kingston, Pa., has joined the sales department of the Toronto Electric Light Company, Ltd., as power engineer.

Mr. Mortimer Freund has resigned from the service of the Navy Department and joined the engineering staff of Mr. Percival R. Moses, consulting engineer, of New York City. Mr. Freund is a graduate of the School of Engineering of Columbia University and has been acting for the past few years as electrical aide to the consulting engineer and inspector of public works, United States Navy Yard, New York.

Prof. R. H. Meyer, of the University of Wisconsin and chairman of the Wisconsin Public Service Commission, has been appointed by the Interstate Commerce Commission a mediator in connection with a controversy between the Illinois Central Railroad and its telegraphers.

Mr. C. W. Noyes has resigned as secretary of the Willimantic (Mass.) Gas & Electric Company to accept a position on the New England sales staff of the Westinghouse Electric & Manufacturing Company.

Obituary

Mr. D. O. Mills, who was president and director of the Niagara Falls Power Company, the Niagara Development Company, and the Niagara Junction Railway Company, as well as of many other corporations, died on Jan. 3d, at his winter home in Millbrae, near San Francisco, in the 85th years of his age.

Mr. P. S. Tirrell, of Groveton, N. H., who until recently was superintendent and chief electrician of the Corry, Deavitt & Frost Electric Company's electric plant in Montpelier, Vt., died Dec. 30th of cancer of the stomach. Mr. Tirrell was one of the inventors of the Tirrell voltage regulator.

Mr. William J. Baxter, one of the pioneers in electric development, died suddenly at his home in Jersey City, Jan. 12th. He was among the first to invent an enclosed arc lamp and a series motor for use on arc-light circuits. These motors were controlled by various devices operated by centrifugal governers, and were turned out in sizes of from 1/10 to 20 h.p. In the latter eighties the Baxter Electric Manufacturing & Motor Company at Baltimore was said to be one of the largest electrical manufacturing works in the world. Of late years Mr. Baxter was chiefly occupied as a writer on electrical and kindred subjects, and in giving testimony as an expert in electrical litigations.

Mr. Edward P. Bryan, until recently vice-president and general manager of the Interborough Rapid Transit Company, died of apoplexy, at San Juan, Porto Rico, aged 64 years. Coming to the Interborough Company from the general railroad field, he organized its engineering and operating forces and got the system into running order. He severed his connection with the company about a year ago on account of impaired health.

Mr. Leroy M. Harvey, sales manager of the Milwaukee district of the Allis Chalmers Company, died at Augusta, Ga., on Jan. 19th. He was formerly with the Westinghouse and Siemens & Halske Companies. He was only 37 years old.

The annual dinner of the American Institute of Electrical Engineers for 1910 will be held at the Hotel Astor, New York, on Tuesday evening, Feb. 24, 1910. Prof. Elihu Thomson, who has been awarded the first Edison Medal, will be the guest of honor on that occasion.

Trade Publications

The Wisconsin Engine Company, Corliss, Wis., manufacturers of high-grade prime movers, have issued bulletin C-1 on "Heavy Duty Corliss Engines." This bulletin is very handsomely gotten up and meant to be the first of a series which will completely cover their output.

The H. W. Johns-Manville Company has started a new house serial under the name of "The J-M Packing Expert." The initial number is devoted principally to telling about asbestos. This firm has also recently issued folders describing the following: No. 100, Pipe and Boiler Insulation; No. 101, Asbestos Packings; No. 102, Building Materials; No. 103, Sectional Conduit; No. 105, Asbestos Sundries; No. 106, Manville Fire Extinguisher.

"Dumping Tubs and Buckets" is the title of the C. W. Hunt Company's bulletin telling of the numerous kinds of coal tubs and grab buckets that this firm is now turning out.

The Pacific Electric Company, Ontario, Cal., is out with a scorching number of "Hot Points" for January.

The Western Electric Company has recently received from the press for general distribution bulletins Nos. 1001 and 1002. These bulletins take up in detail the construction and operating features of magneto non-multiple switchboards with self-restored and manually restored line signals. They contain illustrations of the different essential parts of line circuit apparatus, cord circuit apparatus, as well as different styles of switchboards. Numerous diagrams are also shown, illustrating the wiring connections for the various parts.

These bulletins are the first of a series of 10 switchboard bulletins which are to be issued by the Western Electric Company describing their newest and latest designs of switchboards and telephone apparatus, and will be sent to any address on request.

The Western Electric Company has published a new issue of their bulletin No. 5131, which shows in detail their type IL of motors and generators. A new issue also of bulletin No. 5132 has been published, taking up the type ELC motors of interpole design. These bulletins are ready for distribution.

The Western Electric Company has also recently issued booklets describing the following features of their output:

Hawthorne Arc Lamps.
Intercommunicating Telephones.
Lead-Covered Telephone Cables.
Type "T" Transformers.
Magneto Telephone Sets.
Rural Line Magneto Switchboards.
Telephones in Railway Terminals.
Bridging Telephone Sets.

In addition to the above-noticed booklets, type "T" transformers are also completely described and illustrated in bulletin No. 5270, and the company has also issued bulletin No. 5230, devoted to its line of polyphase induction motors.

"Trumbull Cheer," the house paper of the Trumbull Electric Manufacturing Co., is out in attractive shape in the first issue for 1910.

"The Lighting of Mills and Factories" is the name of a well-gotten-out pamphlet of some 31 pages. It treats the subject from the standpoint of the Holophane Company.

Recent bulletins from the General Electric Company are devoted to the following subjects:

No. 4703A—Variable Release Air-Brake Equipment.
No. 4706—Curve-drawing Ammeters and Voltmeters.
No. 4707—Gasolene-Electric Generating Sets.
No. 4711—Small Plant Alternating-Current Switchboards.
No. 4712—An Exhaust Steam Turbine Installation.
No. 4713—Type F Forms K-2 and K-4 Oil Break Switches.

"Factory Lighting" is the name of a well-illustrated pamphlet, recently issued by the Nernst Lamp Company, which deals with that much-discussed subject, with especial reference to their well-known lamp. The company's house monthly, "The Glower," for January, is out, with information on a wide range of subjects.

Bulletin No. 87 of the Wagner Electric Company tells of its line of alternating-current generators and synchronous motors, and bulletin No. 89 is devoted to Type BW polyphase induction motors.

Goldschmidt Thermit Company's quarterly, "Reactions," is full of the usual number of thermit repair stories.

The Steel City Electric Company has issued a circular, describing the Fallman non-adjustable floor outlet.

The Joseph Dixon Crucible Company announces the publication of "Graphite as a Lubricant," eleventh edition. This is just nicely off the press, being the edition for 1910.

The Dixon Company's monthly, "Graphite," is out with its usual varied assortment of information, both as to the increasing uses of graphite and many other things.

Every two or three years the Dixon Company republishes "Graphite as a Lubricant," which has become a standard work with them. Eeach new edition is thoroughly revised and brought fully to date.

The present edition is more compact that its predecessor, the idea being to concentrate the information into quick, convenient form that is not bulky.

The power-house engineer will find the newest edition of "Graphite as a Lubricant" of considerable value to him, since it deals especially with the lubrication and treatment of power-house machinery.

Some thought has been put upon the appearance of this last edition, and big readable type with liberal margins obtains throughout the 64 pages of the book. Easy to read and worth reading.

"Juice," the house monthly of the Pettingell-Andrews Company, of Boston, has come out for January in an entirely new size, make-up and type. The company is to be congratulated on the improved appearance, and also on the superior quality of its contents.

The Reliance Oil and Grease Company, of Cleveland, has gotten out a booklet about its line of animal, vegetable and mineral oils.

Henry R. Worthington has issued catalogues W-175 and W-176, devoted respectively to the Worthington turbine pumps and to the Worthington Type "D" centrifugal pump. Both of these books are gotten up with the style, finish and excellence of contents characteristic of the Worthington publications. The turbine pumps described are in use for mines, elevators and house service, as well as for fire and boiler feed services.

The latest publications of the Jeffrey Manufacturing Company, of Columbia, Ohio, are booklets 34 and 35, devoted respectively to "Elevator Buckets" and "Conveyors"; catalogue 69-B describing the many forms of the Jeffrey screens; and the very handsome bulletin No. 18, which contains some 32 pages of profusely illustrated descriptions of the different types of air-operated and electrically-operated coal cutters now turned out by the company.

The Black & Lorder Company, of York, have sent out a little book entitled "On the Development of Profit Factors," which is especially designed for circulation among central-station electric-lighting and power companies.

Classified Directory of Manufacturers

ADJUSTERS
Morse, Frank W., Boston, Mass.

AIR AND GAS COMPRESSORS
Allis-Chalmers Co., Milwaukee.
American Air Compressor Works, N. Y.
Blake Mfg. Co., Geo. F., New York.
Chicago Pneumatic Tool Co., Chicago.
Clayton Air Compressor Works, N. Y.
Curtis & Co., Mfg. Co., St. Louis.
Dean Bros. Steam Pump Wks., Indianapolis.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Hall Steam Pump Co., Pittsburg.
Ingersoll-Rand Co., New York.
Knowles Steam Pump Works, New York
Laidlaw-Dunn-Gordon Co., New York.
McGowan Co., John H., Cincinnati.
National Brake & Elec. Co., Milwaukee.
Norwalk Iron Works, Norwalk, Conn.
Platt Iron Works Co., Dayton
Providence Engine Works, Providence
Snow Steam Pump Works, New York.
Sullivan Machinery Co., Chicago.
Worthington, Henry R., New York.

ALTERNATORS
Allis-Chalmers Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Elec. Works, Indianapolis.
General Electric Co., Schenectady, N. Y
National Brake & Elec. Co., Milwaukee
Wesco Supply Co., St. Louis
Western Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg

ANCHORS (GUY)
Holden Anchor Co., Des Moines, Ia.
Matthews & Bro., W. N., St. Louis, Mo

ANNUNCIATORS
Central Electric Co., Chicago, Ill.
Doubleday-Hill Electric Co., Pittsburg
Electric Appliance Co., Chicago.
Haines, J. Allen, Inc., Chicago.
Manhattan Elec. Supply Co., New York
Ostrander & Co., W R., Chicago.
Van Dorn-Elliott Elec. Co., Cleveland.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.

ATTACHMENT PLUGS
Hubbell, Harvey, Bridgeport, Conn.

BATTERIES—PRIMARY
Bunnell & Co., J. H., New York.
Burnley Battery & Mfg. Co., Painesville, Ohio.
Central Electric Co., Chicago
Doubleday-Hill Elec. Co., Pittsburg.
Eastern Carbon Works, Jersey City, N. J.
Edison Mfg. Co., New York.
Elec. Motor & Equipment Co., Newark, N. J
French Battery Co., Madison, Wis.
Gordon Battery Co. New York.
Lawrence Elec. Co., F. D., Cincinnati, O.
Leclanche Battery Co., New York.
Manhattan Electrical Supply Co., Chicago.
Waterbury Battery Co., Waterbury, Conn.
Wesco Supply Co., St. Louis, Mo
Western Electric Co., Chicago.

BATTERIES—STORAGE
American Battery Co., Chicago.
Doubleday-Hill Electric Co., Pittsburg.
Electric Storage Battery Co., Philadelphia.
General Storage Battery Co., New York.
Gould Storage Battery Co., New York.
National Battery Co., Buffalo, N. Y.
Railway Safety Service Co., Springfield, Mass.
Universal Electric Storage Battery Co., Chicago.
Willard Storage Battery Co., Cleveland.

Classified Directory of Manufacturers—Cont'd

BELLS
- Central Electric Co., Chicago.
- Manhattan Electrical Supply Co., New York and Chicago.
- Ostrander & Co., W. R., New York
- Wesco Supply Co., St. Louis.
- Western Electric Co., Chicago.

BELT DRESSING
- Cling Surface Mfg. Co., Buffalo
- Dixon Crucible Co., Jos., Jersey City, N. J.

BELTING
- Boston Belting Co., Boston.
- Eureka Fire Hose Co., New York.
- Jeffrey Mfg. Co., Columbus, O.
- Link-Belt Engineering Co., Philadelphia.
- Pittsburg Gage & Supply Co., Pittsburg.
- Robins Conveying Belt Co. New York.

BLOWERS
- Allis-Chalmers Co., Milwaukee.
- American Blower Co., Detroit.
- American Gas Furnace Co., New York.
- Buffalo Forge Co., Buffalo.
- Chicago Flexible Shaft Co., Chicago.
- Crocker-Wheeler Co., Ampere, N. J.
- Dean Bros. Steam Pump Works, Indianapolis.
- Green Fuel Economizer Co., Matteawan, N. Y.
- Platt Iron Works, Dayton, O.
- Smith, J D., Fdy. Supply Co., Cleveland
- Sprague Electric Co., New York.
- Sturtevant Co., B. F., Hyde Park, Mass.

BLUE PRINT MACHINERY
- Buckeye Engine Co., Salem, O.
- Keuffel & Esser Co., New York.
- Kolesch & Co., New York
- Resolute Machine Co., New York
- Wagenhorst & Co., J. H., Pittsburg.

BOILERS
- Atlantic Works, East Boston, Mass.
- Babcock & Wilcox Co., New York.
- Harrison Safety Boiler Works, Phila.
- Heine Safety Boiler Co., St. Louis.
- Platt Iron Works, Dayton, O.
- Riter-Conley Mfg. Co., Pittsburg.
- Robb-Mumford Boiler Co., South Framingham, Mass.
- Struthers-Wells Co., Warren, Pa.
- Walsh's Holyoke Steam Boiler Co., Holyoke, Mass.
- Wetherill & Co., Robt., Chester, Pa.

BOXES—JUNCTION
- Bossert Electric Construction Co., Utica.
- D. & W. Fuse Co., Providence. R. I.
- Steel City Electric Co., Pittsburgh

BOXES—OUTLET
- Bossert Electric Const. Co., Utica, N. Y.
- Steel City Electric Co., Pittsburgh

BRUSHES—CARBON
- Central Electric Co., Chicago.
- Eastern Carbon Works, Jersey City, N. J
- Holmes Fibre-Graphite Mfg. Co., Germantown, Pa.
- Le Valley Carbon Brush Co., New York.
- National Carbon Co., Cleveland.
- Speer Carbon Co., St. Mary's, Pa.
- Western Electric Co., Chicago.

BUSHINGS-OUTLET
- Steel City Electric Co., Pittsburgh

CABLE HANGERS
- Barron & Co., Jas. S., New York
- Bissell Co., F., Toledo, O
- Standard Underground Cable Co., Pittsburg
- Steel City Electric Co., Pittsburg.
- Wesco Supply Co., St. Louis, Mo.
- Western Electric Co.. Chicago.

CABLE JOINTS
- Dossert & Co., Inc., New York

CARBONS
- Central Electric Co., Chicago.
- Eastern Carbon Works, Jersey City, N. J
- National Carbon Co., Cleveland.
- Reisinger, Hugo, New York.
- Speer Carbon Co., St. Marys, Pa.
- Wesco Supply Co., St. Louis.

CASTINGS
- American Steel Foundries, Chicago.
- Aiton Machine Co., New York.

Classified Directory of Manufacturers—Cont'd
- Lunkenheimer Co. Cincinnati.
- New England Butt Co., Providence, R. I.
- Phosphor-Bronze Smelting Co., Ltd., Philadelphia.

CHAINS FOR ARC LAMPS
- Oneida Community, Ltd., Oneida, N. Y

CIRCUIT BREAKERS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Cutter Electrical Mfg. Co., Philadelphia.
- Doubleday-Hill Electric Co., Pittsburg.
- Fort Wayne Electric Works, Fort Wayne, Indiana.
- General Electric Co., Schenectady, N. Y.
- Hartman Circuit Breaker Co., Mansfield, Ohio.
- La Roche Co., F. A., New York.
- Sundh Electric Co., New York.
- Switchboard Equip. Co., Bethlehem, Pa.
- Ward Leonard Electric Co., Bronxville, N. Y.
- Wesco Supply Co., St. Louis.
- Western Electric Co., Chicago.
- Westinghouse Electric & Mfg. Co. Pittsburg.

CLAMPS—CABLE
- Matthews, W. N., & Bros., St. Louis.

CLEATS
- Blake Signal & Mfg. Co., Boston, Mass.
- Imperial Porcelain Works, Trenton, N. J.
- Pass & Seymour, Inc., Solvay, N. Y.
- Sears, Henry D., Boston.

CLIMBERS
- Klein & Co., Mathias, Chicago.

CLUSTERS
- Benjamin Elec. Mfg. Co., Chicago
- Hubbel, Harvey, Bridgeport, Conn.

COAL AND ASH-HANDLING MACHINERY
- Brown Hoisting Machinery Co. land.
- Case Mfg. Co., Columbus, O.
- Hunt Co., C. W., New York.
- Jeffrey Mfg. Co., Columbus, O.
- Link Belt Co., Philadelphia.
- Mead-Morrison Mfg. Co., Boston.
- Northern Engineering Works, Detroit
- Robins Conveying Belt Co., New York.

COILS—INDUCTION
- Ostrander, W. R., & Co., New York.
- Splitdorf, C. F., New York.

COMMUTATOR LUBRICANT
- Allen & Co., L. B., Chicago.
- Dixon Crucible Co., Jos., Jersey City.

COMMUTATORS
- Homer Commutator Co., Cleveland, O.

CONDENSERS—ELECTRIC
- Marshall, William, New York.

CONDUIT RODS
- Barron & Co., Jas. S., New York.
- Cope, T. J., Philadelphia.
- Doubleday-Hill Electric Co., Pittsburg

CONDUITS
- American Circular Loom Co., Chelsea, Mass.
- The Gillette-Vibber Co., New London, Conn.
- American Conduit Co., Chicago.
- American Vitrified Conduit Co., N. Y.
- Camp Co., H. B., New York.
- Doubleday-Hill Electric Co., Pittsburg.
- Gest, G. M., New York.
- National Conduit & Cable Co., N. Y.
- National Metal Molding Co., Pittsburg
- Orangeburg Fibre Conduit Co., Orangeburg, N. Y.
- Sprague Electric Co., New York.

CONDUIT FITTINGS
- Steel City Electric Co., Pittsburgh

CONDUIT REAMERS
- Steel City Electric Co., Pittsburg.

CONDUIT TOOLS
- Cope, T. J., Philadelphia.
- Steel City Electric Co., Pittsburg

CONTROLLERS
- Allis-Chalmers Co., Milwaukee.
- Case Mfg. Co., Columbus, O.
- Crocker-Wheeler Co., Ampere, N. J.
- Cutler-Hammer Mfg. Co., Milwaukee.
- Elec. Controller & Supply Co., Cleveland

Classified Directory of Manufacturers—*Cont'd*

N. Y. Electric Controller Co., New York.
Simplex Electric Heating Co., Cambridge, Mass.

COPPER CASTINGS
Anderson Mfg. Co., A. & J. M., Boston.
Ward-Leonard Co., Bronxville, N. Y.

CRANES
Northern Engineering Works, Detroit.

CROSS ARMS
Locke Insulator Mfg. Co., Victor, N. Y.

CUT-OUTS AND SWITCHES
Bissell Co., The F., Toledo, O.
Bossert Electric Const. Co., Utica, N. Y.
Central Electric Co., Chicago.
Crouse-Hinds Co., Syracuse, N. Y.
Cutter Elec. & Mfg. Co., Philadelphia.
Ft. Wayne Elec. Wks., Inc., Fort Wayne.
General Electric Co., Schenectady, N. Y.
Hart Mfg. Co., Hartford, Conn.
Manhattan Elec. Supply Co., New York.
Sorenson, P., Brooklyn.
Switchboard Equip. Co., Bethlehem, Pa.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

DIRECT MOTOR DRIVE FOR PLANERS
The Electric Controller & Supply Co., Cleveland.

DRILLS
Morse Twist Drill & Machine Co., New Bedford, Mass.

DRYING MACHINERY
Aiton Machine Co., New York.
Buffalo Foundry & Machine Co., Buffalo.
Devine Co., J. P., Buffalo.
Sturtevant Co., B. F., Boston.

DYNAMOS AND MOTORS
Allis-Chalmers Co., Milwaukee.
American Engine Co., Bound Brook, N.J.
Bogue Electric Co., C. J., New York.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Central Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport. N. J.
Doubleday-Hill Electric Co., Pittsburg.
Eck Dynamo & Motor Wks., Belleville, N. J.
Electro-Dynamic Co., Bayonne, N. J.
Elwell-Parker Electric Co., Cleveland.
Emerson Electric Mfg. Co., St. Louis.
Fort Wayne Electric Works, Fort Wayne.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
National Brake & Elec. Co., Milwaukee
New England Motor Co., Lowell, Mass.
Ridgway Dynamo & Motor Co., Ridgway, Pa.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Boston.
Triumph Electric Co., Cincinnati.
Wagner Electric Mfg. Co., St. Louis.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

ELECTRIC RAILWAY SUPPLIES
Railway Safety Service Co., Springfield, Mass.

ELECTROMAGNETS
Acme Wire Co., New Haven, Conn.
Schureman, J. L., Co., Chicago.
Splitdorf, C. F., New York.

ELEVATORS
American Tool & Machine Co., Boston.
Caldwell & Son Co., H. W., Chicago.
Jeffrey Mfg. Co., Columbus.
Link Belt Eng'g Co., Philadelphia.
Obermayer Co., S., Cincinnati.
Otis Elevator Co., N. Y.
Poole Eng'g Mch. Co., Baltimore.

ENGINEERING CONSTRUCTION
Elm City Engineering Co., New Haven, Conn.

The Cutler-Hammer Co., of Milwaukee, has just issued a 128-page booklet in which the subject of the control of electrically-operated elevators is very fully covered. This company has been engaged in the manufacture of electric controlling devices for many years, and their booklet on elevator controllers is more than a mere catalogue, being in fact a concise treatise on the subject.

The first section of the booklet contains illustrated descriptions of full-magnet and semi-magnet direct-current controllers for high-speed, moderate-speed and slow-speed passenger and freight elevators, together with descriptions of sidewalk lift controllers, reversible and non-reversible controller for belt-driven freight elevators, and mechanically operated controllers for use where current conditions are extremely variable. Illustrations and descriptions are also given of such necessary elevator accessories as brake magnets, car switches, limit switches, etc.

The second section of the booklet is devoted to similar controllers for use on alternating-current circuits, and the concluding pages contain tables of useful information, including suggestions regarding the proper type of motor to use in each case.

Classified Directory of Manufacturers—Cont'd

ENGINES—GAS AND GASOLINE
Allis-Chalmers Co., Milwaukee.
Buckeye Engine Co., Salem, O.
Carlisle & Finch Co., Cincinnati, O.
De La Vergne Machine Co., New York.
Elbridge Engine Co., Rochester, N. Y.
Marine Engine & Machine Co., N. Y.
Mietz, A., N. Y.
Otto Gas Engine Works, Philadelphia.
Power & Mining Machinery Co., Cudahy, Wis.
Westinghouse Machine Co., Pittsburg.
Wood & Co., R. D., Philadelphia.

ENGINES—STEAM
Allis-Chalmers Co., Milwaukee.
American Blower Co, Detroit.
Am. Engine Co., Bound Brook, N. J.
Ball Engine Co. Erie, Pa.
Blake Mfg. Co., Geo F., New York.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo.
Frick Co., Waynesboro, Pa.
Hooven, Owens, Rentschler Co., Hamilton, Ohio.
Mecklenburg Iron Wks., Charlotte, N. C.
Providence Eng'g Works, Providence.
Shepherd Eng'g Co., Franklin, Pa.
Southwark Fdy. & Mch. Co., Philadelphia.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Watertown Eng. Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg.
Wetherill, Robert & Co., Chester, Pa.

EXHAUST HEADS
American Spiral Pipe Works, Chicago.
Direct Separator Co. Syracuse.
Hoppes Mfg. Co., Springfield, O.
Pittsburg Gage & Supply Co., Pittsburg.
Sturtevant Co., B. F., Hyde Park, Mass.
Watson & McDaniel Co., Philadelphia.
Wright Mfg. Co. Detroit.

FANS AND MOTORS
Century Electric Co., St. Louis.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Elec. Co., Pittsburg.
Eck Dynamo & Motor Wks, Belleville, N. J.
Elec. Motor & Equip. Co., Newark, N. J.
Emerson Electric Mfg. Co., St. Louis.
Ft. Wayne Elec. Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Wesco Supply Co., St. Louis.
Western Electric Co. Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg.

FANS—EXHAUST AND VENTILATING
Allen Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Emerson Elec. Mfg. Co., St. Louis.
Green Fuel Economizer Co., Matteawan.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Boston.
Western Electric Co., Chicago.

FIXTURES—GAS AND ELECTRIC
Benjamin Elec. Mfg. Co., Chicago.
Cleveland Gas & Fixture Co., Cleveland
Gail-Webb Mfg. Co., Buffalo.
Goodwin & Kintz, Winsted, Conn
Wells Light Mfg. Co., New York.

FLASHERS
Advertising Mirrograph Co., Brooklyn
Campbell Electric Co., Lynn, Mass.
Elec. Motor & Equip. Co., Newark, N. J
Haller Machine Co., Chicago.
Reynolds Elec. Flasher Mfg. Co., Chicago

FLEXIBLE SHAFTS
Chicago Flexible Shaft Co., Chicago.
Stow Flexible Shaft Co., Philadelphia.
Stow Mfg. Co., Binghamton, N. Y

FRICTION TAPE AND CLOTHS
Massachusetts Chemical Co.

FUSES
Arknot Co., Hartford, Conn.
Chase-Shawmut Co.
Chicago Fuse Wire & Mfg. Co.
D. & W. Fuse, Providence, R. I.
Johns-Manville Co., H. W., New York.

Classified Directory of Manufacturers—*Cont'd*

GAS ENGINE SPECIALTIES
- Lunkenheimer Co.

GAUGES—PRESSURE, STEAM, WATER
- Am. Steam Gauge & Valve Co., Boston.
- Ashton Valve Co., Boston.
- Bristol Co., Waterbury, Co., Conn.
- Hohmann & Maurer Mfg. Co., Rochester.
- Manning, Maxwell & Moore, New York.
- Pittsburg, Gauge & Supply Co., Pittsburg.
- Star Brass Mfg. Co., Boston.
- Walworth Mfg. Co., Boston.

GEARS
- New Process., Rawhide. Co.
- Nuttal Co., R. D. Pittsburg.

GERMAN SILVER
- Seymour Mfg. Co Seymour, Conn

GLASS
- Phoenix Glass Co., New York.

GLOBES, SHADES, ETC.
- Holophane Glass Co., New York
- Phoenix Glass Co., New York.

GRAPHITE
- Dixon Cruc. Co., Jos., Jersey City, N. J.

GUARDS—INC. LAMPS
- Gail-Webb Mfg. Co., Buffalo.
- Hubbell, Harvey, Bridgeport.
- Matthews & Bro., W. N., St. Louis.

HANGER BOARDS
- Ft. Wayne Elec. Works, Ft. Wayne, Ind-

HANGERS—CABLE
- Chase-Shawmut Co., Newburyport, Mass.
- Standard Underground Cable Co., Pittsburg.

HEATING DEVICES, ELECTRIC
- American Elec'l Heater Co., Detroit.
- Barr Elec. Mfg. Co., W. J., Cleveland.
- General Electric Co., Schenectady, N. Y.
- Johns-Manville Co., H. W., New York.
- Simplex Electric Heating Co., Cambridge, Mass.
- Vulcan Electric Heating Co., Chicago.

HEATING—EXHAUST STEAM
- Am. District Steam Co., Lockport, N. Y
- Diamond State Fibre Co., Elsemere, Del.
- Mica Insulator Co., New York.

HOISTS AND CONVEYORS
- Hunt, C. W., Co., New York.
- Jeffrey Mfg. Co., Columbus, O.
- Northern Engineering Works, Detroit.

HYDRAULIC MACHINERY
- Dayton Globe Iron Works Co., Dayton.
- Dean Bros. Steam Pump Wks., Indianapolis.
- Leffel & Co., James, Springfield, O.
- Pelton Water Wheel Co., San Francisco.
- Platt Iron Works Co., Dayton, O.
- Risdon-Alcott Turbine Co., Mount Holly, N. J.
- Smith Co., S. Morgan, York, Pa.

IMPREGNATING APPARATUS
- Buffalo Foundry & Machine Co., Buffalo
- Devine Co., J. P., Buffalo.
- Hubbard's Sons, Norman, Brooklyn.

INDICATORS
- American Steam Gauge & Valve Mfg Co.

INSTRUMENTS—ELECTRICAL
- American Instrument Co., Philadelphia
- Atwater Kent Mfg. Co., Philadelphia.
- Baillard, E. V., New York.
- Biddle, James G., Philadelphia.
- Bristol Co., Waterbury, Conn.
- Clark Electric Meter Co., Chicago.
- Connecticut Telephone & Electric Co., Meriden, Conn.
- Cutter Elec. & Mfg. Co., Philadelphia.
- Dongan Instrument Co., Albany, N. Y.
- Duncan Elec. Mfg. Co., Lafayette, Ind.
- Eldredge Elec. Mfg. Co., Springfield, Mass.
- Foote-Pierson & Co., New York.
- Fort Wayne Electric Works, Ft. Wayne Ind.
- General Electric Co., Schenectady.
- Keystone Elec. Instrument Co., Phila
- Leeds & Northrup, Philadelphia.
- Machado & Roller, New York.
- Pignolet, Louis M., New York.
- Queen & Co., Philadelphia.
- Robert Instrument Co., Detroit.
- Sangamo Electric Co., Springfield, Ill.

Classified Directory of Manufacturers—Cont'd

Schaeffer & Budenberg, New York
Simplex Co., Newark, N. J.
Wagner Electric Mfg. Co., St. Louis.
Westinghouse Elec. & Mfg. Co., Pittsburg
Weston Elec. Instr. Co., Newark, N. J.
Whitney Elec'l Instr. Co, New York.

INSULATING MACHINERY
Aiton Machine Co., New York.
New England Butt Co., Providence, R. I.

INSULATING MATERIAL COMPOUNDS—CLOTH AND PAPER
Anderson Mfg. Co., A. & J. M., Boston.
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—COMPOUNDS PAINTS AND VARNISHES
Macon-Evans Varnish Co., Pittsburg.
Massachusetts Chem. Co., Walpole, Mass
Standard Paint Co., New York.
Sterling Varnish Co., Pittsburg.

INSULATING MATERIAL—FIBRE
Am Vulcanized Fibre Co., Wilmington.
Diamond State Fibre Co., Elsmere, Del.
Kartavert Mfg. Co., Wilmington, Del.
Morris Elec. Co., Wilmington, Del.
United Indurated Fibre Spec. Co., Lockport, N. Y
Wilmington Fibre Spec. Co., Wilmington.

INSULATING MATERIAL—LAVA
American Lava Co., Chattanooga, Tenn
Kruesi, P. J., Chattanooga.
Steward Mfg. Co., D. M., Chattanooga

INSULATING MATERIAL—MICA
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—PORCELAIN
Imperial Porcelain Works, Trenton, N J.
Locke Insulator Mfg. Co., Victor, N. Y.
National Porcelain Co., Trenton, N. J.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATING MATERIAL—TAPE
Amer. Electrical Wks., Philipsdale, R. I.
Massachusetts Chem. Co., Walpole, Mass
Morgan & Wright, Detroit
New York Insulated Wire Co., N. Y.
Okonite Co., Ltd., New York
Schott, W. H., Chicago.
Standard Underground Cable Co., Pittsburg.

INSULATORS—GLASS
Hemingway Glass Co., Louisville
Locke Insulator Mfg. Co., Victor, N. Y
Sears, Henry D., Boston.

INSULATORS—PORCELAIN AND COMPOSITION
Anderson Mfg. Co., A. & J. M., Boston.
Imperial Porcelain Works, Trenton, N. J
Johns-Manville Co., H. W., New York
Locke Insulator Mfg. Co., Victor, N. Y
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O

INSULATOR SUPPORTS
Steel City Electric Co., Pittsburgh

JACKS
Watson-Stillman Co., New York.
Henderer's Sons, A. L., Wilmington, Del

JUNCTION BOXES
Standard Underground Cable Co., Pittsburg, Pa.
Bossert Elec. Const. Co., Utica, N. Y

KNIFE SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

LAMPS—ARC
Adams-Bagnall Elec. Co., Cleveland.
Am. Arc Lamp Co., Kalamazoo, Mich.
Anderson Mfg. Co., A. & J. M., Boston.
Beck Flaming Lamp Co., New York.
Excello Arc Lamp Co., New York.
Ft. Wayne Electric Works, Ft. Wayne.
General Electric Co., Schenectady.
Hamburger, Felix, New York.
Helios Mfg. Co., Philadelphia.
Marquette Elec. Mfg. Co., Chicago.
Toering Co., C. J., Philadelphia.
Warner Arc Lamp Co., Muncie, Ind
Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg

LAMPS—INCANDESCENT
American Electric Lamp Co., Phila., Pa.
Banner Electric Co., Youngstown, O.
Bay State Lamp Co., Danvers, Mass
Boston Incandescent Lamp Co., Danvers, Mass.
Brilliant Electric Lamp Co., Cleveland.
Bryan-Marsh Co., New York.
Buckeye Electric Co., Cleveland.
Columbia Inc. Lamp Co., St. Louis.
Economy Electric Co., Warren.
Edison Dec. & Min. Lamp Co., Harrison, N. J.
General Electric Co., Harrison, N. J.
New York & Ohio Co., Warren.
Novelty Incandescent Lamp Co., Emporium, Pa.
Rooney Elec. Lamp Co., New York
Shelby Electric Co., Shelby, O
Stuart Howland Co., Boston.
Wesco Supply Co., St Louis.
Western Electric Co. Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg.

LIGHTNING ARRESTERS
Anderson Mfg. Co., A. & J. M., Boston.
D. & W Fuse Co., Providence, R. I.
Electric Service Supplies Co., Phila.
Lord Electric Co., New York
Westinghouse Elec. & Mfg. Co., Pittsburg.

LINE MATERIAL
Anderson Mfg Co A. & J. M., Boston.

LOCKERS
Edward Darby & Sons Co., Philadelphia.
Merritt & Co., Philadelphia.

LOCOMOTIVES—INDUSTRIAL
Goodman & Co., Chicago

Classified Directory of Manufacturers—Cont'd.

Jeffrey Mfg. Co., Columbus, O.
Porter Co., H. K., Pittsburg.
Vulcan Iron Works, Wilkesbarre, Pa.

LUBRICANTS
Dixon Cruc. Co., Jos., Jersey City, N. J

MAGNET WIRE
Acme Wire Co., New Haven, Conn
Griffin, Frank B., Oshkosh, Wis.
Roebling & Sons, Trenton, N. J.
Seymons Mfg. Co., Seymons, Conn

MALLEABLE CASTINGS
Jeffrey Mfg. Co., Columbus, O.

METAL POLISH
Hoffman, George W., Indianapolis, Ind.

METALS
American Platinum Wks., Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

MICA—(See Insulating Material.)

MINING MACHINERY
Allis-Chalmers Co., Milwaukee
Dean Bros. Steam Pump Wks., Indianapolis.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
Power & Mining Machinery Co., Cudahy.

PINS—STEEL
Locke Insulator Mfg. Co., Victor, N. Y.

PLATINUM
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

PLUGS
Dickinson Mfg. Co., Springfield, Mass.
Freeman Elec. Co., E. H., Trenton, N. J.
General Mfg. & Sup. Co., Trenton, N. J.
Paiste Co., H. T., Philadelphia.

PLUGS—ATTACHMENT
Hubbell Harvey, Bridgeport, Conn.

POLES—ARC LAMP
Mott Iron Works, J. L., New York.

POLES, BRACKETS, PINS, ETC.
Bissell Co., F., Toledo, O.
Cresap Co., The, Bristol, Tenn.
Humbird Lumber Co., Sandpoint, Ida.
Kellogg Switchboard & Sup. Co. Chicago.
Sand Point Cedar Co., Sandpoint, Ida.
Southern Exchange Co., New York.
Worcester Co., C. H., Chicago.

PORCELAIN—(See Insulating Machinery).

POWER TRANSMISSION MACHINERY
Case Mfg. Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Phila., Pa
Mead-Morrison Mfg. Co., Boston, Mass
Robins Conveying Belt Co., New York.

PRESSES, DIES AND SPECIAL MACHINERY
Watson-Stillman Co., New York.

PULLEYS
Rockwood Mfg. Co, Indianapolis, Ind.

PUMPS—ELECTRIC
Allen Electric Co., Chicago, Ill.
Allis-Chalmers Co., Milwaukee, Wis.
Conover Condenser Co., Paterson, N. J.
Dean Bros Steam Pump Wks., Indianapolis.

PUMPS—STEAM
Dean Bros. Steam Pump Wks., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Platt Iron Works Co., Dayton, O.
Quimby, Wm. E., New York.
Watson Machine Co., Paterson, N. J.
Worthington, H. R., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Deming Co., Salem, O.
Morris Company, I. P., Philadelphia, Pa
Platt Iron Works Co., Dayton, O.

PUMPS—VACUUM
Alberger Condenser Co., New York.
Dean Bros. Steam Pump Wks., Indianapolis.
Hubbard's Sons, Norman, Bklyn., N. Y.
Platt Iron Works Co., Dayton, O

Classified Directory of Manufacturers—*Cont'd*

PUSH BUTTONS
Dunbar Bros., Bristol, Conn.
Sarco Company, New York.

RAIL-BONDS
Chase-Shawmut Co., Newburyport, Mass
Lord Electric Co., New York.
Roebling's Sons Co., J. A., Trenton, N J

RECEPTACLES
Benjamin Electric Mfg. Co., Chicago, Ill.
Freeman Elec. Co., E. H., Trenton, N. J.
Paiste Co., H. T., Philadelphia, Pa.

RECORDING INSTRUMENTS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.

REFLECTORS
Frink, I. P., New York.
Goodwin & Kintz, Winsted, Conn.
National X Ray Reflector Co., Chicago, Ill.
Phoenix Glass Co., New York.

REPAIRING
Gregory Electric Co., Chicago, Ill.
Heck, Louis, Newark, N. J.
Van Dorn-Elliott Electric Co., Cleveland, Ohio.
Ward, Leonard Electric Co., Bronxville, N. Y.

RESISTANCE UNITS
Cutler-Hammer Mfg. Co., Milwaukee.
Simplex Electric Heating Co., Cambridge, Mass.

RHEOSTATS
Automatic Electric Co., Chicago, Ill.
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman & Co., J. L., Chicago, Ill.
Sundh Electric Co., New York.
Ward Leonard Electric Co., Bronxville, N. Y.

ROSETTES
General Mfg. & Supply Co., Trenton.
Hart Mfg. Co., Hartford, Conn.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston, Mass
Trumbull Elec. Mfg. Co., Plainville, Conn.

RUBBER MACHINERY
Aiton Machine Co., New York.

SEARCHLIGHTS
Bogue Elec. Co., C. J., New York.
Carlisle & Finch Co., Cincinnati, O.

SECOND-HAND APPARATUS
Bender, George, New York.
Chicago House Wrecking Co., Chicago.
Dustin Co., Chas. E., New York.
Gas & Electric Development Co., N. Y.
Gregory Electric Co., Chicago, Ill.
Linder, H. J., New York.
Richter, Eugene, Philadelphia, Pa.
Station Equipment Co., Chicago, Ill.
Thompson, Joseph H., Jr., New York.
Toomey, Frank, Philadelphia, Pa.
Yearsley & Levene, Philadelphia, Pa.

SHADE HOLDERS
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SHADES
Holophane Co., New York.
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SIGNS—ELECTRIC
A. & W. Sign Co., Cleveland, O.
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C., Parkersburg, W. Va.
Metropolitan Engineering Co., N. Y.
Reynolds Elec. Flasher Mfg. Co., Chicago, Ill.

SIGN LETTERS
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C, Parkersburg, W. Va.
Matthews & Bro., W. N., St. Louis, Mo.

Classified Directory of Manufacturers—Cont'd

SLEEVING
- Belden Mfg. Co., Chicago, Ill.
- Benjamin Electric Mfg. Co., Chicago, Ill.
- Bryant Electric Co., Bridgeport, Conn.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Electrical Mfg. Co., Rochester.
- Crouse-Hinds Co., Syracuse, N. Y.
- Dunton & Co., M. W., Providence, R. I.
- Federal Electric Co., Chicago, Ill.
- Freeman Electric Co., E. H., Trenton.
- General Mfg. & Supply Co., Trenton.
- Johns-Manville Co., H. W., New York.
- Marshall Elec. Mfg. Co., Boston, Mass.
- Pass & Seymour, Solvay, N. Y.
- Peru Electric Mfg. Co., Peru, Ind.
- Porcelain Electrical Mfg. Co., Trenton.
- Stanley & Patterson, New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn.
- Weber Electric Co. (Henry D. Sears, General Sales Agent, Boston, Mass.).
- Yost Electric Mfg. Co., Toledo, O.

SOLDER
- Belden Mfg. Co., Chicago, Ill.
- Walworth Mfg. Co., Boston, Mass.
- Western Electric Co., Chicago, Ill.

SOLDERING FLUX
- Allen Co., L. B., New York.
- Dunton & Co., M. W., Providence.

SOLDERING IRONS
- Simplex Electric Heating Co., Cambridge, Mass.
- Vulcan Elec. Heating Co., Chicago, Ill.

SOLENOIDS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Schureman, J. L., Co., Chicago, Ill.

SPEED INDICATORS
- Schaeffer & Budenberg, New York.

SPRINGS
- Barnes Co., Wallace, Bristol, Conn.
- Dunbar Bros. Co., Bristol, Conn.
- Manross, F. N., Forestville, Conn.

SUPPLIES—ELECTRICAL
- Am. Elec'l Supply Co., Chicago, Ill.
- Central Electric Co., Chicago, Ill.
- Central Electric Supply Co., New York.
- Cobb, H. E., Chicago, Ill.
- Commercial Electrical Supply Co., St. Louis, Mo.
- Dearborn, Electric Co., Chicago, Ill.
- Doubleday-Hill Elec. Co., Pittsburg, Pa.
- Electric Appliance Co., Chicago, Ill.
- Electrical Material Co., Baltimore, Md.
- Erner & Hopkins Co., Columbus, O.
- Ewing-Merkle Elec. Co., St. Louis, Mo.

Classified Directory of Manufacturers—Cont'd

- Garton Co., W. R., Chicago, Ill.
- Hudson Electric Supply Co., New York.
- Latham & Co., E. B. New York.
- Machado & Roller, New York.
- Manhattan Elec'l Supply Co., New York.
- Metropolitan Elec'l Supply Co., Chicago.
- Nagel Electric Co., W. G., Toledo, O.
- Novelty Electric Co., Philadelphia, Pa.
- Ostrander & Co., W. R., New York.
- Patrick, Carter & Wilkins Co., Phila.. Pa.
- Pettingell-Andrews Co., Boston, Mass.
- Robertson Electric Co., Buffalo, N. Y.
- Sherman-Brown-Clements Co., N. Y.
- Stuart-Howland Co., Boston, Mass.
- Union Electric Co., Pittsburg.
- United Electric & Apparatus Co., Boston.
- Wesco Supply Co., St. Louis, Mo.
- Western Electric Co., Chicago.

SUPPLIES—TELEPHONE
- Am. Elec. Telephone Co.
- International Teleph. Mfg. Co.
- Kellogg Switchboard & Supply Co., Chicago.
- Western Electric Co., Chicago.

SWITCHBOARDS
- Adam Electric Co., Frank, St. Louis, Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Burke Electric Co., Erie, Pa.
- C. & C. Electric Co., Garwood, N. J.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Crescent Elec'l Mfg. Co., Rochester, N.Y.
- Crocker-Wheeler Co., Ampere, N. J.
- Crouse-Hinds Co., Syracuse, N. Y.
- D'Olier, Jr., Co., Henry, Philadelphia.
- Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
- General Electric Co., Schenectady, N. Y.
- Grady Co., S. S., Cambridge, Mass.
- Hill Electric Co., W. S., New Bedford, Mass.
- Ideal Elec. & Mfg. Co., Mansfield, O.
- Jones Electrical Co., New York
- La Roche Co., F. A., New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn
- Westinghouse Elec. & Mfg. Co., Pittsburg.

SWITCHES
- Anderson Mfg. Co., A. & J. M., Boston.
- Dickinson Mfg. Co.

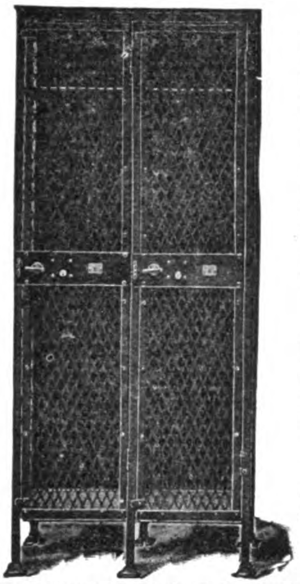
ARC LIGHTS
- Sarco Co., New York.

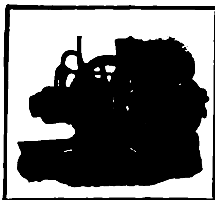
CANOPY
- Sarco Co., New York.

CEILING
- Jones Electrical Co., New York.
- Krantz Mfg. Co., H., Brooklyn, N. Y.
- Sorensen, P., Brooklyn, N. Y.

CLOCK
- A. & W. Electric Sign Co., Cleveland, O.
- Campbell Electric Co., Lynn, Mass.
- Elec. Motor & Equip. Co., Newark, N. J.
- General Electric Co., Schenectady, N. Y.
- Hartford Time Switch Co., Hartford.
- Manhattan Elec'l Supply Co., New York.
- Prentiss Clock Improvement Co., N. Y.
- Specialty Mfg. Co., Youngstown, O.
- Sorensen, P., Brooklyn, N. Y.
- Trumbull Elec. Mfg. Co. Trumbull, Conn.

SWITCHES—KNIFE
- Adam Electric Co., Frank, St. Louis Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Mfg. Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Elec'l Mfg. Co., Rochester, N. Y.
- Crouse-Hinds Co., Syracuse, N. Y.
- Garton Co., W. R., Chicago, Ill
- General Electric Co., Schenectady, N. Y.
- Hill Electric Co., W. S., New Bedford, Mass.





Classified Directory of Manufacturers—Con't'd

Ideal Elec. & Mfg. Co., Mansfield, O.
La Roche Co., F. A., New York.
Lang Electric Co., J., Chicago, Ill.
Lundin Electric & Machine Co., Boston.
Manhattan Elec'l Supply Co., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Mutual Electric & Machine Co., Wheeling, W. Va.
Ohio Brass Co., Mansfield, O.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Solvay, N. Y.
Trumbull Elec. Mfg. Co., Plainville Conn.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

OIL

Adam Electric Co., Frank, St. Louis, Mo.
Condit Elec'l Mfg. Co., Boston, Mass.
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
Helios Mfg. Co., Philadelphia, Pa.
Hill Electric Co W. S., New Bedford, Mass.
Pettingell-Andrews Co., Boston, Mass.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

SNAP

Bissell Co., F., Toledo, O.
General Electric Co., Schenectady N. Y.
Hart Mfg. Co., Hartford, Conn.
Sarco Company, New York.

PENDANT

Sarco Company, New York.

TACHOMETERS

Schaeffer & Budenberg, New York.

TAPE

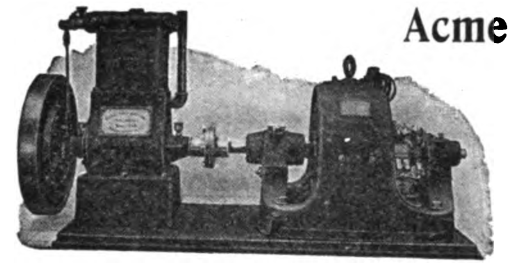
American Elec'l Wks., Philipsdale, R. I.
Boston Woven Hose & Rubber Co. Cambridge, Mass.
Brixey, W. R., New York.
Diamond Rubber Co., Akron, O.
Dunton & Co., M. W., Providence.
Electric Appliance Co., Chicago.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goodrich Co., B. F., Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
Hartford Rubber Works, Co., Hartford, Conn.
Johns-Manville Co., H. W., New York
Knowles, C. S., Boston, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
Massachusetts Chem. Co., Walpole, Mass.
Mica Insulator Co., New York.
Morgan & Wright, Chicago, Ill.
National Insulator Co., Boston, Mass.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Pennsylvania Rubber Co., Jeannette, Pa.
Republic Rubber Co., Youngstown, O.
Revere Rubber Co., Boston, Mass.
Standard Paint Co., New York.

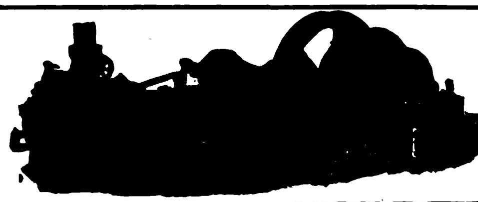
TELEPHONES

American Bell Telephone Co., Boston.
Connecticut Telephone & Electric Co., Meriden, Conn.
Couch Co., S. H., Boston, Mass.
Electric Goods Mfg. Co., Boston, Mass.
Gail-Webb Mfg. Co., Buffalo, N. Y.
Manhattan Elec'l Supply Co., New York.
Novelty Electric Co., Philadelphia, Pa.
Russell Electric Co.; Danbury, Conn.
Schmidt-Wilckes Elec. Co., Weehawken, N. J.
Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
Vote-Berger Co., La Crosse, Wis.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co.

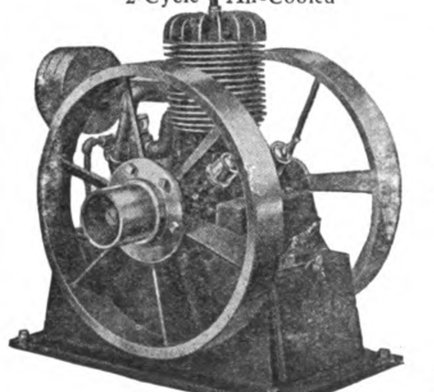
THEATER DIMMER

Campbell Electric Co., Lynn, Mass.
Cutler-Hammer Mfg. Co., Milwaukee





2-Cycle Air-Cooled



Classified Directory of Manufacturers—Cont'd

Simplex Electric Heating Co., Cambridgeport, Mass.
Union Elec. Mfg. Co., Milwaukee, Wis.
Universal Electric Stage Lighting Co. New York.
Ward Leonard Electric Co., Bronxville, N. Y.
Wirt Electric Co., Philadelphia, Pa.

TIME SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

TRANSFORMERS
Am. Transformer Co., Newark, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Irwin & Co., O. C., Crawfordsville, Ind.
Kuhlman Electric Co., Elkhart, Ind.
Lafayette Electrical Mfg. Co., Lafayette, Ind.
Moloney Electric Co., St. Louis, Mo.
Packard Electric Co., Warren, O.
Peerless Transformer Co., Warren, O.
Pittsburg Transformer Co., Allegheny, Pa.
Wagner Elec. Mfg. Co., St. Louis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

TROLLEY WHEELS
Anderson Mfg. Co., A. & J. M., Boston.

TURBINES—STEAM
Allis-Chalmers Co., Milwaukee, Wis.
Am. Turbine Eng. Co., Washington, D. C.
Ball & Wood Co., New York.
De Laval Steam Turbine Co., Trenton.
General Electric Co., Schenectady, N. Y.
Hooven, Owens, Rentschler Co., Hamilton, O.
Morris Co., I P., Philadelphia, Pa.
Westinghouse Mach. Co., Pittsburg, Pa

VALVES
Am. District Steam Co., Lockport N. Y.
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston, Mass.
Crane Co., Chicago, Ill.
Crosby Steam Gauge & Valve Co., Boston.
Fairbanks Co., New York.
Homestead Valve Mfg. Co., Homestead, Pa
Jarecki Mfg. Co., Erie, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Valve and Fitting Co. Pittsburg, Pa.
Powell Co., W. M., Cincinnati, O.
Schutte & Koerting Co., Philadelphia.
Walworth Mfg. Co., Boston, Mass.

VARNISH—ARMATURE AND COIL
Calman & Co., Emil, New York.
Eagle Paint & Varnish Co., Pittsburg.
Growthwell, A., New York.
Macon-Evans Varnish Co., Pittsburg, Pa.
Massachusetts Chem. Co., Walpole, Mass.
Sherwin-Williams Co., Cleveland.
Standard Paint Co., New York.
Standard Varnish Works New York
Sterling Varnish Co., Pittsburg, Pa.

WATER WHEELS
Allis-Chambers Co., Milwaukee, Wis
Dayton Globe Iron Works, Dayton, O.
Doble & Co., Abner, San Francisco, Cal.
Leffel & Co., James, Springfield, O.
Lombard Governor Co., Ashland, Mass.
Morris Co., I. P., Philadelphia, Pa.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co. Dayton, O.
Risdon-Alcott Turbine Co. Mt. Holly, N. J.
Smith Co., S. Morgan, York, Pa.
Trump Mfg. Co., Springfield, O.

WATTMETERS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.
Diamond Meter Co., Peoria, Ill.
Duncan Electric Mfg. Co., Lafayette, Ind.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
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Johns-Manville Co., H. W., New York.
Keystone Electrical Inst. Co., Phila., Pa.
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Whitney Electrical Inst., Co., New York.

WIRE—

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Waterbury Co., New York.
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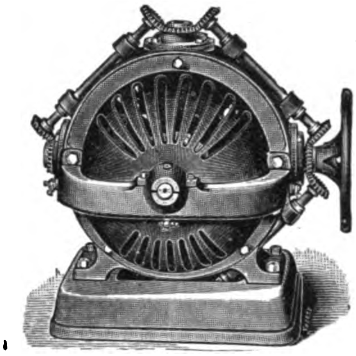

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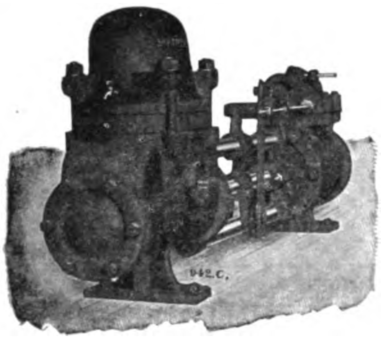

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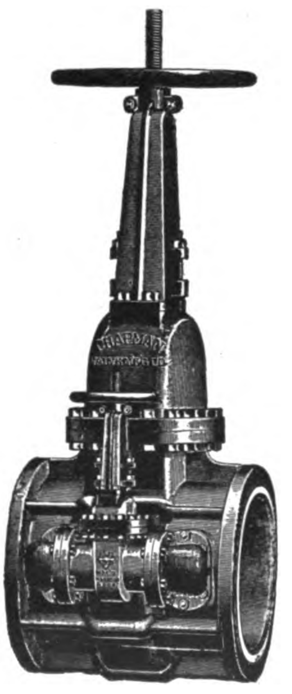

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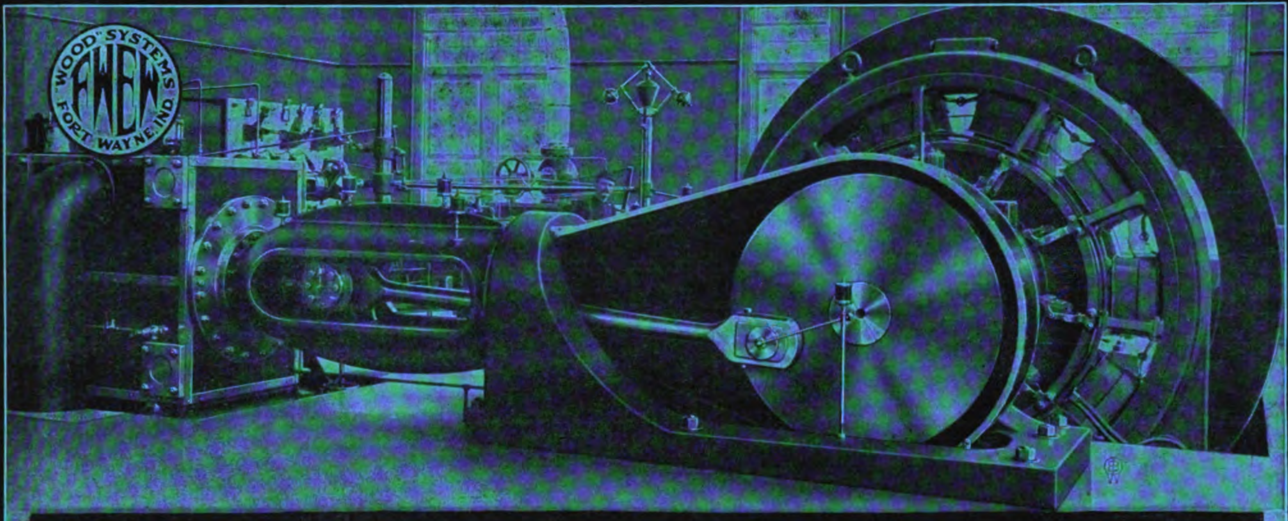

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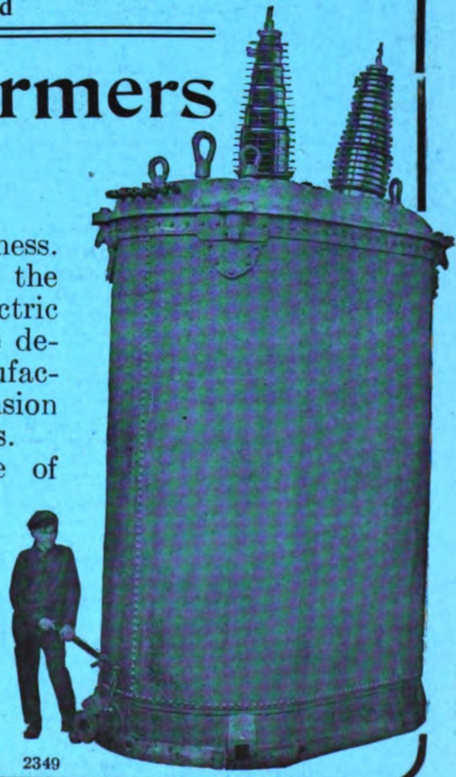

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THE ELECTRICAL AGE COMPANY, 45 E. 42d Street, NEW YORK

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No. 2

MARCH, 1910

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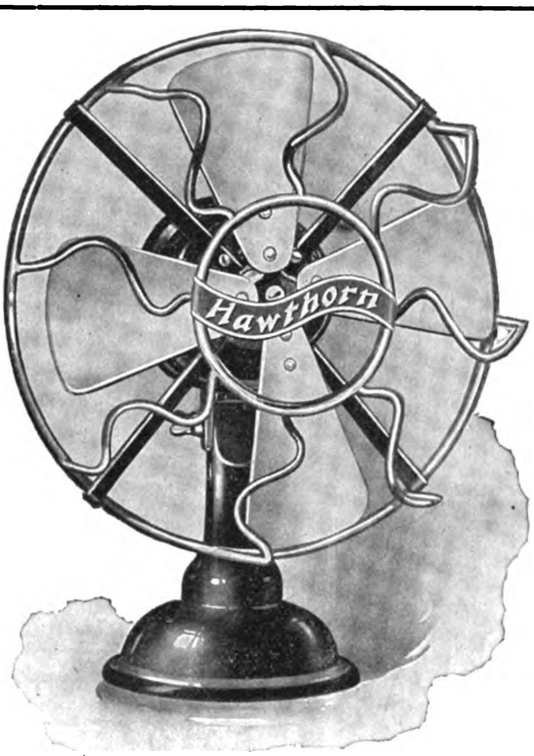
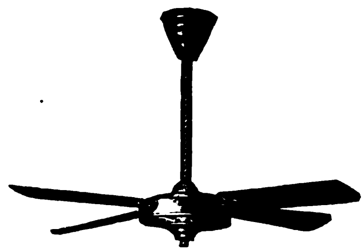
12 inch Wind Power Oscillating Fan Motor



8 inch Desk Fan Motor



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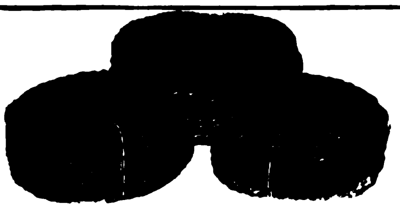
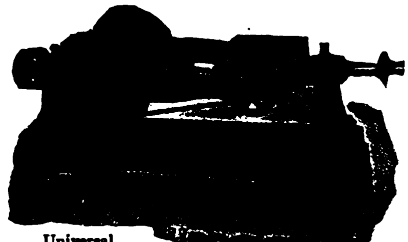
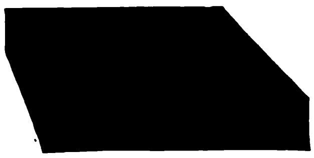
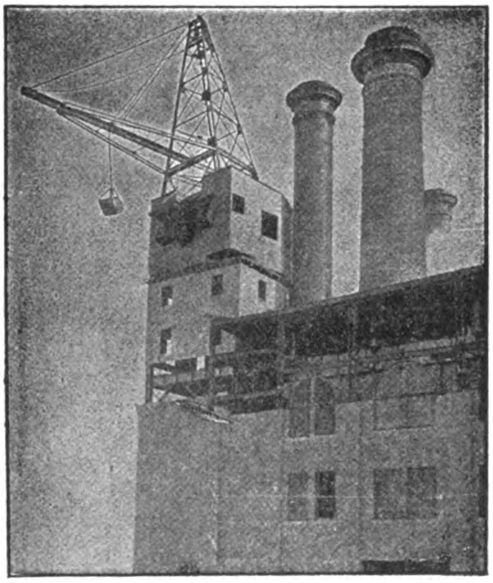


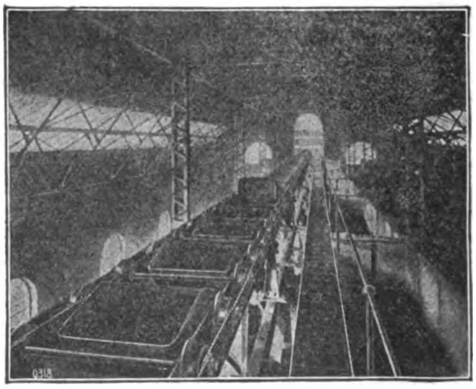


Universal Stranding Machine





This is probably the highest hoist for unloading coal in the United States. This plant is built on the banks of the Mississippi for the unloading and distributing of coal at the great station of the Union Electric Light and Power Co., St. Louis, Mo.



The bucket, standing vertically, is dumping its load

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EDITORIAL

LEADING ARTICLES

Electrification of Steam Railways

The dawn of the day when the great steam railways of the United States would retire their locomotives and, either buy storage batteries, or by some system of current collection such as a third rail or trolley line, operate their trains electrically, has been eagerly awaited since first electric motors were applied to traction work. In reading the technical journals of the eighties and early nineties it is almost pathetic in the light of after knowledge to note the enthusiastic predictions made by the optimist. Few and short were to be the days of the clumsy steam locomotive, according to the prophesy of those who cared to write on the subject. In a few years these inefficient, coal-eating machines would be either broken up and remade into electric locomotives, or stored in the museums.

Twenty years after in looking over the field we know that the prophesy was largely of a dreamy, airy and unsubstantial sort.

Steam locomotives of 1910 are bigger and better and more numerous than ever, and the advent of the electric locomotives for their work, except in very special cases, is still in the net of events. About the only thing that can be said is that we know much more about what can, and what cannot be expected, of the use of electric locomotives on steam roads than ever before, and that our knowledge is constantly growing.

Two additions to the already voluminous literature of the subject have been made recently in an article by F. Darlington in the *Engineering Magazine*, and in a paper read before the American Society of Mechanical Engineers by L. R. Pomeroy.

The former discussion is a review of the alleged advantages of electrification of steam roads and attempts to show that the saving in coal bills, which is estimated at an average of about 50 per cent., and the savings in locomotive maintenance and repairs, which are taken as averaging about 50 per cent. together with the possibilities of traffic increase, will offset the increase in fixed charges imposed by electrification when the conditions affecting the above factors are favorable, especially where traffic is dense, operating conditions unusually hard, or coal is high and electrical energy is cheaply available from water power. So much for the main line. The case for terminals is easier to make out, and one feature dwelt upon is the possibility of saving valuable space by double-decking terminals and by building over the tracks, both, of course, only possible with electric operation.

A case is worked out comparing the costs of steam and electric operation of 100 miles of road having 20 trains a day and a fuel cost of 20 cents per locomotive mile, as against electric locomotives using water power that costs $75 per kw. to develop. Wages and fixed charges are eliminated and the resultant estimated daily costs are $710 and $160, respectively, a saving of $550 in favor of electric operations. The case is too special to be of very wide application.

The plea is closed with directing attention to the very real progress that is being made in improving and cheapening the cost of installing electric service on steam roads. The future lies in the progress of the art, and the lessening of the burden of capitalization to be charged against electrification.

The paper presented to the mechanical engineers is much more detailed than the magazine article, being intended for a more special class of readers. In the cases worked out the savings in coal bills by electric operations are usually much less than that assumed above, in some instances being taken as not more than 10 per cent. It is not difficult to present cases where the proposed electrification makes a very poor showing, and this writer presents several such.

The result shown in these two discussions only serves to illustrate what is very obvious on an inspection of the problem. In any proposition where such a large number of factors are involved and the relative values of the factors are so variable, as in the case under discussion, nearly an infinite number of different solutions are bound to appear.

For instance, in considering this question, to mention only a few of the many factors, there are: Interest, depreciation, maintenance, cost of coal, cost of developing electric power, cost of line construction, costs of equipment, wage readjustment, real estate considerations, possible development of passenger traffic, same of freight traffic and last, but not least, the trend of future developments. Here are twelve general variables, all made up of numerous lesser component variables, and all more or less liable to fairly wide limits of variation. Perhaps the first one, the rate of interest to be paid on the investment of capital, is the most constant, yet even this may change as widely as 25 per cent. The public looks on the credit of trunk-line railways as fairly stable. Their securities are favorite investments. They are permitted by law where many other investments are barred. Yet it is an actual fact that one of the large steam road electrifications in this country was figured on a 5 per cent. interest basis, while another of the same class was based on 4 per cent.

If there is such a range in the limits of the most stable variant, what can be expected when the limits of the others are considered? Looking at a few of them we know that depreciation and depreciation estimates vary as much as 100 per cent.; that average maintenance of steam locomotives alone ranges from 35 cents to 5 cents per locomotive mile and less. The cost of coal varies as much as 300 per cent. The cost of developing electric power from water may range from 0.2 of a cent per kilowatt-hour up. Line constructions and electric equipment costs vary enormously, and are continually tending to decrease. The saving of wages by the substitution is widely different in different cases. Real estate savings will be absolutely different for each case, and so on throughout the list.

In this maze of changing quantities, this veritable whirlpool of variables estimated and variables actual, how are we to pick our way? What be gotten from statements *ad infinitum,* if none will agree with any other? Why discuss the case at all in the abstract? Of what value are anything but actual results and figures indisputable?

With all this in those special cases that have been already worked out, the results are surely encouraging. In this magazine we have lately shown the notable net economics made in the operation of the Mersey road. The Manhattan record has become a classic. The New York Central is about to extend its electric zone 20 miles beyond its present limits, and the New York, New Haven and Hartford are preparing to push the electric service 40 miles further to New Haven. These records and movements are the most convincing testimony as to what has been done, though the officials are not as yet giving much information on complete operating records. Thus these instances, special though they be, show that the cause of electrification is making progress.

We think that experience has shown, and will continue to show, that a few actual records are worth many estimates, but it must be remembered that all records have to be preceded by estimates. Therefore, the value of those estimates. When all the conditions are clearly stated, carefully worked out, and above all, set forth in terms that admit full comparison, both in total and in unit costs, they are of great help to those who are to make the records of the future. But we would urge that in every case all the principal elements be taken into consideration, and all results be finally expressed in terms that make them comparable with other studies of the same nature, *i. e.,* to dollars and cents. Thus in the course of time will be built up a mass of data that will afford a real indication of what can be done. With the separate working out of each case, and its addition to the whole story, the vital commercial aspects of trunk-line electrification will pass from the realm of speculative to that of exact science. But the first requisite for solid progress is that all estimates, records and discussions be rigidly brought down to expression in terms of that ultimate test of sound engineering—the balance sheet.

Economics of Feeder Design

The problem of finding the most economical cross-section of feeders for lighting power and traction purpose has been much discussed since the time that Lord Kelvin announced his famous law. Based on a geometrical proposition that the product of two complementary variables is a maximum when the variables are equal, it set forth that when the sum of the interest and other fixed charges on the money invested in the conductor equals the annual value of the power lost therein, the most economical condition was attained. More recently it has been customary to add to the fixed charges on the conductor those on the amount of generating capacity investment that must be charged to supplying the loss in the feeder at maximum load. In many cases, however, this factor may be omitted. Frequently, for instance, the selection of the maximum capacity of a plant is based on factory practice in setting the differences between successive capacities of a line generator. Often the selection is determined by prices or delivery, or any one of several circumstances entirely distinct from the capacity *per se.* Only in rather rare cases is the size selected finally determined by the amount of loss in the feeder or transmission. Hence only in those cases where the generating capacity is actually so determined should the value of that portion tied up in supplying the feeder losses be charged against the feeders.

As regards the determination of fixed charges on the conductors, the questions of depreciation and replacement charges involved have been pretty thoroughly threshed out. Practice in these respects is constantly becoming more stable, and will continue to do so.

Unfortunately, it is the last member of the equation, the value of the power annually lost in the conductor—that is, a far from easy thing to determine in advance. The same uncertainty that attaches to the prediction of what the load factor on a power plant will be, in all but very special cases, naturally applies to the load factors on the various feeders by which the load is sent out of the plant. After the plant is in operation, if properly equipped, it is easy to determine what the factor is, and the same may be said for a feeder that has a wattmeter or curve-drawing instrument in the circuit.

But the predetermination of the load on a given feeder and its distribution is rarely possible, and for a new system it will always remain a case where calculation should never be tempered with judgment, and where experience must play an important part.

With the passing of time and the enormous growth of the electrical industries, new plants and layouts will become relatively rarer, and an increasing proportion of the annual purchase of feeder conductors will be devoted to replacing out-worn or outgrown lines. In this case there is usually a record to go on, and the determination of the probable annual loss becomes possible in various ways.

Of these, probably the most accurate and ingenious yet proposed is that detailed by Mr. H. B. Gear in an article in this issue. Briefly outlined, it rests on an analysis of the load curves for the station or feeder, as the case may be, and on the development of a formula which enables all the factors involved to be expressed in terms of a single variable, the resistance.

Having thus expressed the sum of the losses in terms of a common variable, a well-known application of the calculus to the determination of maxima and minima enables the condition of maximum economy to be readily determined.

The results work out in a very simple form, and are in such shape as permit a ready application to all cases where a load curve is available, or can be safely assumed. While, as worked out by the writer, the method is mainly applicable to light and power conditions, the modifications necessary to apply it to many different uses are self-suggestive. About the only cases of feeders with determinate loads where it cannot be safely used are those where the size of conductor is determined by the other conditions than the most economical loss; as, for example, by maximum permissible drop.

That the results obtained by the application of this method give current densities somewhat below the usual practice, only serves to show the caution with which all formulæ should be used. If judgment and experience were not the main factors in successful engineering, how beautifully easy it all would be. The reasons given by the author for the divergencies are typical examples of this truth.

A New Prime Mover

The oft-repeated experience of looking for one thing and finding another, has once more brought about the unexpected. In this issue is given the description of a new type pump which is operated directly by the explosion of gas on the surface of the liquid. The inventor confesses that the ideas underlying the invention are the result of a search for a practical gas turbine. The latter is one of the most attractive subjects of research of the present day. The power and lighting interests, the traction and automobile interests and the new art of flying are all anxious to seize on the fascinating possibilities of a simple, compact, durable high-speed prime-mover, capable of operating on gas, gasolene or oil. Such a device, through the lessening of both fixed charges and fuel costs on the production of electrical energy, would enormously increase the use of electrical apparatus and stimulate nearly all lines of electrical industry.

As far as the gas turbine is concerned, the invention of the explosion pump, if it may be so termed, does not appear to bring it any nearer, but the principles involved in the pump itself are of sufficient novelty to invite a careful study.

The idea of exploding a mixture of gas and air on the surface of water with the object of raising the water is not new. For the last 40 years it has been tried in one way or another. In this device, however, the ingenious principle of making the movements of the mass of water itself control and actuate the pump mechanism is the novel feature. By the moving mass of water surging from high to low levels all pump functions, that is, the addition of fresh water, the exhaustion of burnt gases, the drawing in of a fresh charge and its compression, are performed in a quiet and orderly manner, and with very few and exceedingly simple working parts.

But the broader interest in the invention lies in the development of a new gas cycle in which the expansion line is carried down to atmospheric pressure. To-day there is no type of gas engine known to us that permits the expansion of the charge beyond the limits of the original suction volume. Therefore, the full-load exhaust of a gas engine takes place when the pressure is still between two or three atmospheres. The energy thus wasted in the exhaust is a considerable portion of the total energy of the charge. It is in the saving of a proportion of this lost energy that the new cycle developed by the explosion pump is of especial interest.

As laid down by the inventor, an ideal gas-engine cycle should fulfil the following requirements:

(*a*) The suction stroke drawing in the charge.

(*b*) The compression stroke of a variable length depending on the degree of compression desired.

(*c*) The working stroke, which should be much longer than the suction stroke to carry the expansion as far as possible.

(*d*) The exhaust stroke should also be long, like the working stroke, but its exact length would depend on the clearance.

All four strokes will thus be of unequal length and no gas engine has so far met these conditions. The explosion pump cycle by exhausting down to atmosphere should give a greater efficiency than has been possible with any cycle heretofore known.

Aside from the low expansion pressure, another attractive possibility is involved in the use of water in the internal portions where metal has heretofore always been used. One of the chief problems in gas-engine design is to meet stresses caused by the expansion strains, due to the high temperature involved. By the use of changing water internally, these stresses are largely eliminated, as the operating temperature is kept very low.

Another novel feature of this type of prime-mover is the storing of energy in the column of water, thus making a reciprocating water flywheel instead of the ordinary type.

The speed of working is evidently fixed by the period of the oscillating water column, and this for a given charge must depend on the mass of the water and length of the discharge pipe. The control of the cycle is capable of many ingenious modifications, so that the results that may be attained are not so simple as the means of attaining them would indicate.

The further development, reaching even to a power-house in which water forms the links between the exploded gas and an electrical generator, seems more fanciful than probable. Yet as the inventor points out, there is not a very wide margin of efficiency to be overcome before the net fuel consumption of such a plant might be on the right side of the balance.

A possibility is also involved in the device as an auxiliary for small water-power plants where, in times of low water, the pump might be used to return as much of the tail water as may be necessary up to the reservoir, and so enable the plant to operate 24 hr. with the expense of adding the pump and a duplicate pipe line, or for 12 hr. by installing the pump alone and a couple of extra valve fittings.

Variations in Railway Equipment Design

The diversity of means which can be taken to arrive at ends that are essentially similar is one of the striking features in the comparison of European and American machinery.

Starting from the same theory, and with the same ultimate outcome in view, designers of equal ingenuity and technical equipment are consciously, or unconsciously, influenced by the subtle differences in training and fashions of thought. More potent still in causing a different development are the differences in environment and different ways of meeting the exacting requirements of commercial competition.

Thus the effect of the high cost of labor and lower cost of material in the United States, as compared with the comparatively low cost of labor and the higher cost of material abroad, can be traced all through the output of electrical apparatus and machinery of the two countries. It has become the usual thing to find, for example, a German motor of equal rated capacity to a given American motor, much better finished in workmanship, and also much lighter in weight, and generally of less robust design.

In those cases where American machine designs have emigrated to Europe to be turned out in large quantities, it would appear that they become influenced by the conditions in their new habitat. This is certainly the case with men who emigrate, and it is only natural. The building of an American-designed generator or other machine in a shop on the other side is therefore bound to undergo some modification, if the surrounding conditions are to be met.

That this has proved to be the case with at least one well-known type of electrical machinery would be indicated by the information given in the description of the car equipment in use on the Lancaster branch of the Midland Railway in England in this issue. Here, where the reduction of weight is a very important factor, the advantage both for motors alone and for complete equipment lies with the American emigrants. The case is presented in full, and as the performance of the light-weight equipment, which will be given in the next installment, is quite as good as that of its competitor. It would seem that the reduction of weight has not been carried too far.

A comparison of the drawings and diagrams reveals a likeness that shows that the changes in the development of the present types of control apparatus have apparently about reached their limit.

Economics of Feeder Calculation

By H. B. GEAR

General Inspector Commonwealth Edison Co., Chicago

The determination of the most economical sizes of conductors for feeders, mains and transformers is of great importance and the principles governing their design should be thoroughly understood.

The distributing equipment forms a large proportion of the investment of a central station property, and the net earnings are, to a large extent, dependent upon its economy of design and operation.

In the selection of the size of a conductor for a feeder or transmission line, the energy loss tends to diminish as the size of the conductor is increased, and *vice versa*. The generating capacity required to supply the energy loss also follows a similar law.

There is a point at which the sum of the fixed charges on conductor plus fixed charges on generating capacity plus the value of energy loss is a minimum. The size of the conductor which produces this condition of minimum annual cost is that which is the most economical to employ.

The fixed charges are composed of interest on the capital, depreciation of the physical property, taxes and insurance. These quantities are necessarily computed at different rates in conformity with varying conditions in the character of the property.

The energy loss requires the consumption of fuel, and is computed at the cost of energy as delivered at the switchboard from which the circuit is supplied.

In calculating interest the investment figure should include the cost of the conductor with its insulation and any other expense which is proportional to its cross-section; also the cost of that portion of the generating equipment which is required to supply the loss of energy in the circuit at the time of the maximum load of the year.

Interest should be figured at the rate paid on the bonded debt or at the current rates for the use of money for similar public service utilities.

Depreciation should be based upon the life of the apparatus and conductors, allowing for the possibility of changes in the state of the art, and the probable second-hand value of the equipment at the end of its period of service.

The rate of depreciation is stated as a percentage and varies with the different kinds of equipment. For instance, if the life of a lead cable is found by experience to be 10 years, the depreciation would be 10 per cent. annually, less the scrap value of the copper and lead at the end of the 10-year period. If this was 50 per cent. the depreciation would be 10 per cent. of the original cost of the cable, the depreciation would be figured at 5 per cent., or if the scrap value were 25 per cent., the depreciation would be 1/10 of 75 per cent. or 7.5 per cent. annually.

The rate of figuring depreciation is necessarily a matter of judgment based on the best experience available, and is, therefore, apt to vary somewhat, according to the purpose for which the figures are to be used.

The continued evolution of the art of manufacturing electrical machinery and equipment and the rapid growth of the central station industry have caused the abandonment of the older types long before they were worn out, in order to get the more efficient newer ones. This has resulted in much higher rates of depreciation in many cases than would have prevailed had the machinery been allowed to serve out its normal life.

Generating machinery has, however, reached a reasonably high state of perfection, and can be counted on at the present time to serve during the life of its wearing parts and its insulation, which are the chief elements which are subject to depreciation.

Where the prime-mover is a waterwheel the life of the unit as a whole is more likely to be realized in actual service, as the possibilities of improvement in hydraulic equipment seem to be more limited than with steam machinery, and the size of the unit is usually made as large at the start as the water supply will justify.

Managers of large properties who have been successful in carrying their equipment through the evolution of the art with a rapid growth are, therefore, apt to consider depreciation at a higher rate than those who are starting with new and modern equipments from the ground up. The more experienced figure depreciation on generating equipment at about 6 to 7 per cent. and on buildings at 3 per cent., with an average of about 5 per cent. on the whole plant.

The usual rate of interest on bonds issued for public utilities is 5 per cent. Taxes and insurance vary directly as the amount invested, and they must be considered as fixed charges of the same class as interest and depreciation. They vary somewhat with the locality, but are usually from 1.5 to 2 per cent. The total fixed charges on station equipment may, therefore, be considered as 5 per cent. interest, 5 per cent. depreciation and 2 per cent. taxes and insurance, a total of 12 per cent.

It is, of course, assumed in the above figures that the repair and renewal account will stand all necessary maintenance costs from year to year, which are required to keep the plant in economical operating condition, and not allow the property to run down.

The rate on hydraulic development might be considered somewhat lower because of the more stable character of the equipment and smaller proportion of the total investment which is subject to wear and tear. The damage from floods must be reckoned with, however, and this sometimes reduces the life of the investment very greatly. In distributing lines the depreciation is higher and depends on the nature of the equipment, but the scrap value is a much larger proportion of the original cost than is the case with station apparatus.

Weather-proof wire consists of about 80 per cent. copper and 20 per cent. insulation in the sizes ordinarily used for feeders. There is no depreciation on the copper except the labor of replacing it about once in 10 or 12 years, when the insulation is worn out. The increase in the value of copper as years go by is likely to offset the loss on the insulation, so that at best it is an uncertain quantity. It will be conservative, however, to figure 10 per cent. on the 20 per cent. of insulation or 2 per cent. and 1 per cent. for the labor of replacing, making a total of 3 per cent. of the original cost of the wire. Poles have a life of about 15 years with little salvage value. Other material must be replaced every five to ten years. The average rate for overhead lines may, therefore, be taken at 6 per cent. with alternating-current systems and 4 to 5 per cent. with low-tension systems.

The life of lead sheathed paper or rubber cables is as yet indeterminate, but there is good reason to believe that these may be serviceable for at least 15 years. The scrap value is comparatively high, as the copper is a large part of the original cost, and the lead sheath constitutes a considerable percentage of the cross-section of the cable. It is, therefore, fair to estimate the depreciation on lead sheathed cables at 3 per cent., for cables of 4/0 and over and at 5 per cent. for the smaller sizes.

In a growing system the replacement of feeders, due to the expansion of the load, results in more rapid depreciation than is experienced in a system where the feeder conductors remain undisturbed until they are too far gone to be of further service.

In estimating the value of generating capacity required to deliver the loss at maximum load, the cost of boilers, prime-movers and generators should be included, as all are affected. This cost varies greatly in different plants, depending upon the size and character of the equipment. In engine-driven stations of less than 1000 kw. the value of this equipment runs from $125 to $150 per kilowatt, while in turbine plants this cost is reduced to $80 or $100 per kilowatt. In turbine plants of 5000 kw. and upward the investment, exclusive of buildings and real estate, is as low as $65 in some cases.

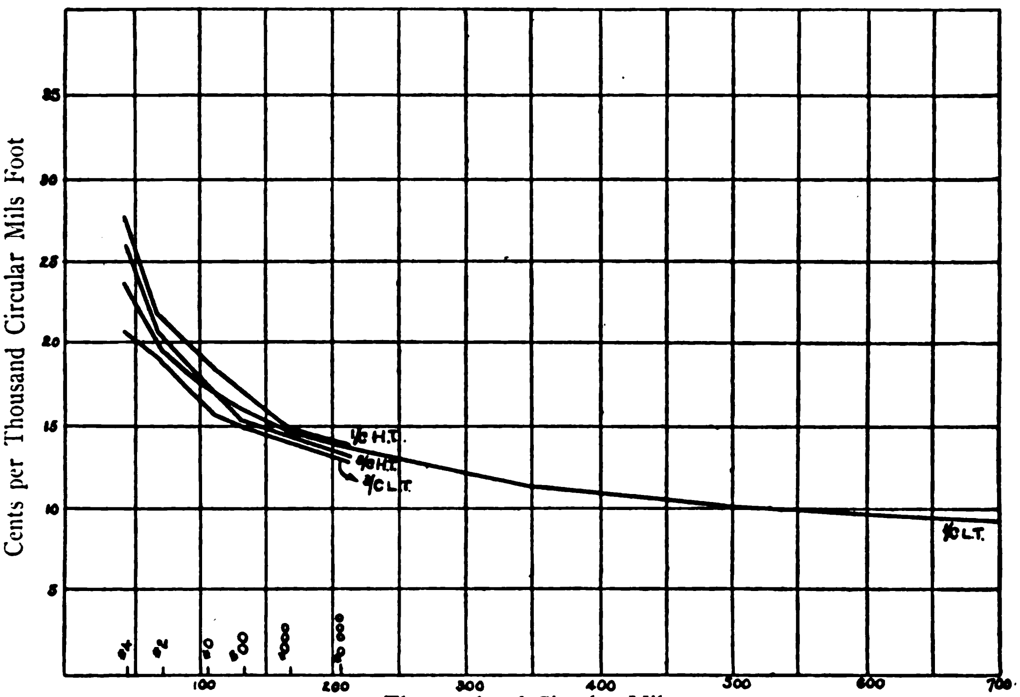
In direct-current plants, which generate at the distributing voltage, the generators must be wound to deliver the pressure required by the longer feeders. The shorter feeders may, therefore, be designed to carry the load with reference to heating only, as nothing can be saved in generating capacity by using larger conductors. The value of generating capacity may, therefore, be ignored in selecting the size of such feeders.

The total fixed charges on underground cable and conduit work may be taken at 5 per cent. interest, 4 per cent. depreciation and 1 per cent. taxes, a total of 10 per cent. Similarly the total rate on the average overhead system should be taken at 12 per cent.

Line transformers have an average life of 12 to 15 years, the scrap value being about 20 per cent. of the original cost, making the rate of depreciation about 6 per cent. These may, therefore, be included as a part of the overhead distributing system in figuring the fixed charges, if desired.

GENERAL EQUATION

The investment in conductors varies inversely as their resistance per 1000 ft.; the investment in generating capacity and the value of the energy loss vary directly as the resistance per 1000 ft. It is, therefore, possible to establish an algebraic equation having each of three elements of annual cost expressed in terms of a common variable, R, the resistance per 1000 ft. of conductor.



Thousands of Circular Mils

Fig. 1.—CURVES OF CABLE COSTS

If a represents the annual value of the investment in conducting capacity element, b the annual value of the investment in generating capacity and c the annual value of the energy lost in the conductors, the relation of these quantities may be expressed by the equation

$$y = \frac{a}{R} + bR + cR,$$

y being the sum of the three values. This equation is now fully discussed hereafter.

Such an expression is possible, since the cost of insulation varies approximately with the size of the conductor, and the pole-line or conduit-line investment is practically the same for any one of several adjacent sizes of wire or cable, and is, therefore, eliminated from the equation.

COST OF CONDUCTOR

The value of the conductors composing a circuit is directly proportional to their size and inversely to their resistance when the conductors are bare or insulated for overhead construction. With lead sheathed cable the cost is not directly proportional, except when a few adjacent sizes are considered separately in comparison with each other.

For bare wire the product of weight, W, per 1000 ft. by resistance, R, per 1000 ft. for all sizes is WR = 32, while with weather-proof insulation it is WR = 38 for the sizes No. 4 to No. 0, or 36 for sizes for 2/0 to 350,000 c.m. The value of 1000 ft. of conductor at 15 cents per lb. is, therefore, 0.15 W dollars. Hence when $W = \frac{38}{R}$, the cost per conductor of a circuit L 1000 ft. long is $\frac{0.15 \times 38 L}{R}$ dollars.

With fixed charges at 9 per cent., this element of annual cost is

$$a = \frac{0.09 \times 0.15 \times 38 L}{R} = \frac{0.513 L}{R}$$

dollars per year per conductor. When bare wire is used

$$W = \frac{32}{R} \text{ and } A = \frac{432 L}{R}$$

With underground conductors there is no approximately constant ratio between cost of conductor and resistance, except in the sizes of cable above 4/0 B. & S. The value of insulation and lead sheath is a large proportion of the cost of the smaller sizes of cable, and a change in the size of the copper conductor does not make a proportionate change in the cost of the cable.

The curves in Fig. 1 show the variation in cost per 1000 cir. mils of single and three conductor cables for low-tension work and for ordinary primary distributing voltages.

The resistance of a mil foot of copper at ordinary temperatures being about 10.4 ohms, this is also the resistance of 1000 cir. mils of conductor 1000 ft. long. If R is resistance per 1000 ft. and M is the number of thousands of circular mils, the cost of a single conductor cable is M × the cost per 1000 cir. mils. $R = \frac{10.4}{M}$ whence $M = \frac{10.4}{R}$ and the cost of the cable is $\frac{L \times 10.4 \times P}{R}$ where P is the price per 1000 cir. mils.

For single conductor low-tension paper cable P averages $1.20 for cables from 2/0 to 500,000 cir. mils, and the value of each conductor is

$$\frac{10.4 \times 1.2\,L}{R} = \frac{12.48\,L}{R}.$$

With fixed charges assumed at 9 per cent., the annual cost due to conductors is

$$a = \frac{0.09 \times 12.48\,L}{R} = \frac{1.12\,L}{R}$$

per conductor. In applying this, if the most economical size proved to be below or above the sizes for which the cost was assumed, the figures should be corrected, using the price per 1000 cir. mils corresponding to the size which seems on the first approximation to be the most economical. In this way the most economical size may be determined on the second determination if the first seems to have been based on false premises.

With three conductor cables the cost per 1000 cir. mils in the curve is based on the total cross-section of the three conductors. In this case the cost of the cable is $\frac{3 \times 10.4\,P\,L}{R}$ and

$$a = \frac{0.09 \times 3 \times 10.4\,P\,L}{R} = \frac{2.8\,P\,L}{R}$$

Thus the value of a may be derived for different kinds of cable and at various values of copper, lead and insulation. It must be borne in mind that these values are for a single cable. Where a circuit is composed of more than one cable, this must be taken into account in figuring the total annual cost for the circuit. That is, for a two wire circuit the value of a is doubled and for three cables it is tripled.

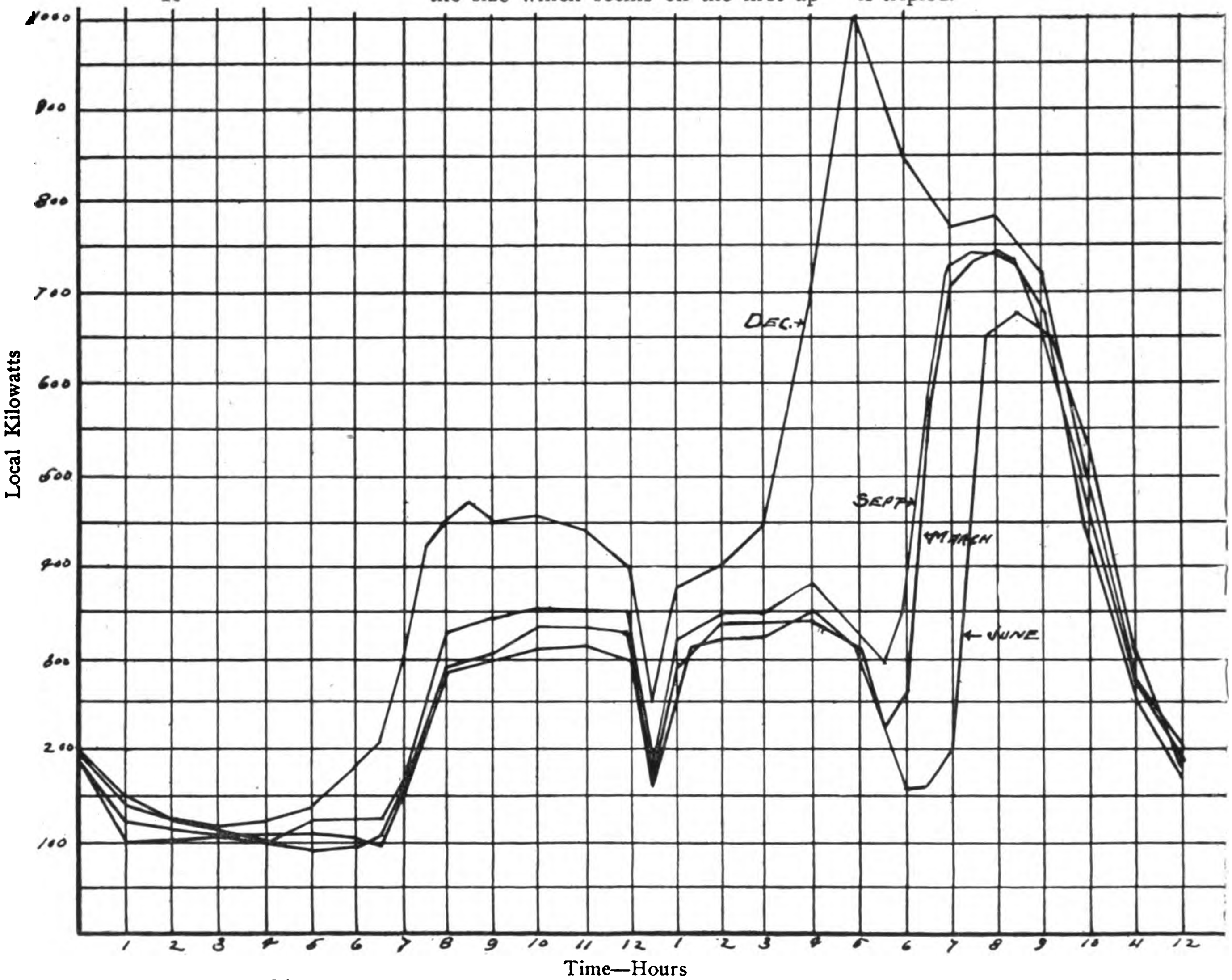


Fig. 2.—TYPICAL DAILY LOAD CURVES—LIGHTING FEEDER WITH SOME POWER LOAD

FIXED CHARGES ON GENERATING EQUIPMENT

Where conditions are such that a saving in generator capacity could be made or some capacity released for commercial load by the use of larger conductors, the fixed charges on generating equipment should be considered one of the elements of annual cost of operating a circuit. This is usually the case where alternating current is distributed through potential regulators or through substation transforming apparatus, which converts the feeder loss into a load on the armature of the generator.

Where the loss is represented by the range of voltage of the generator fields, a saving in generating capacity cannot always be realized, as operating conditions usually necessitate a range of 10 to 15 per cent. in the generator fields, which proportionately reduces the ampere rating of the armature for a given rated capacity.

The station capacity required to supply the energy loss at the time of the annual maximum load is $\frac{C^2 R L}{1000}$ kw.

The value of this capacity is represented by steam and electrical equipment in a steam station. The real estate, building and accessories are not usually sufficiently affected to require their consideration as an element of cost.

In a hydraulic development the value of generator and water-wheels is the only part affected materially. The value of generating capacity in a steam station varies with the size of the units from $100 to $150 per kw. in engine-driven stations and from $75 to $100 in turbine stations. The value of station capacity required to supply the loss on a feeder when the cost is $100 per kw. is $\frac{100 \times C^2 R L}{1000}$ and the fixed charges at 12 per cent. are

$$b = 0.12 \times 0.1\ C^2 R L$$
$$= 0.012 \times C^2 R L$$

dollars per conductor.

CALCULATION OF ENERGY LOSS

The loss of energy on a circuit during a year is dependent upon the daily and hourly variation of load throughout the year. The loss for any hour may be considered as $C^2 R$, when C is the average value of the current during that hour.

The variation from hour to hour in general distribution work changes from day to day, depending upon the habits of the people who use the electricity, and from season to season as the length of the daylight hours changes. During the winter months the use of light begins in the late afternoon before the day power load has been cut off. This overlapping causes a very sharp peak in the load curve in many cases. In Fig. 2 typical average curves are shown for a lighting feeder which carries some day power load for the months of March, June, September and December. The energy loss will evidently be different on this feeder each month in the year, being least during the summer months and most during December. Fig. 3 shows similar curves for a power circuit which carries some lighting during the evenings. This curve is also similar to that which prevails on a transmission system where a considerable amount of power is supplied to industrial concerns during the day.

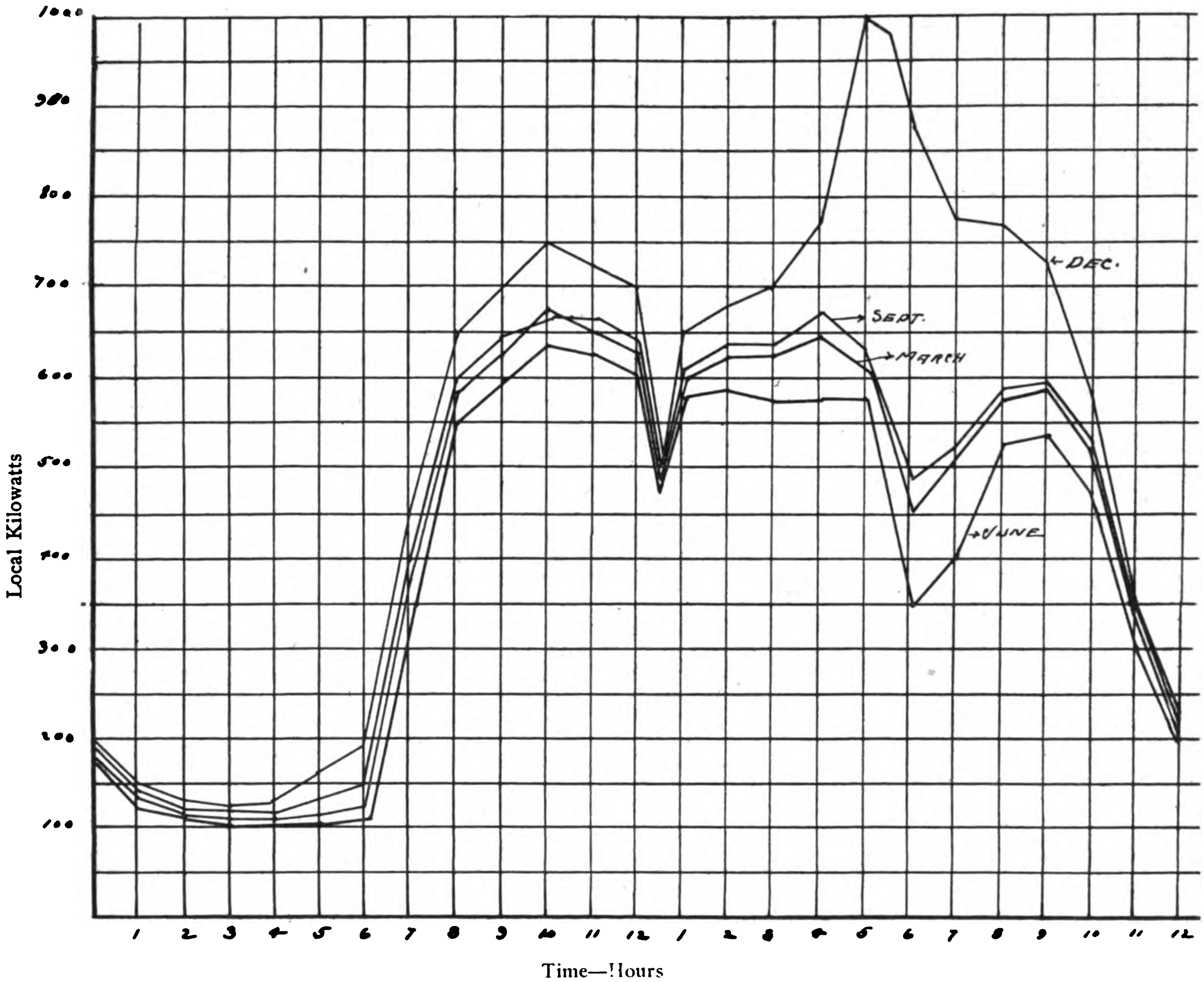


Fig. 3.—TYPICAL DAILY LOAD CURVES—POWER FEEDER WITH SOME LIGHTING LOAD

The annual loss on a circuit-carrying load of given characteristics may be computed with sufficient accuracy for practical purposes as follows:

Taking the curve representing an average day in March, assume a resistance of one ohm and compute the value of $C^2 R$ for each hour of the day. The sum of these 24 quantities is proportional to the kilowatt hours loss on an average day in March. Repeat this operation for the June, September and December curves. Add the sum of the four curves and multiply by 91, this being the number of days in each quarter of the year. This grand total is proportional to the annual loss in kilowatt hours on any feeder carrying a load having the general characteristics assumed.

LOSS FACTOR

The ratio of the loss as thus calculated to the value of the loss if the feeder had carried the maximum load of the year every hour of the year may be called the *loss factor,* just as the ratio of the actual output for the year to the possible output at the rate of the maximum load is called the *load factor* of a circuit.

For instance, if a circuit carries a maximum load of 100 kw. and delivers an amount of energy equivalent to a load of 100 kw. during 2190 hr. per year, the load factor of, the feeder for the year is $\frac{2190}{24 \times 365} = 25$ per cent.

Similarly if the total kilowatt hour loss on a circuit for a year is equivalent to the loss at maximum load multiplied by 2190, the loss factor for the feeder year is 25 per cent.

If C is the current at the annual maximum load and R is the resistance per 1000 ft. of conductor, the loss at the time of the annual maximum load is $C^2 R$.

If the loss factor of the feeder is 20 per cent., the annual loss is

$$\frac{C^2 R}{1000} \times 1752 \text{ kilowatt-hours.}$$

The loss factor for a load having the characteristics illustrated in Fig. 2 is 16 per cent., while that of the curves in Fig. 3 is 25 per cent.

In a constant current circuit the loss factor is the ratio of the number of hours the circuit is operated during the year to the total number of hours in the year. It is the same as the load factor of the circuit.

When the character of the load curve is known, the loss factor may be determined and the annual loss of energy calculated in terms of R, the resistance per 1000 ft. of conductor without difficulty.

The loss at the annual maximum load being C^2 R L, the annual loss in kilowatt hours is equivalent to the product of the maximum load loss by the number of hours in the year and by the loss factor.

There being 8760 hr. in a year, this is $\frac{C^2 R L \times 8760 \times F}{1000}$ or 1.4 C^2 R L when the loss factor is 16 per cent. The value of this energy may be computed at the cost of fuel and supplies, as no extra labor is required to deliver it, as a rule. The cost can, therefore, be taken at about 1 cent in smaller plants 0.7 cents in larger engine plants and 0.5 to 0.4 cents in turbine plants.

At 1 cent per kilowatt hour, the value of the energy loss per conductor is c = 0.014 C^2 R L dollars per year at 16 per cent. loss factor or 0.021 C^2 R L at 24 per cent. loss factor.

SUMMARY OF ANNUAL COSTS

The total annual cost is, therefore, the sum of the three quantities, a, b and c. For weather-proof wire with station capacity at $100 per kw. and a loss factor of 16 per cent. at 1 cent. a kilowatt-hour, the annual cost is

$$a + b + c = \frac{0.513 L}{R} + 0.012 C^2 R L + 0.014 C^2 R L$$

$$= \frac{0.513 L}{R} + 0.026 C^2 R L.$$

It is desired to ascertain when the value of these three elements will be a minimum for given values of C the current at the time of the annual maximum load and L the length of conductor in thousands of feet. The only variable in the equation being R. the value of a + b + c = y will be a minimum, according to the rule of the calculus, when $\frac{dy}{dR} = 0$.

If

$$y = \frac{0.513 L}{R} = 0.026 C^2 R,$$

then

$$\frac{dy}{dR} = \frac{0.026 C^2 R^2 L - 0.513 L}{R^2}$$

When this is 0,

$$0.026 C^2 R^2 L - 0.513 L = 0$$

and

$$C^2 R^2 = \sqrt{\frac{0.513}{0.026}} = 19.7,$$

whence

$$C R = \sqrt{19.7} = 4.44$$

and $R = \frac{4.44}{C}$ when the most economical size is used.

For instance, if C = 100 amperes, R = 0.0444 ohm, which is about the resistance of 4/0 cable.

It is apparent from the form of this result that the length of the circuit does not affect the economical size for a given value of maximum load current. The doubling of the length of a line doubles all of the elements of cost, and, therefore, has no effect on the point of minimum annual cost as long as the working voltage remains the same.

The voltage used should be as high as is practicable, in order that the current values may be as low as possible, since the size of the conductor is fixed by the current. In distribution work, the voltage being fixed by practical considerations of safety and continuity of service, as well as by the nature of the current, whether direct or alternating, the current values and sizes of conductors are fixed by the load on the circuit. With transmission lines, the voltage is limited somewhat by the cost of insulating wires and apparatus, but the upper limit is usually fixed by the practicability and safety of operation. The voltage being chosen as high as is practicable, the maximum load current is thus fixed, and the best size of conductor for that load may then be determined by the foregoing method.

PRACTICAL ILLUSTRATIONS

For illustration, a few cases, which are common in practice for both larger and smaller systems, are carried through herewith:

Case I.—Value of weather-proof wire taken at 15 cents per lb. with generating capacity at $125 per kw., energy at 0.1 cent. per kw-hr. and a load curve such that the loss factor is 12 per cent. Under these conditions

$$a = \frac{0.513 L}{R}, \quad b = 0.15 C^2 R L,$$

$$c = 0.0105 C^2 R L,$$

and the total cost is

$$\frac{0.513 L}{R} + 0.0255 C^2 R. L.$$

whence

$$C^2 R^2 = \frac{0.513}{0.0255} = 20.1,$$

and C R = 4.48 for each conductor carrying the current C.

This, therefore, applies only to a two-wire or three-wire circuit in which each conductor carries current normally. With a three-wire Edison feeder with neutral half the size of the outers, the amount of copper is increased 25 per cent., without inincreasing b and c, and

$$a = \frac{0.513 \times 1.25 L}{R} = \frac{0.641 L}{R}.$$

Hence

$$C\,R = \sqrt{\frac{0.641}{0.255}} = 5.01$$

for the outer conductors of a three-wire circuit.

Similarly with a four-wire three-phase feeder with neutral the same size as the phase wires, the amount of copper is increased 33 per cent. and whence

$$a = \frac{0.513 \times 1.33\ L}{R} = \frac{0.684}{R},$$

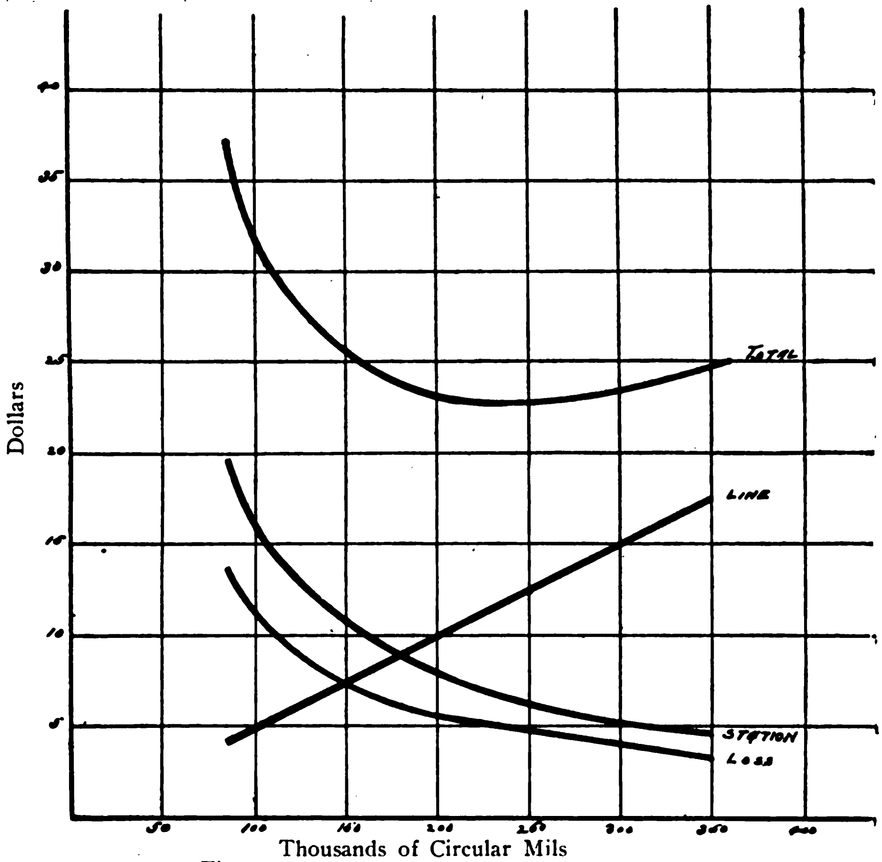


Fig. 4.—CURVES OF CHARGE AND LOSS RELATIONS

$$C\,R = \sqrt{\frac{0.684}{0.0255}} = 5.17.$$

These values involve a current density of about 0.5 ampere per 1000 cir. mils, which is much lower than is commonly found. This is probably due to the fact that the expenditure of funds for line conductors is plainly before the engineer, while the value of the generating capacity which he ties up by cutting the size of the conductor to a minimum is not so apparent. Often, too, there is reserve generating capacity, which is already paid for and can as well be used to supply line losses as not. Under such circumstances if generating capacity is to be ignored, the annual cost becomes a + c, which for the conditions assumed for a two-wire feeder is $\frac{0.513\ L}{R} + 0.0105\ C\ R.$

Hence

$$C\,R = \sqrt{\frac{0.513}{0.0105}} = 7.0$$

for a circuit in which each wire carries current, or

$$C\,R = \sqrt{\frac{0.641}{0.0105}} = 7.81$$

for a three-wire Edison feeder with neutral half size, and

$$C\,R = \sqrt{\frac{0.684}{0.0105}} = 8.07$$

for a four-wire three-phase feeder with neutral same size.

Case II.—Weather-proof wire at 15 cents a lb., generating capacity at $80 a kw., energy at 5 cents per kw-hr. and load curve such that the load factor is 18 per cent. Under these conditions

$$a = \frac{38 \times 0.15 \times 0.09\ L}{R} = \frac{0.513\ L}{R},$$

$$b = \frac{80 \times 0.12}{1000} C^2\ R\ L$$

$$= 0.0096\ C^2\ R\ L,$$

$$c = \frac{0.005 \times 8760 \times 0.18\ C^2\ R\ L}{1000}$$

$$= 0.0079\ C^2\ R\ L.$$

Hence

$$C\,R = \sqrt{\frac{0.513}{0.0175}} = 5.43$$

per conductor which carries a current C.

If generating capacity is ignored

$$C\,R = \sqrt{\frac{0.513}{0.0079}} = 8.1.$$

This calls for a conductor having 0.081-ohm resistance for 100 amperes, which is about equivalent to 1260 cir. mils per ampere. Three-wire Edison and four-wire three-phase values are readily obtained as above.

Case III.—Underground cables at values given in Fig. 4, generating capacity at $80 per kw., energy at 4 cents per kw-hr. and loss factor at 25 per cent. With single conductor low-tension cable, No. 2 to 2/0 the cost per 1000 cir. mils averages $1.80. Hence

$$a = \frac{0.09 \times 10.4 \times 1.8\ L}{R} = \frac{1.68\ L}{R},$$

$$b = \frac{80 \times 0.12\ C^2\ R\ L}{1000}$$

$$= 0.0096\ C^2\ R\ L,$$

$$c = \frac{0.004 \times 8760 \times 25\ C^2\ R\ L}{1000}$$

$$= 0.0087\ C^2\ R\ L$$

and

$$C\,R = \sqrt{\frac{1.68}{0.0183}} = 9.5$$

per conductor carrying current C.

With 100 amperes $R = \frac{9.5}{100} =$ 0.095, which is nearly the resistance of No. 0 conductor. Hence the value assumed for cost of cable was practically correct.

If the current were 500 amperes, the value of cable should be chosen at that for 500,000 cir. mils, which is $1.02. Then

$$a = \frac{1.68 \times 1.026}{1.8\ R} = \frac{0.9516}{R},$$

$$C\,R = \sqrt{\frac{0.951}{0.0183}} = 7.2.$$ At 500 amperes R should be made $\frac{500}{7.2} =$ 0.0144, which is approximately the resistance of a 700,000 cir. mils cable. The cost of that size per circular mil

is only 5 per cent. less than 500,000, and the result is, therefore, as nearly correct as it can be made. If this were a low-tension feeder with neutral half size, the cost of the feeder would be \$2.04 + \$1.30 = \$3.34 per 1000 cir. mils. Hence

$$a = \frac{3.34 \times 0.09 \times 10.4\ L}{R},$$

$$b = 2 \times 0.0096\ C^2\ R\ L$$

and

Hence

$$C\ R = \sqrt{\frac{6.74}{0.0549}} = 11,$$

$$R = \frac{0.11}{100} = 0.011,$$

which is nearest the resistance of No. 0 cable.

Case IV.—Three conductor cables, generating capacity at \$80 per kw.,

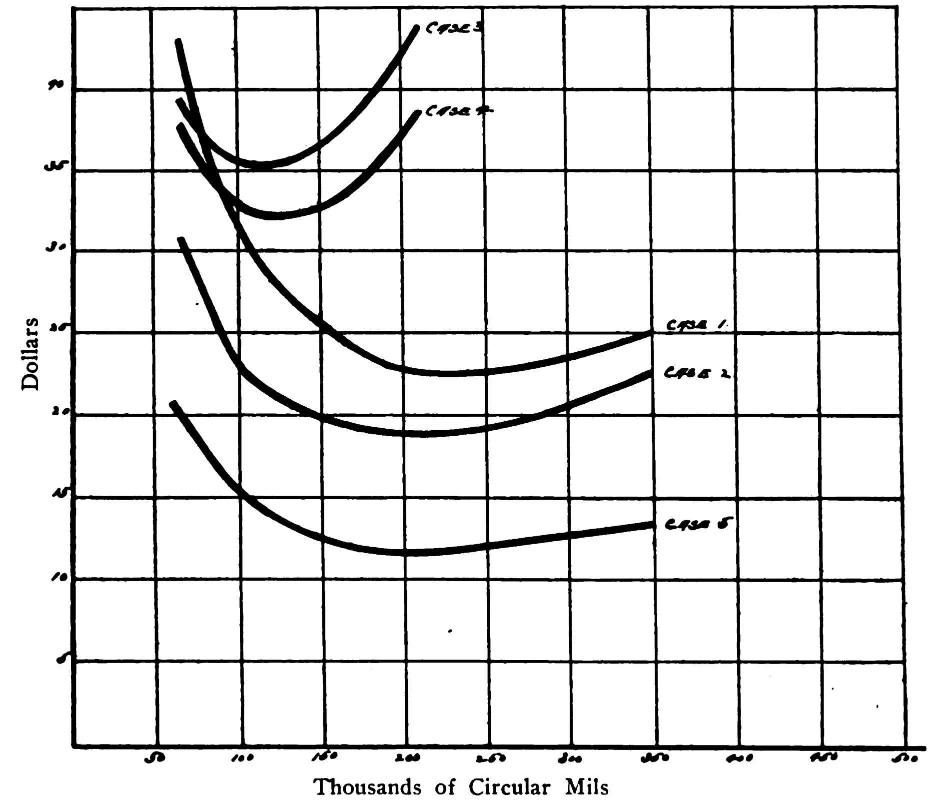


Fig. 5.—CURVES OF TOTAL COSTS FOR CASES WORKED OUT

$$c = 2 \times 0.0087\ C^2\ R\ L$$
$$= 0.0174\ C^2\ R\ L$$

for the feeder.

$$C\ R = \sqrt{\frac{3.12}{0.0366}} = 9.2$$

and

$$R = \frac{9.2}{500} = 0.0184,$$

which is between the resistance of 500,000 and 600,000 cir. mils cable. This covers the outer wires only, the neutral being considered as carrying no load and as half the size of the outer.

In the case of a four-wire three-phase feeder with neutral the same size as the phase wires, the value of the feeder at 100 amperes is

$$4 \times 1.80 = \$7.20 \text{ and } a = \frac{6.74\ L}{R},$$

$$b + c = 3 \times 0.0183,\ C^2\ R\ L$$

$$= 0.0549\ C^2\ R\ L.$$

energy at 0.4 cent per kw-hr. and loss factor at 25 per cent, 2000 volt, three phase, 100 amperes. The cost of cable is \$1.50 per 1000 cir. mils.

$$a = \frac{\$1.50 \times 0.09 \times 10.4\ L}{R} = \frac{1.41}{R}$$

per conductor.

$b + c = 0.0183\ C^2\ R\ L$ per conductor, as each carries the current C.

$$C\ R = \sqrt{\frac{1.41}{0.0183}} = 8.8,$$

$$R = \frac{8.8}{100} = 0.088,$$

which is nearest the resistance of 2/0 cable.

Case V.—Bare wire overhead, water power generating capacity at \$100 per kw., copper at 15 cents per lb., current 100 amperes. The depreciation item in the fixed charges on conductors may be ignored, as there is no insulation to be replaced. Fixed charges may, therefore, be computed at 5 per cent. interest and 1 per cent. taxes, or 6 per cent. on the line wire.

$W = \frac{32}{R}$ and the cost per 1000 ft. is

$$0.15\ W = \frac{15 \times 32}{R}.$$

Hence

$$a = \frac{0.06 \times 0.15 \times 32}{R} = \frac{0.288}{R}.$$

The value of station capacity being \$100 per kw. is $\frac{100\ C^2\ R}{1000} = 0.1\ C^2\ R$

and

$b = 0.1 \times 0.12\ C^2\ R = 0.012\ C^2\ R.$

The power being derived from water falls, $c = 0$.

The annual cost is

$$a + b = \frac{0.288}{R} + 0.012\ C^2\ R.$$

$$C\ R = \sqrt{\frac{0.288}{0.012}} = \sqrt{24} = 4.9.$$

$$\text{At 150 amperes } R = \frac{4.9}{150} = 0.032,$$

which is about the resistance of a 300,000 cir. mils cable.

This represents a very low-current density, due to the fact that fixed charges on line capacity are only half those on station capacity. It is, therefore, economical to invest money in line conductors which will make more of the generating capacity available for commercial load when it is required.

In cases where distributing feeders are supplied from water power through a transformer substation, the calculation for the best size of feeders should be made with the cost of generating transmission and substation equipment in view, in determining the fixed charges on generating capacity.

The curves in Fig. 4 show how the line charges, station capacity charges and line losses (with steam power) are related to each other where the line current is 100 amperes. The line is weather-proof wire and other conditions are those assumed in Case I.

Fig. 5 shows the curves of total cost for Cases I, II, III, IV and V.

The application of the foregoing principles to distributing mains cannot be carried out, as such mains carry indeterminate loads, and should be so designed that the drop on them will not exceed 2 per cent. In many cases this requirement involves the use of larger conductors than would be required from mere economic considerations of line loss.

Distant Control Switchgear

STEPHEN Q. HAYES

PART II—Continued

The direct-pneumatic operation of oil switches or circuit-breakers has not been used to any great extent, but the electro-pneumatic operation was applied by the General Electric Company to the oil circuit-breakers they supplied about the year 1898 to the power plant of the Brooklyn Edison Company. In the early type used in the Bay Ridge station for the control of 6600-volt generators, the breaker comprised three pairs of inverted U-shaped copper strips, the ends of which entered contacts mounted under oil contained in wooden buckets. These three pairs of strips, giving four breaks per phase, were attached to and lifted by a cross-head operated by the piston in the air cylinder. This piston was moved by compressed air controlled by three magnets—one to latch the switch open or closed and the other two to admit air above or below the piston to close or open the breaker. Emergency knife switches shunted by a fuse were placed in series with the oil-breaker and heavy shorts were pulled on the knife switches to save the oil-breaker. This practice seems very strange now in view of the splendid performances of oil-breakers, but these were pioneer breakers and their operation was more or less problematical.

The next step in the design of the electro-pneumatic breaker illustrated was one of the 300-ampere, 10,000-volt, three-pole breakers supplied in 1900 to the Metropolitan St. Ry. Co. Here the wooden tubs have been succeeded by brass pots mounted on porcelain insulators with each contact in a separate pot and each pair of pots in a separate masonry compartment, this being the forerunner of the well-known H3 motor-operated oil-breaker made by this manufacturer. This breaker for the Metropolitan plant was operated by compressed air, but there was only one magnet which works on a D valve in opposition to a spring, and when the magnet was energized the valve is operated in such a manner as to admit air above the piston and exhaust it below, closing the main contacts. If current is cut off the spring operates the valve in such a manner as to open the breaker. An air-controlled latch holds the breaker in the open position and keeps the cross-head from falling closed.

Until a very recent date all of the large capacity high voltage oil-breakers made by the General Electric Co. have been electrically operated, but for the latest type of high-voltage breaker electro-pneumatic operation has been resorted to again. Fig. 20 shows one of the 100,000-volt pneumatically operated oil-breakers supplied by the General Electric Co. for the Feather River plant of the Great Western Power Co. Each three-pole breaker consists of three independent pneumatically operated single-pole units operated by a single valve controlled electrically from the switchboard.

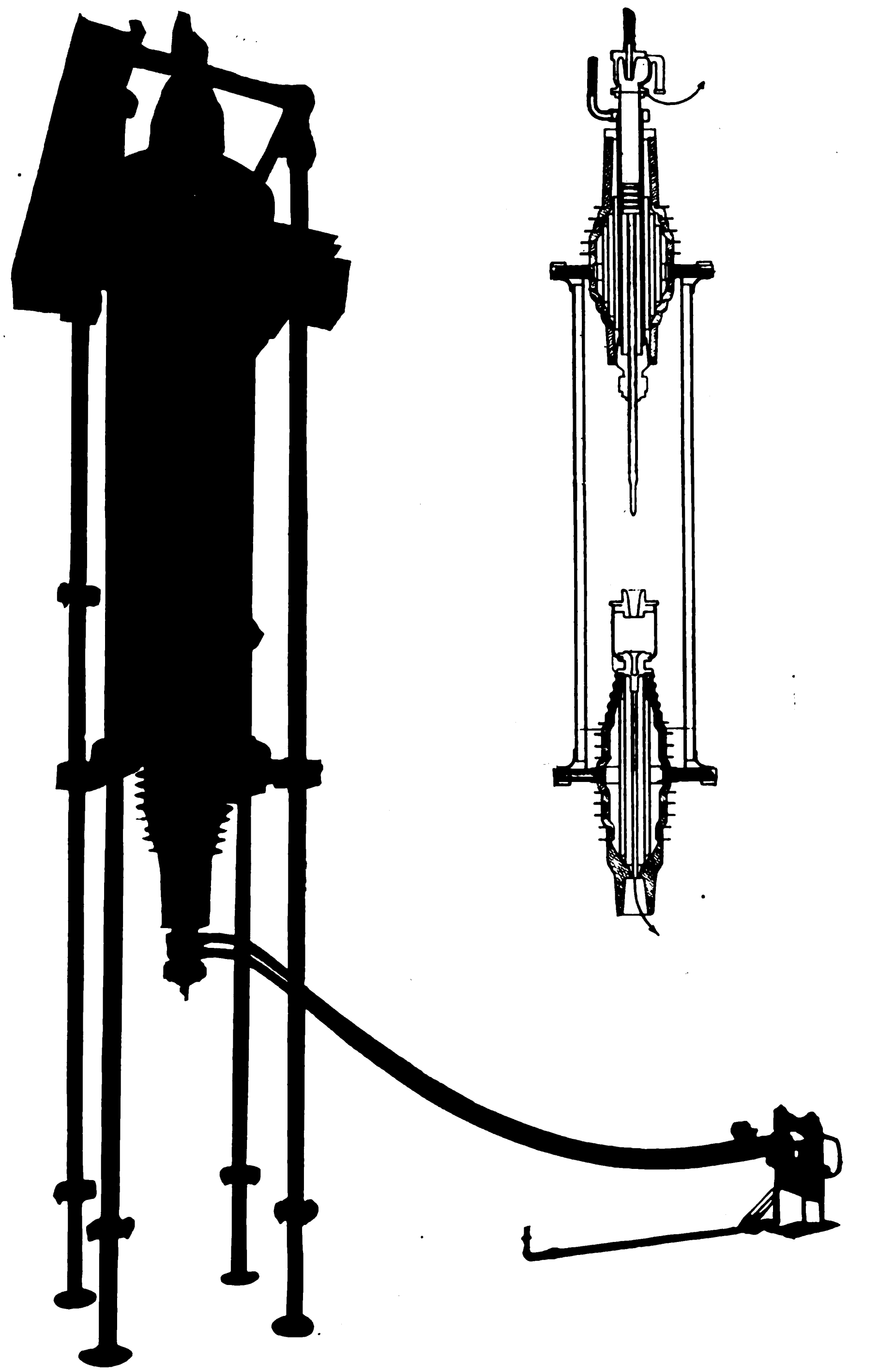


Fig. 20.—AMERICAN (G. E.) 100,000-VOLT PNEUMATICALLY OPERATED OIL-BREAK SWITCH

Each pole of the breaker consists of a steel tube, forming an explosion chamber with an oil-filled insulated bushing at each end. The upper insulator supports the contacts and the lower contains the piston which operates the contact rod. The switches are arranged in a vertical position and the lead enters at the top and leaves at the bottom. Air under a pressure of 80 lb. is used, and each switch is provided with a storage tank holding 3 cu. ft. of air. Check valves and air-strainers are used with insulated hose between the storage tanks and the switch.

SECTION I.—ELECTRICALLY OPERATED OIL BREAK MAIN SWITCHES AND BREAKERS

As it is impossible to describe and illustrate all of the types of electrically operated oil switches and circuit-breakers now on the market, a few representative ones made by the Westinghouse E. & M. Co. and the General Electric Company will suffice as showing the general tendency of design. Most manufacturers have two different types of oil switches or breakers—one employed on circuits of less than 44,000 volts, and the other on circuits of higher voltage. For the circuits below 44,000 most manufacturers have two or more types, the larger of which can be counted on to open the circuits satisfactorily with an almost unlimited amount of power available on the bus bars, while the smaller ones have ultimate breaking capacities ranging from about 10,000 kw. down, depending on the design. The smaller breakers are almost invariably solenoid operated top connected with metal tanks and insulated linings and are made either with each set of contacts in independent tanks or—for the smaller sizes and lower voltages—with all the contacts in the same tank.

Fig. 21 shows a three-pole breaker that is built by the Westinghouse E. & M. Co. in capacities up to 300 amperes at 3300 volts, 200 amperes at 6600 volts with an ultimate breaking capacity of 1500 kw. one-phase, 2500 kw. three-phase and 3000 kw. two-phase. This breaker is operated from two solenoids, one being used to close the toggle mechanism and the other to trip the toggle. A small single-pole, double-throw signal switch is mounted on the frame and operated by the moving mechanism. The main contacts are wedge-shaped and renewable arcing tips are provided. All poles of the breaker are completely submerged in the oil contained in a single sheet metal tank lined with wood, having wooden barriers between the poles and provided with filling and draining plugs.

Fig. 22 shows the next larger size of breaker of the same make, which is built in capacities up to 2000 amperes at 600 volts and 200 amperes at 22,000 volts with an ultimate breaking capacity of 5000 kw. one-phase, 8500 kw. three-phase and 10,000 kw. two-phase. This breaker, as that described above, is operated by solenoids that are hidden in the cut by the mounting frame and the tank. Through a very simple system of levers the operating solenoids are connected to a cast-iron cross-bar, to which are fastened the movable contact arms. To the lower end of a wooden arm is fastened a metal yoke with a conical contact on either end for the smaller sizes, while for the 2000-ampere size a laminated brush is used. When the circuit is closed these contacts engage with the two stationary contacts forming one pole of the breaker. Each stationary contact is supported by a porcelain insulator rigidly secured to the top frame. Each pole of the breaker has an independent tank in which its live metal parts are submerged in oil. These tanks are provided with insulated linings so shaped as to reduce the quantity of oil to a minimum. The wooden arm to which the movable contacts are connected forms a barrier between the stationary contacts when the breaker is opened.

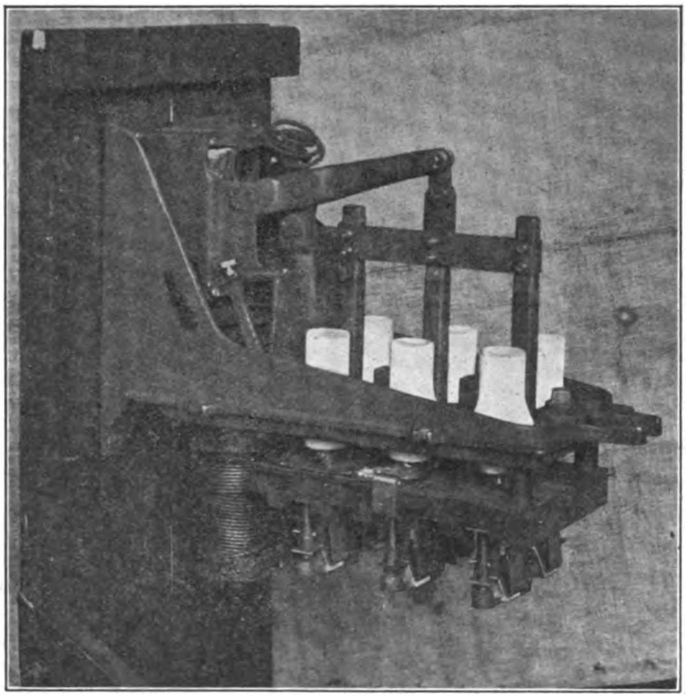


Fig. 21.—AMERICAN (WESTINGHOUSE) ELECTRICALLY OPERATED OIL-BREAKER

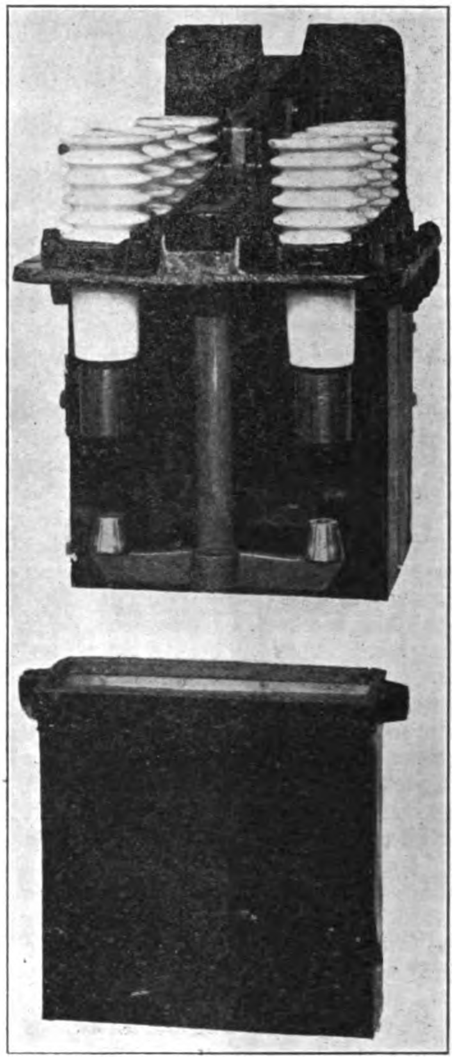


Fig. 22.—AMERICAN (WESTINGHOUSE) ELECTRICALLY OPERATED OIL-BREAKER

The two breakers described above are self-contained and can be mounted on a wall, framework or suitable support, or may be placed in a masonry structure, if desired. The independent cellular construction of placing each pole of the breaker in a separate masonry compartment is not ordinarily required in plants having a capacity that would permit the use of these breakers.

Fig. 23 shows a breaker built in single-pole units in capacities up to

3000 amperes at 600 volts and 100 amperes at 33,000 volts and having an ultimate breaking capacity of 6000 kw. for two units on a single-phase circuit, 10,400 kw. for three on three-phase and 12,000 kw. for four on two-phase. Each pole of the breaker is intended for mounting in a masonry compartment, and two- three- or four-pole units are made by connecting the solenoids of two, three or four poles in the same operating circuit. The mechanism and the terminal insulators are mounted on a treated soap-stone base, and a simple system of toggles operated by a powerful solenoid is used for closing the breaker. A second solenoid is used to upset the toggle and trip the breaker. A single-pole double-throw switch is mounted on the breaker and is operated by the motion of the levers in opening or closing the breaker. This switch controls the signals on the switchboard.

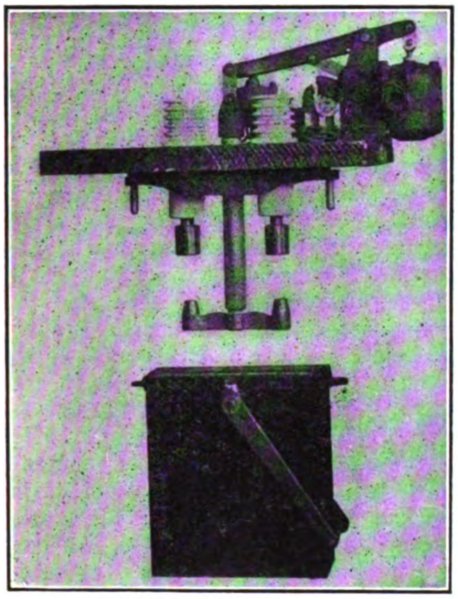


Fig. 23.—AMERICAN (WESTINGHOUSE) SOLENOID-OPERATED OIL CIRCUIT-BREAKER

Fig. 24 shows a 300-ampere 15,000-volt S. P. S. T. oil circuit-breaker of General Electric Co. make that is primarily intended for placing in masonry compartments and arranged in sets of two, three or four as two-pole, three-pole or four-pole breakers. This breaker is arranged for solenoid control and the makers assign various rupturing capacities, depending on the exact type, whether it is mounted on a switchboard or in a cell and whether it is non-automatic or instantaneous automatic.

Fig. 25 shows the corresponding 100-ampere, 45,000-volt, single-pole, single-throw oil circuit-breaker of the same general design intended for mounting in a cell and arranged for solenoid operation.

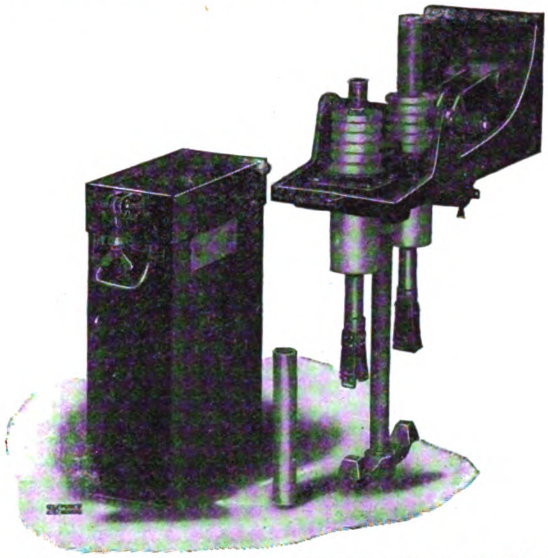


Fig. 24.—AMERICAN (G. E.) ELECTRICALLY OPERATED 15,000-VOLT BREAKER

The breakers for use on circuits of less than 44,000 volts with breaking capacities whose limit is only reached in the largest plants are made usually in either of two forms, one of which is essentially a bottom connected motor operated device, while the other is top connected solenoid operated.

Fig. 26 shows one of the oil breakers supplied by the General Electric Co. for the generating stations and substations of the N. Y. C. & H. R. R. R. With this type of oil-breaker the leads are brought to the bottom of the two metal tanks in each compartment and the circuit is completed through the plunger rods that pass through insulated bushings in the top of the tanks. These rods are connected together by metal cross-pieces and where the amount of current exceeds that which the plunger rods can carry, laminated copper brushes are used for bridging across between the pots. The brushes and plungers are lifted by means of wooden rods operated by a motor-driven mechanism located at the top of the breaker. Each pole of the breaker is installed in separate masonry compartments and fire-proof doors are used for closing in the compartments. This style of breaker is very compact and is particularly well suited for connecting to bus bars located directly below the breaker on the lower gallery. The disadvantages of the breaker are the two live metal pots in the same compartment, the absence of gauge glasses to determine the height and condition of the oil in the pots, the difficulty of connecting to bus bars in a gallery above the breaker and the fact that a broken wooden plunger rod will result in the breaker falling closed rather than open.

Fig. 27 shows a solenoid operated top connected breaker that is built in capacities up to 3000 amperes and in voltages up to 33,000. Each pole of the breaker is enclosed in a separate fire-proof masonry structure and a single powerful mechanism mounted on a cast-iron base and resting on a treated soapstone slab is used with a two-, three- or four-pole breaker. The cone contacts on the smaller sizes and brush contacts on the larger, as well as the general design of this breaker, are such that the tendency is to open rather than to stick, and as the open position is maintained by gravity, failure of the mechanism, breakage of the operating rods, or other unforeseen contingencies, will cause the breaker to fall open rather than closed. The two terminals of

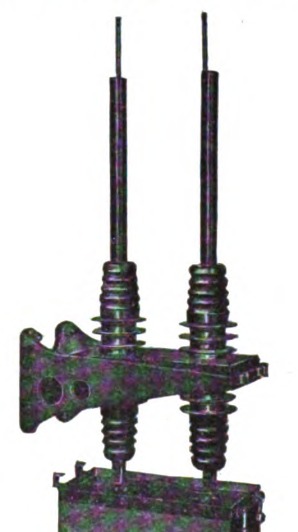


Fig. 25.—AMERICAN (G. E.) 45,000-VOLT BREAKER

each phase are in a single metal tank with insulated lining, and each tank is provided with a gauge glass for observing the height and condition of the oil. The doors of the compartments are frequently provided with clear wire glass panes to permit ready inspection. The leads of this breaker leave the top of the tank and pass out through porcelain bushings set in soapstone blocks in the back wall of the structure. These leads usually come out in separate compartments that keep them isolated from each other and the leads to the bus bars, feeders, generators, etc., may all run upward or all downward, or some up and some down. This flexibility is often of great advantage and permits the generator-breakers being placed on one floor with the bus bars above them and below the feeder-breakers, thus minimizing the space occupied and the amount of material necessary.

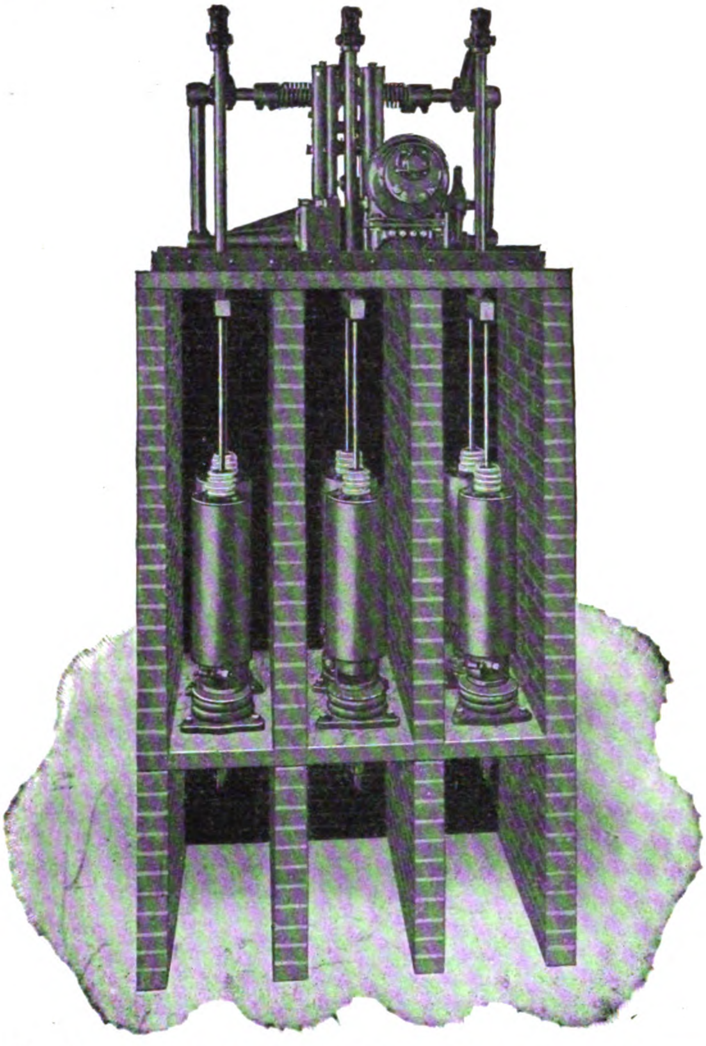


Fig. 26.—AMERICAN (G. E.) 11,000-VOLT MOTOR-OPERATED OIL-SWITCH, NEW YORK CENTRAL RAILROAD

Another advantage of this type of construction is that it permits mounting the disconnecting switches for isolating the oil circuit-breakers on the back wall of the breaker structure and when so located there is far less chance of an attendant closing these disconnecting switches, while a second attendant is working on the breaker, than if the switches were on one floor and the breaker on the other.

Owing to the leads being brought out through the back wall and septums being provided to separate the leads, this type of breaker ordinarily requires more floor space than is needed for that shown on Fig. 26 if the bus bars are located below the breakers. With the bus bars back of the breaker approximately the same floor space is required for the two types, while with the bus bars above the breakers the top connected breaker has the advantage.

Top-connected breakers have their contacts and terminals near the top of the oil and are not so apt to be troubled with sediment and dirt settling on these contacts as if they were placed at the bottom.

The breakers shown in Fig. 23 to Fig. 27 are primarily intended for use in power plants where the cellular construction for the bus bars, wiring, etc., is needed or desired. In generating stations of about 6000 kw. and upward where the generators feed into bus bars and the entire output of the station may be concentrated on a ground or short circuit, it has been found of the utmost importance to isolate the bus bars, wiring and connections in fireproof masonry compartments in such a manner that leads of opposite polarity are separated by soapstone, concrete, brick or similar material. These fireproof walls, barriers, septums, etc., prevent an arc starting in one place and communicating to adjacent conductors. The amount of current available momentarily at the point of trouble in large stations of 13,200 volts or less where the generators are connected to a bus is something enormous, and every precaution must be taken to prevent trouble from spreading. For such voltages the question of suitable dis-

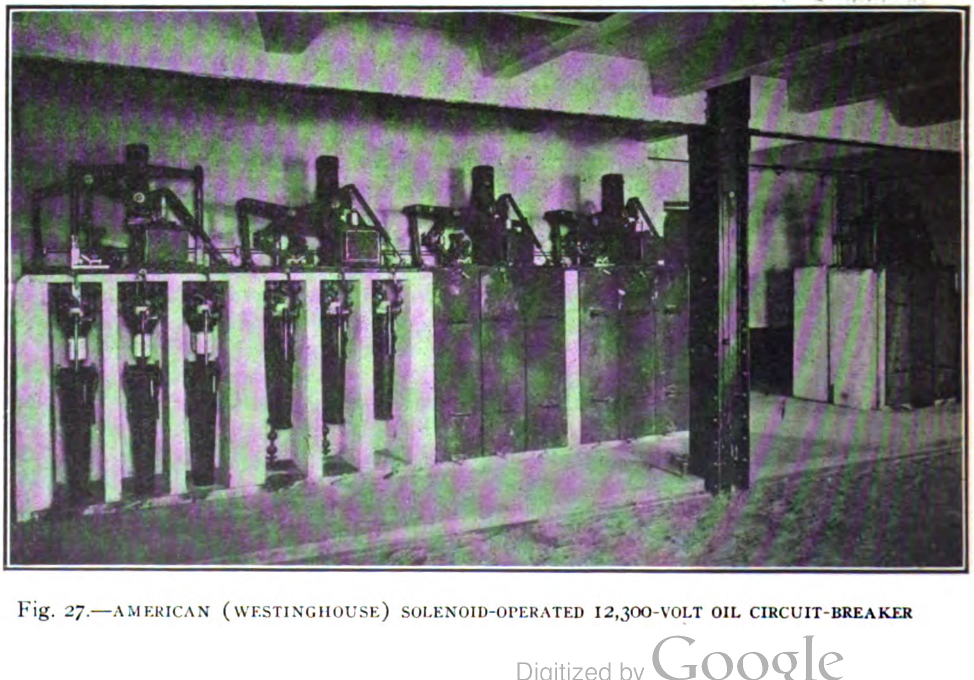


Fig. 27.—AMERICAN (WESTINGHOUSE) SOLENOID-OPERATED 12,300-VOLT OIL CIRCUIT-BREAKER

tances and insulation are comparatively simple.

Where the generators are connected to step-up transformers giving voltages from 33,000 to 135,000, or even higher, the question of enclosing the bus bars and wiring for the high-tension circuits becomes an entirely different proposition.

Some engineers are of the opinion that the cellular construction should be used for large capacity circuits of any voltage, and motor-operated bottom-connected breakers have been designed that work in well with the enclosed bus-bar construction. It is the opinion of other engineers, including the writer, that the open system of wiring is preferable for voltages of 44,000 and higher for the following reasons:

First, the violence of an arc and the destructive effect of short circuit depend on the amount of current available at that point or are inversely proportional to the voltage for the same amount of power; and while fireproof barriers and cellular construction are required on large capacity plants of comparatively low voltage, they are unnecessary for higher voltage plants of the same or even larger capacity.

Second, the striking distance from wire to ground has to be greatly reduced over what could be obtained with open wiring in the same space, as the fireproof barriers offer a more or less perfect ground for high-voltage circuits, and the higher the voltage the more perfect the ground.

Third, a more expensive building and more costly construction are needed with enclosed bus bars and wiring than for open wiring.

Fourth, inspection and repair are more difficult for bus bars, wiring, disconnecting switches, lightning arresters, etc., that are boxed in masonry compartments and only visible and accessible by the removal of doors, than if everything was in plain sight. Inspection will be more frequent and thorough, and incipient trouble will be noticed far sooner, with open wiring than with enclosed, as the station attendant in a few minutes' walk can see everything and does not have to remove many doors and visit two or three floors to examine the condition of the apparatus.

Fig. 28 shows a motor-operated bottom-connected oil-breaker used in the 60,000-volt circuits at the Toronto receiving station of the Toronto & Niagara Power Company. The breaker is arranged with two wooden pots about 10 in. diameter, 32 in. long, forming one pole of the breaker mounted in a horizontal wooden platform supported at the four corners by porcelain insulators mounted on wooden rods. Each pole of the breaker is in a fireproof masonry compartment about 3 ft. 0 in. wide, 4 ft. 6 in. deep and 7 ft. 6 in. high, open at the bottom for the incoming and outgoing leads.

The circuit between the terminals in the bottom of the two pots forming one pole of the breaker is made through metal plunger rods attached to a metal cross-piece external to the tanks. A motor-operated mechanism connecting through wooden rods to the metal cross-piece moves it and the plunger vertically upward to open the circuit. The exposed metal parts above the tank and the bare terminals below necessitate the enclosing of the breaker in a masonry structure for the protection of the attendant. Doors are provided for each compartment of the structure to permit the ready inspection of the tanks, etc., but the removal or breaking of a door leaves these live metal parts a source of danger.

This type of breaker works in well with an enclosed system of bus bars located on the floor below the breakers. It requires a comparatively small amount of oil, and the operating mechanism, consisting of a motor with suitable rods, clutches, etc., is located on a base, above the pots, supported by the walls of the compartment and entirely independent of the outgoing leads.

In addition to the necessity of a masonry structure for this breaker, there is a certain amount of disadvantage in the fact that the mechanism, motor, etc., are at such a height from the floor that it is necessary for the attendant to stand on a ladder to oil the motor or adjust the mechanism. In common with all other types of bottom-connected breakers, this one has no oil gauges, and the sediment in the oil tends to settle on the contacts. A certain amount of trouble is also experienced in securing and maintaining an oil-tight joint where the metal contact and terminal pass through the bottom of the wooden oil pots.

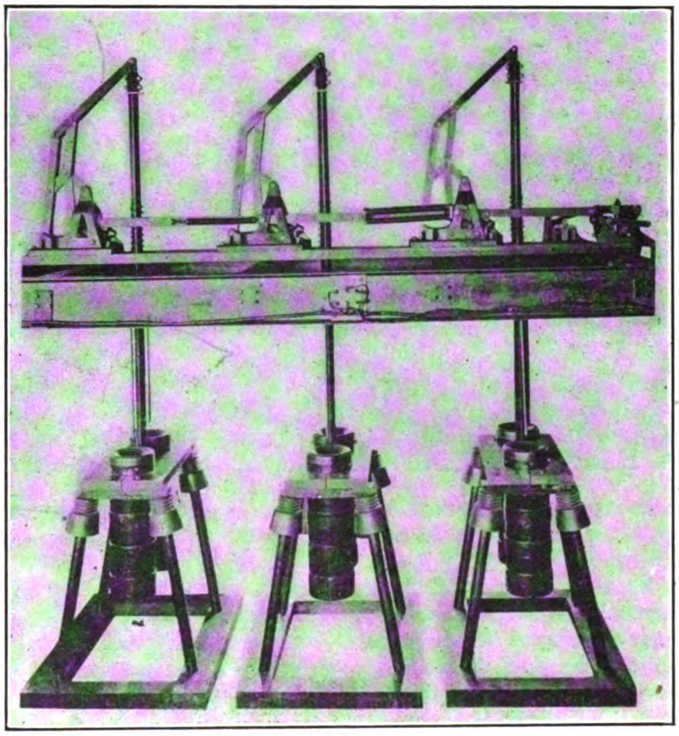


Fig. 28.—AMERICAN (G. E.) 60,000-VOLT OIL SWITCH

Fig. 29 shows a large solenoid-operated breaker which is used on the circuits of the Ontario Power Company and guaranteed to open satisfactorily under any condition of overload or short circuit that might exist in their plant where it was expected that there would be ultimately about 200,000 kva. on the bus bars at 66,000 volts. The tanks of this breaker are made of boiler iron lined with insulating material, and the entire construction is exceedingly rugged and well suited to the severe operating conditions it is guaranteed to handle. The operating solenoid of this breaker is located near the floor, and all of the mechanism is readily accessible.

The development in America, by the Westinghouse Electric and Manufacturing Company, of the condenser type of bushing, with its capacity distributed in such a way as to secure a practically uniform potential gradient throughout the mass of the insulation, has facilitated the design of high-tension oil-breakers. Due to the fact that there is practically no external static field where the lead passes through the top of the case, a cast-iron cover can be used with the bushing solidly clamped to the cover. This construction permits the assembling of all of the mechanism on this cover and greatly simplifies assembling and inspection.

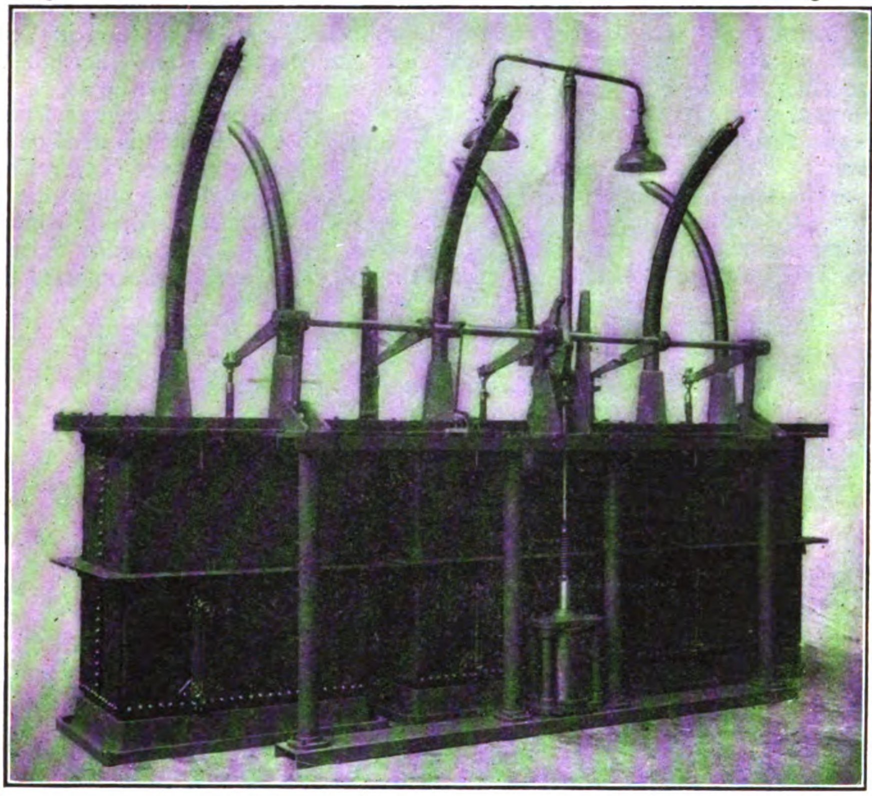


Fig. 29.—AMERICAN (WESTINGHOUSE) 66,000-VOLT SOLENOID-OPERATED OIL CIRCUIT-BREAKER

Fig. 30 shows a 44,000-volt, 3-pole, 300-ampere breaker arranged for distant mechanical control and temporarily set up for the purpose of testing. Each pole of the breaker is located in a welded steel tank with treated linings and is complete with all of its mechanism on its cast-iron top. As each pole is entirely independent, with the operating rod forming the only connection between them, the spacing of the poles can be made to suit the station wiring. For electrical operation a solenoid replaces the bell crank device. This is the type of breaker supplied by the Westinghouse Electric and Manufacturing Co. to the Societe Industriale Italiana for their carbide plant near Rome for the control of 1860-kva., 48,000-45-volt transformers. As a matter of interest, it might be stated that the tank is approximately 3 ft. 0 in. high, and the top of the leads 6 ft. 0 in. above the floor.

The operating mechanism of each pole consists of a toggle actuating a simple system of levers and links with a pull rod connecting the poles so that all open and close with the same movement. All adjustments are made after the mechanism has been assembled on the cover and before the latter is placed in the insulated oil tank.

Fig. 31 shows the contacts, terminals and mechanism of one pole of this type of 44,000-volt breaker, and shows its great simplicity and fewness of points to be insulated when compared with the Oerlikon breaker shown in Fig. 17, with its six double breaks in series per phase. This Westinghouse breaker, as shown in Fig. 31, has its stationary contacts deeply immersed in oil and screwed directly on the end of the brass tube that forms the lead through the condenser bushing. The movable contacts are self-aligning, and the bushing provided with a heavy spring that is compressed when the breaker is closed. These movable contacts are carried by a heavy crossbar, and the current is transmitted through braided shunts so that the compression springs will not be damaged by the passage of the current through them. When closing, a wiping motion is obtained until a solid butt contact is obtained. Both the stationary and movable contacts are readily renewable.

Where the pull rod passes through the cast-iron cover, a stuffing box is provided that acts as a wiper in removing oil from the rod. The cover is securely bolted to a flange riveted to the upper edge of the tank, and all hand holes are provided with dust and moisture-proof hinged covers. The hand holes in the top cover are of sufficient size to permit the ready removal of the movable contacts and cross-bar without dismounting the other parts of the circuit-breaker. The condenser bushing leads with the stationary terminals can readily be unclamped and removed through the cover.

As may be noted, both in Figs. 30 and 31, the series transformers for the operation of the ammeters and relays are clamped directly around the condenser bushing leads which form the single turn primary. This permits the use of a simple compact and cheap form of series transformers.

Fig. 32 shows one of the same type of breakers supplied by the Westinghouse E. & M. Co. to the Southern Power Co. for their 100,000-volt lines, while similar breakers are being built for the 110,000-volt circuits of the

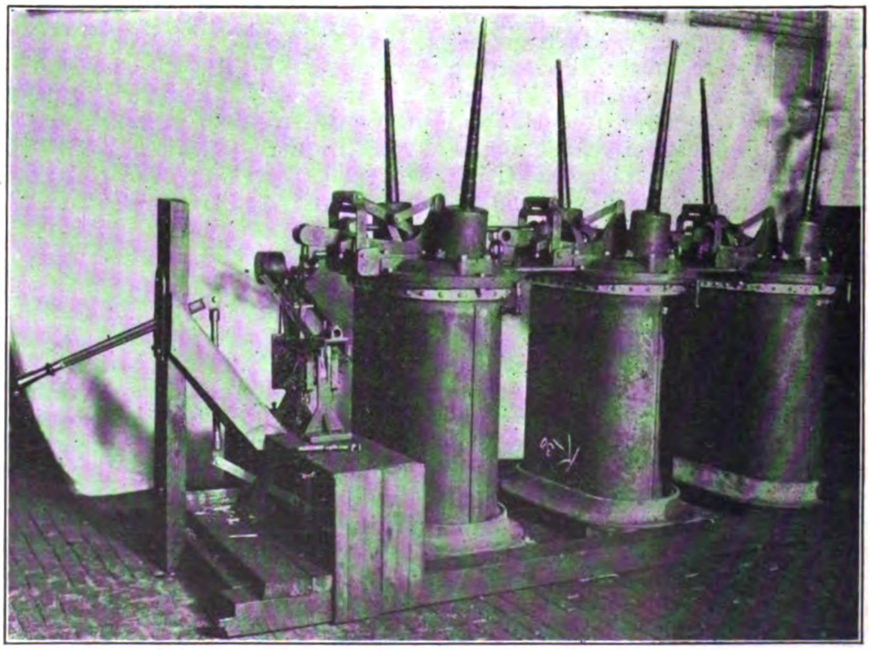


Fig. 30.—AMERICAN (WESTINGHOUSE) ELECTRICALLY OPERATED 44,000-VOLT BREAKER

Hydro Electric Power Commission of Ontario. The general features of this breaker correspond closely with those of the 44,000-volt breakers just described. The manufacturers rating for ultimate breaking capacity of these 3-pole breakers is 60,000 kw. at 44,000 volts, 80,000 kw. at 66,000 volts, and 100,000 kw. at 88,000 volts, and 120-000 kw. at 110,000 volts. Breakers of this same type have been designed for even higher voltages than 110,000, but up to the present none of them have been put in service for voltages above 110,000 volts. As these ultimate breaking capacities are conservative and based on generators in one station or closely adjacent, it is felt they can satisfactorily handle any amount of power that is apt to be concentrated at any point on any power transmission system.

Before closing this portion of the article, it is advisable to make a few remarks about automatic features in connection with circuit-breakers.

The various breakers previously described can be made either automatic or non-automatic. The automatic feature can be obtained in most cases either by a series trip, a series relay, or a relay operated from series transformers. With the series trip or series relay, straight overload protection with or without a time limit can be obtained, but it is almost impossible to secure any differential or reverse current action without the use of series transformers.

Opinions differ on the question of automatic or non-automatic breakers in various circuits, but usual American practice is about as follows: Generator breakers are made non-automatic or provided with reverse current relays. The breakers for the low-tension side of step-up transformers or the high-tension side of step-down transformers are made overload, while those on the secondary side of the same transformers are made non-automatic. Occasionally differential relays are provided to trip out both high- and low-tension breakers in case of an internal short circuit or a ground in the winding of a transformer. On outgoing transmission lines, overhead relays are usually furnished, while on incoming lines operating in multiple, reverse current relays or selective relays are provided for the purpose of cutting out a damaged line without affecting the other lines. Where two stations are tied together, series transformers are sometimes placed on each end of each line, with their secondaries connected together in such a manner that if the current leaving one station does not all reach the other station, suitable relays will be actuated to cut out the defective tie line at each end.

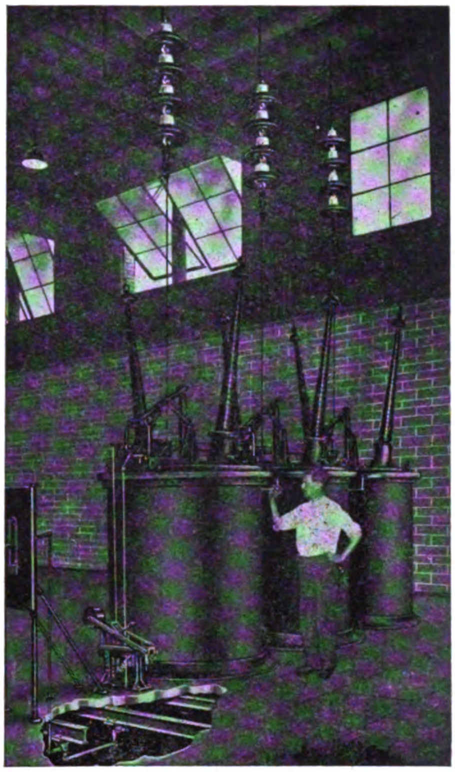


Fig. 32.—AMERICAN (WESTINGHOUSE) 110,-000-VOLT ELECTRICALLY OPERATED CIRCUIT-BREAKER

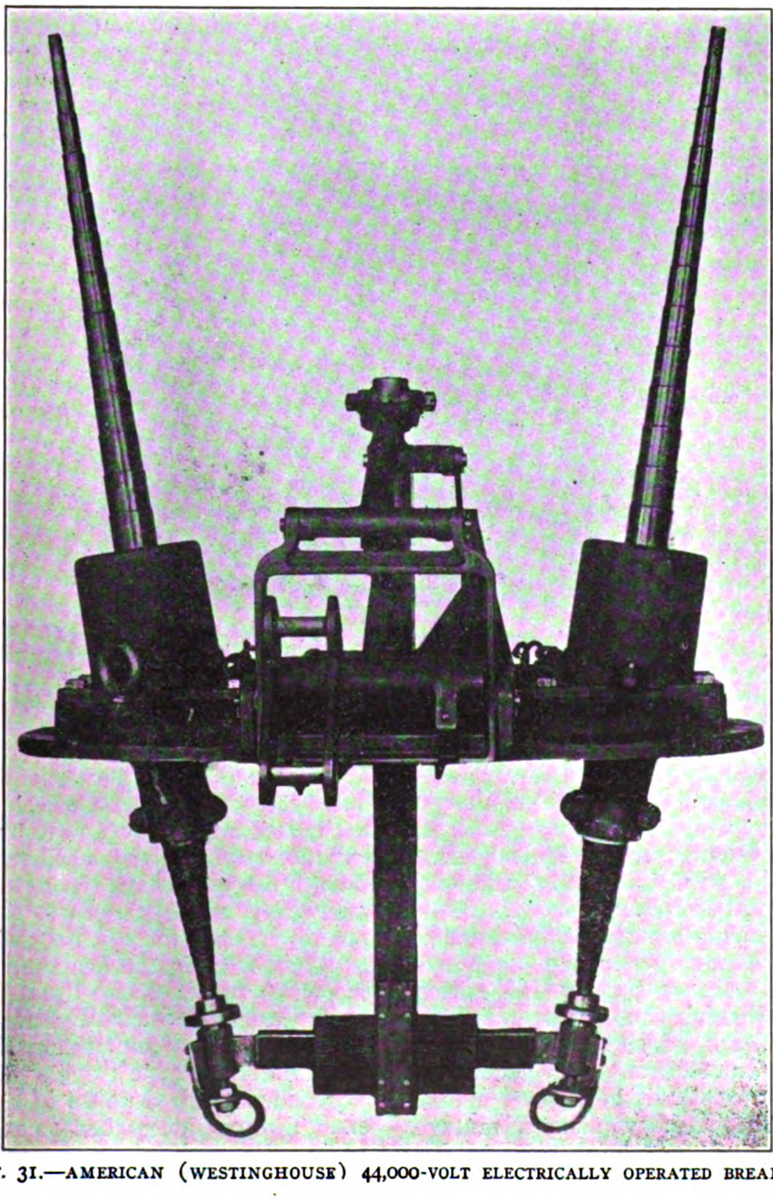


Fig. 31.—AMERICAN (WESTINGHOUSE) 44,000-VOLT ELECTRICALLY OPERATED BREAKER

(*To be continued.*)

What To Do

In his experiments with storage batteries Mr. Edison has had men at work for years with a patience unparalleled. More than a half-ton of reports on experiments with batteries have been made. The work was continued night and day for more than three years, and more than 9000 experiments were made without obtaining the results which Mr. Edison wanted. A visitor to whom this was told, exclaimed:

"Then all those experiments were practically wasted?"

"Not at all," said Mr. Edison. "I now know 9000 things not to do."

The Plant of the Milwaukee Commonwealth Power Co.

T. S. WATSON

Consulting Engineer, Commonwealth Power Co.

The Commonwealth Power Co. of Milwaukee is a corporation operating under the public service laws of the State of Wisconsin. Its business is the furnishing of electric power and steam heat. But, unlike most other such companies, this was the outgrowth of the necessity for simpler, more efficient power arrangements of several allied interests. The most important of these are the Jos. Schlitz Brewing Co. and the Continental Realty Co., the latter a large owner of business property in the heart of Milwaukee. Inasmuch as the companies concerned use a great deal of power, and that, with but little increase in expenditure, the plant could be made of sufficient capacity to provide for a large amount of outside commercial service, the generating station here described was built and has now been in successful operation for more than a year.

The plant of the Commonwealth Power Co. is located about 1½ miles from the main business center of the city on the west bank of the Milwaukee River, near the Holton Street viaduct. This location makes it possible to receive coal by water, which admits of the lowest possible freight rates, and also enables water to be taken directly from the river for boiler feed and condensing purposes.

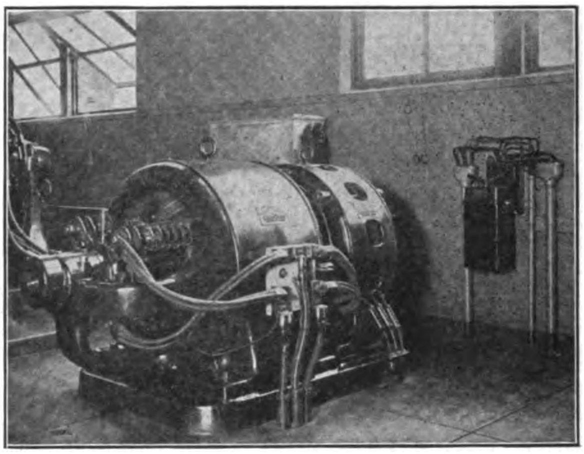
The concrete foundation of the building is supported on piling, as the earth is very unstable close to the river. The superstructure of the building is of brick. The roof is of tile and concrete, nearly flat, and is supported by structural steel trusses. The building is about 110 ft. square and is divided into boiler- and engine-room by a brick fire wall running north and south. The engine-room is slightly larger than that containing the boilers.

Coal is delivered to the plant in barges which come from the lower lakes. As of course no boats can come during the winter season, ample storage for the winter's supply has to be provided, and a space approximately 100 ft. by 500 ft., having a capacity of about 40,000 tons, and owned by an allied interest, is reserved for this just north of the viaduct. Two electrically equipped, man trolley, Johnson coal bridges are provided for unloading the barges. These receive their electrical supply from a motor generator, to be described later, and have the grab bucket balanced. The bucket has a capacity of two and one-half tons.

In delivering the coal from the piles to the boiler-room the same traveling bridges and buckets are employed. These deliver the coal, which is run of mine, to hoppers which were built on the bridges and which have screens made of grizzly bars set at an angle of approximately 45°. The coal which does not pass the screen is carted away in wagons and used in other steam plants. That which does pass the screen is delivered to a 20-in. electrically driven Robins belt conveyer extending under the run of the bridges, which carries it to the end of the boiler-house, where it is dumped into a bucket elevating conveyer. This conveyer, which is motor-driven, encircles the boiler-house and disposes of the coal in the four 40-ton hoppers, one for each boiler, which are located above and in front of the boilers. This same bucket conveyer takes the ashes from the pits beneath each furnace and delivers them to a fifth bunker, from which they can be discharged either to wagons or to barges in the river. Each of the boiler hoppers is provided with an Avery automatic scale so that accurate records of the coal consumption can be maintained.

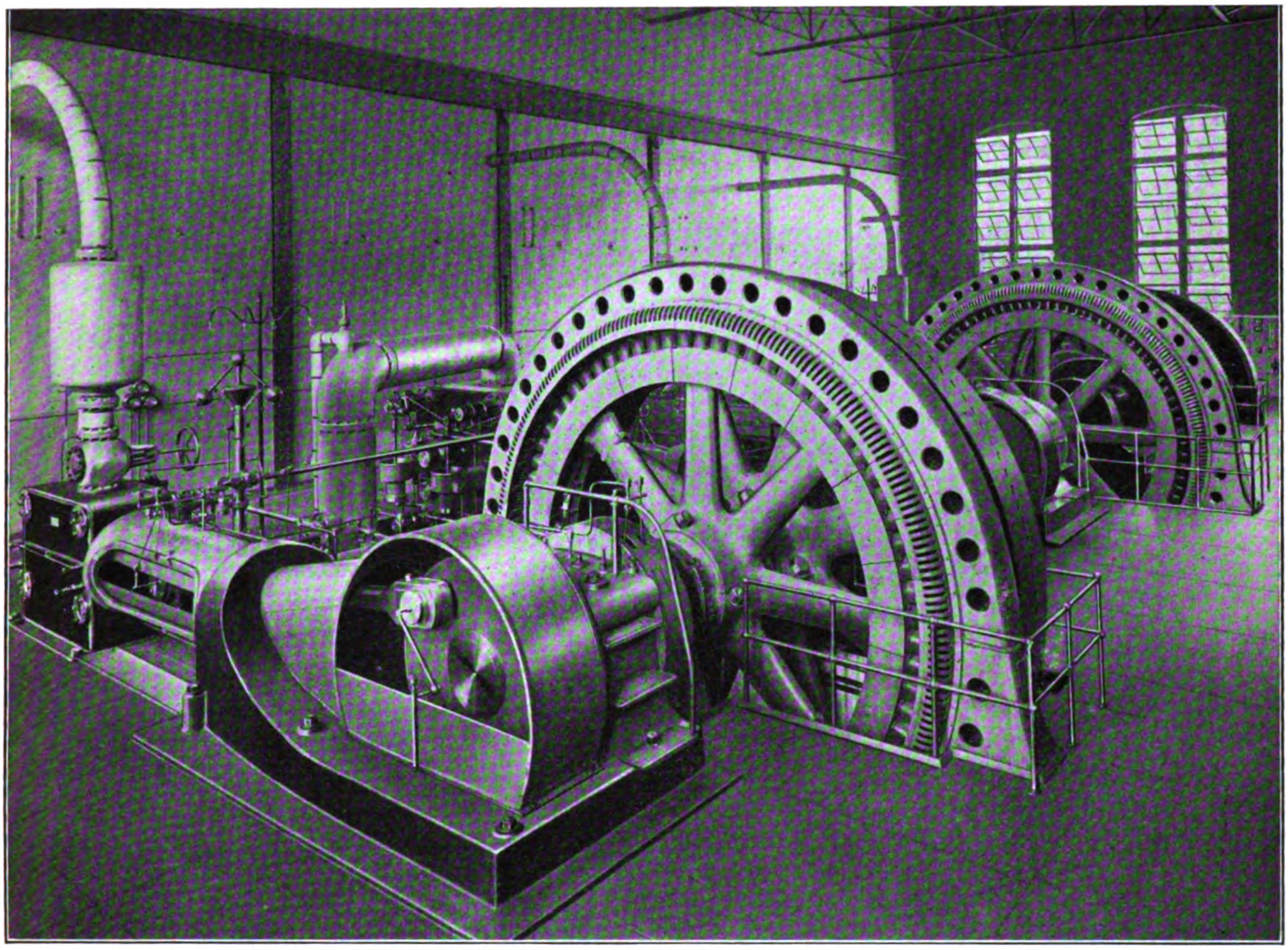
The steam generating equipment consists of four 500-h.p. Edge Moor boilers, having 5000 sq. ft. of heating surface each, which are provided with mechanical stokers. The boilers and furnaces are built in a novel manner which seems to have many advantages over the ordinary brick setting. The furnace proper is built with brick walls in the usual manner, but in addition has a brick roof over the entire combustion chamber. By this means the boiler does not come in direct contact with the flame of the fire, but only with the hot gases, which make three passes through the tubes. The boiler itself is enclosed in walls of asbestos 2½ in. thick. The object of these is twofold: first, to prevent infiltration of air, and second, to keep the radiation losses as small as possible. Each boiler is provided with an independent self-supporting steel stack 66 in. outside diameter and 145 ft. high. These are lined for half their height with 4 in. of vitrobestos. Foster superheaters give a superheat of about 90 degrees.

The boiler feed water is obtained from the condenser hot well and is delivered to the heater by a motor-driven centrifugal pump. Duplicate cross-connected lines of 5-in. pipe connect the hot well and the heater and boilers.



MOTOR GENERATOR EXCITER SET WITH STARTER

The Dodge heater used is of rather peculiar construction and acts both as an open and closed heater and filter. The water from the hot well enters the heater and receives heat from the exhaust steam of the auxiliaries and then passes downward through a sand filter from which it goes to the feed pumps. These force it back through a second filter in the heater in which the water passes upward and then to the boiler. This method of treatment seems to be very satisfactory for the river water, as little trouble has been experienced with deposits in the boilers. Two outside-packed 12 and 6 by 12 in. plunger feed pumps are used.



INTERIOR OF GENERATING STATION, COMMONWEALTH POWER COMPANY

The piping arrangements are such that, if necessary, water can be taken from the city mains or the river.

Steam is taken from each boiler by bends of 6-in. pipe which connect to a 12-in. welded steel header which runs in the rear of the boilers. In the loop is placed a Davis stop-and-check valve, and an angle valve is used where each bend enters the header. Steam for the main units is delivered at a pressure of 165 lb. The auxiliary machinery receives steam at 125 lb. pressure from an auxiliary steam loop in which the pressure is reduced. Steam is delivered to the generating units through bends connected to the top of the steel header and having an angle valve at the header. Crane separators are placed on each line.

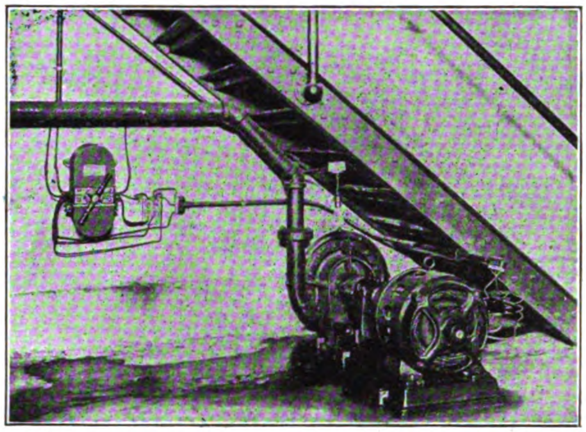
In the boiler-room is also located the dry-air pump for the condenser. This is of the rotative crank and flywheel type, and was made by the Union Steam Pump Co.

The engine-room contains two 1000-kw. and one 500-kw. generating units, a steam-driven exciter set, a motor generator exciter set, a motor generator set for furnishing current to the coal unloaders, switchboard, oil pumps, etc. It is spanned by a 25-ton electric crane arranged to be operated from the floor.

The two 1000-kw. generating units are of the revolving field type and have 72 poles. When operating at 100 rev. per min. they deliver three-phase, 60-cycle current at 2300 volts. These units are direct connected to 24-in. and 50 by 48-in. heavy duty cross-compound Corliss engines which operate under a steam pressureof 165 lb. and 26-in. vacuum, referred to a 30-in. mercury column. The steam has about 70 deg. of superheat at the throttle. A flywheel 18 ft. in diameter and made very heavy gives extremely close regulation. The third main generating unit has a capacity of 500 kw. when turning 120 rev. per min. Except for size and capacity, it is the same as the larger units. It is driven by a 20-in. and 40 by 36-in. heavy duty cross-compound Corliss engine which operates under the same conditions as the larger engines. All the main journals are of the four-piece type with wedge adjustment. The engines are provided with the standard eccentrics long-range cut-off Corliss valve gear usually furnished by the builders of the engine. The selection of these sizes of units makes the installation very pliable so that it will operate at highest efficiency at all loads.

The exhaust from all the engines discharges into a common exhaust main of cast-iron pipe, which enlarges through its length from 24 in. to 36 in. where it connects to the riser leading to the 48-in., 2500-kw. Tomlinson type B barometric condenser located just outside the building. The exhaust piping from each engine is fitted with special valves which effectually prevent any air leakage to the exhaust line when the engine is not in operation. Injection water for the condensers is taken from the river by duplicate 12-in. double-suction single-stage centrifugal pumps driven by enclosed horizontal high-speed engines, either of which is sufficient for the work. The overflow from the hot well discharges to the river. This arrangement of the central condenser plant gives the most direct flow for the exhaust steam and makes the handling of the condensing water the easiest possible. In this installation the exhaust pipe was very carefully designed, so that there is no perceptible loss in vacuum throughout its entire length. This is a somewhat common trouble in central condenser plants.

A gravity oil system is used for supplying lubricating oil to all bearings. The oil is pumped from a receiving tank in the basement to a storage tank and filter supported above the engine-room in the roof trusses. An average head of about 25 ft. is maintained.



INDUCTION MOTOR-DRIVEN CENTRIFUGAL BOILER FEED PUMP

Excitation of the generators is usually obtained by means of a 65-kw. induction motor generator set, which delivers direct current at 120 volts. The motor receives current at 2200 volts, three phase and 60 cycles, and revolves 850 rev. per min.. For furnishing exciting current when starting up the main generators, a 120-volt, direct-current machine, direct connected to a high-speed steam engine, is installed.

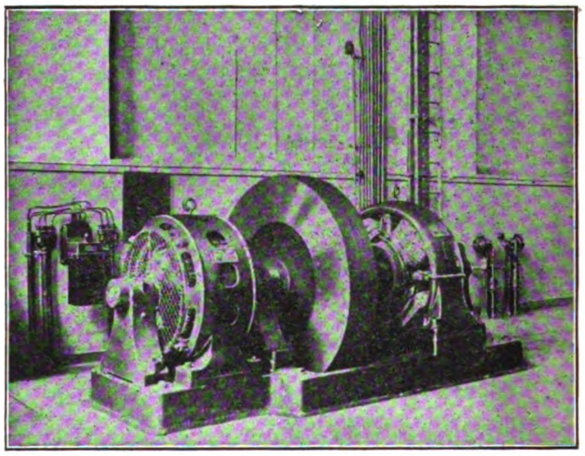
Of particular interest is the installation of a four-bearing flywheel motor generator set which furnishes current to the coal hoists. The motor is of the ordinary squirrel cage type designed for 110-h.p. capacity and to operate under a pressure of 2200 volts, on 60 cycle, three-phase current. The direct-current generator of the set is of special interpole design and rated at 75 kw. Its average load is about 60 kw., but it is guaranteed to carry 200 kw. for one minute without injurious flashing or burning. It has carried instantaneous loads of as high as 240 kw. This has been made possible by the use of a machined solid steel flywheel weighing 7500 lb. which retains sufficient stored energy to carry the short-time peak loads.

The switchboard is made of dark mottled marble with beveled edges and has 11 panels. There are two exciter panels, one for the motor generator and one for the engine-driven unit; two direct-current and one alternating-current panel for the various motors; three generator panels and three feeder panels. Wagner indicating and Westinghouse recording instruments are used on the switchboard, while General Electric oil switches with remote, mechanically operated control are used for high-tension service. A Tirrill regulator is also installed.

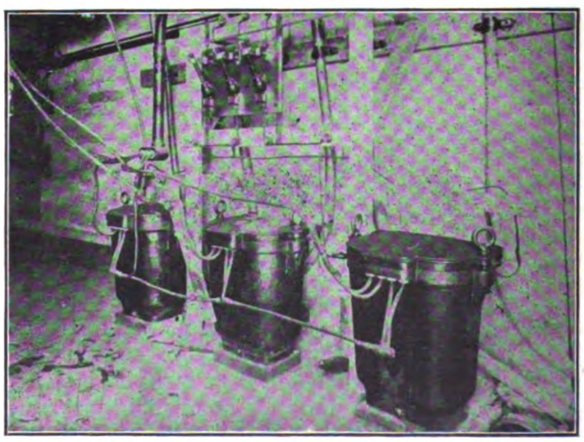
An electrically driven air compressor of the same character as used on street-cars is installed in the basement for supplying compressed air for cleaning the electrical apparatus and blowing the boiler tubes.

Two cables, either large enough to carry the full output of the generating station, lead to the main substation at the Jos. Schlitz Brewing Co.'s plant. These are carried in conduits. From this point power is distributed to other substations about the brewing establishment and to three stations in the business section located in the Alhambra, Majestic and Kopmeier buildings. Of thees substations the largest is located in the basement of the Alhambra building.

This consists of one 200- and one 300-kw. synchronous and one 55-kw. induction motor generators. The induction set is used to supply current at light loads and also for starting the synchronous sets on the direct-current side. Direct current at 120 volts is supplied by the three-wire system. At the Alhambra substation is also located a low-pressure boiler plant for supplying steam heat. The Majestic building substation, nearly opposite the Alhambra, contains no motor generator sets, but receives direct current from the Alhambra station by wires carried in a tunnel connecting the two buildings, which also carries steam-heating mains. The alternating-current bus bars in the two theatre substations are tied together by a cable running in the tunnel, so that if the feeder line from the brewery substation to either of the others is disabled, there will be no interruption to service.



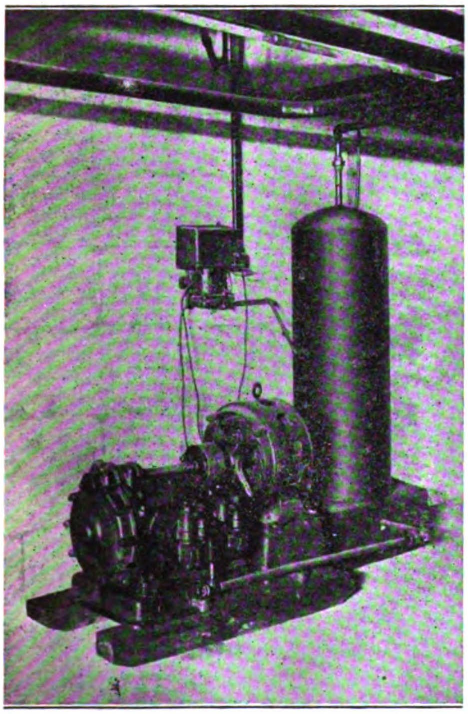
FLY WHEEL MOTOR GENERATOR SET FOR OPERATING COAL HOISTS



MOTOR-DRIVEN AIR COMPRESSOR WITH STORAGE TANK

For general power and lighting purposes, distribution is by means of a three-phase four-wire system which gives alternating current at 220 or 128 volt. Three-phase motors are used for all power purposes. The new Auditorium is one of the largest lighting customers of the company.

In the operating load of the power plant almost ideal conditions exist. The brewery takes a large amount of day load and some night load. The day load is from eight to five. There is also a continuous day load from other consumers. In the evening a lighting load comes on which practically replaces the day load. These various demands for power give the station a load factor of practically 50 per cent. Under these conditions the station has been operated under the best of loads and a remarkable plant economy has been shown. With an average 24-hr. load of about 12,000



MOTOR-DRIVEN AIR COMPRESSOR WITH STORAGE TANK

kw. the average coal consumption for a month has been 3½ lb. per kw-hr., and it is expected that this will still be improved upon.

The operating record of this station has also shown exceptional reliability in service. Since the new plant has been put in commission there has been no serious interruption of service at any time.

Mr. Wm. B. Uihlein is chief superintending engineer of the Commonwealth Power Co. Allis-Chalmers Company furnished all engines and electrical apparatus, together with their necessary auxiliaries.

A British Plan For Raising Load Factor

A new development in the electric-heating problem is presented in the Therol system, now on exhibition at the offices of the Therol Company, 30 Church Street, New York. The system has been in successful operation in England for several months, and is, in the opinion of the British technical press, likely to do much toward in-

creasing the current supply to residences and hotels.

The Therol system, by a method of heat storage, aims to provide control stations with 100 per cent. load-factor consumers. Several are in use by British central stations and they are now supplying current to Therol consumers at about one-fourth or one-fifth the price of current for lighting alone.

The apparatus consists, in its simplest form, of an iron block in which is placed a removable heat unit. A coil is cast in the iron block, the block being heated to a temperature of 500 to 800 degrees fahr. It is surrounded by magnesia insulation, outside of which is a water jacket to absorb any heat which may escape through the first layer of insulation. Outside the water jacket is another layer of magnesia, giving an efficiency of over 90 per cent. in the storage of heat.

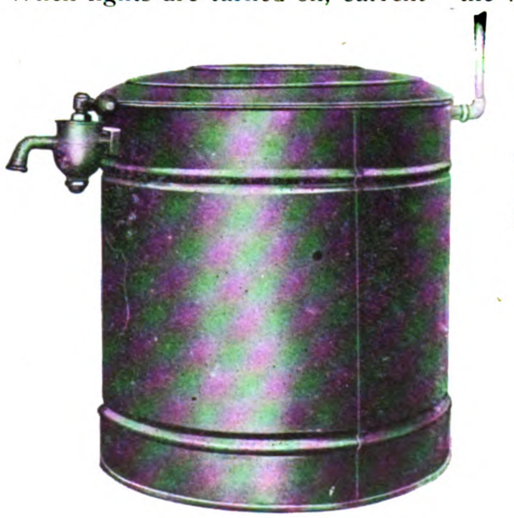
When lights are turned on, current is automatically switched off the heater in sufficient quantity to supply the lights, thus creating no increase in the constant demand on the station. Current can also be drawn from the heater's constant supply for ironing, Therol cooking, or any other domestic use.

No water is stored under the Therol system. Heat only is stored, and used as occasion may demand for the instantaneous heating of water. As the temperature of the iron block is several hundred degrees, as soon as water is introduced into the coil imbedded in the block it is turned into superheated steam. This steam is introduced into water at normal temperature, raising it to boiling, or any lesser degree of

heat, according to the quantity of superheated steam introduced.

An ordinary heater, consuming a constant supply of 300 watts, will provide 30 gal. of water for domestic use at the highest temperature at which it can be used, 110 to 120 degrees, besides providing for three to four hours' burnings of lights up to the maximum demand of 300 watts.

A cooker is supplied, operated in connection with the heater, which consumes, for ordinary purposes, 100 watts during a part of the day. This supply of current is drawn from the heater, and when not used in the cooker goes toward storing heat for the water supply.



Therol Water Heater

Heating Element

Water Coil

Metal Block with Magnesia Insulation

An English Single-Phase Electrification

By JAMES DALZIEL and JOSIAH SAYERS*

Motors.—Coming to the apparatus in detail, the Westinghouse motors are shown on Fig. 14, and are salient pole motors. They are plain series compensated with commutating high-resistance leads. The compensating winding is let into slots in the pole faces.

The Siemens motors, which are shown in Fig. 13, have a distributed winding on the stator, somewhat similar to the winding of a polyphase motor. A connection diagram of the motor is shown in Fig. 11. There are other, and have therefore no detrimental effects by way of adding to this circulating current. Incidentally, one constructional difference between direct-current and single-phase motors having resistance leads for commutation may here be pointed out, namely, that in the latter the coil-to-coil connections closing the winding are made not on the commutators, but on connection lugs at the back of the armature, single commutation leads being taken through the slots to the commutator from these lugs.

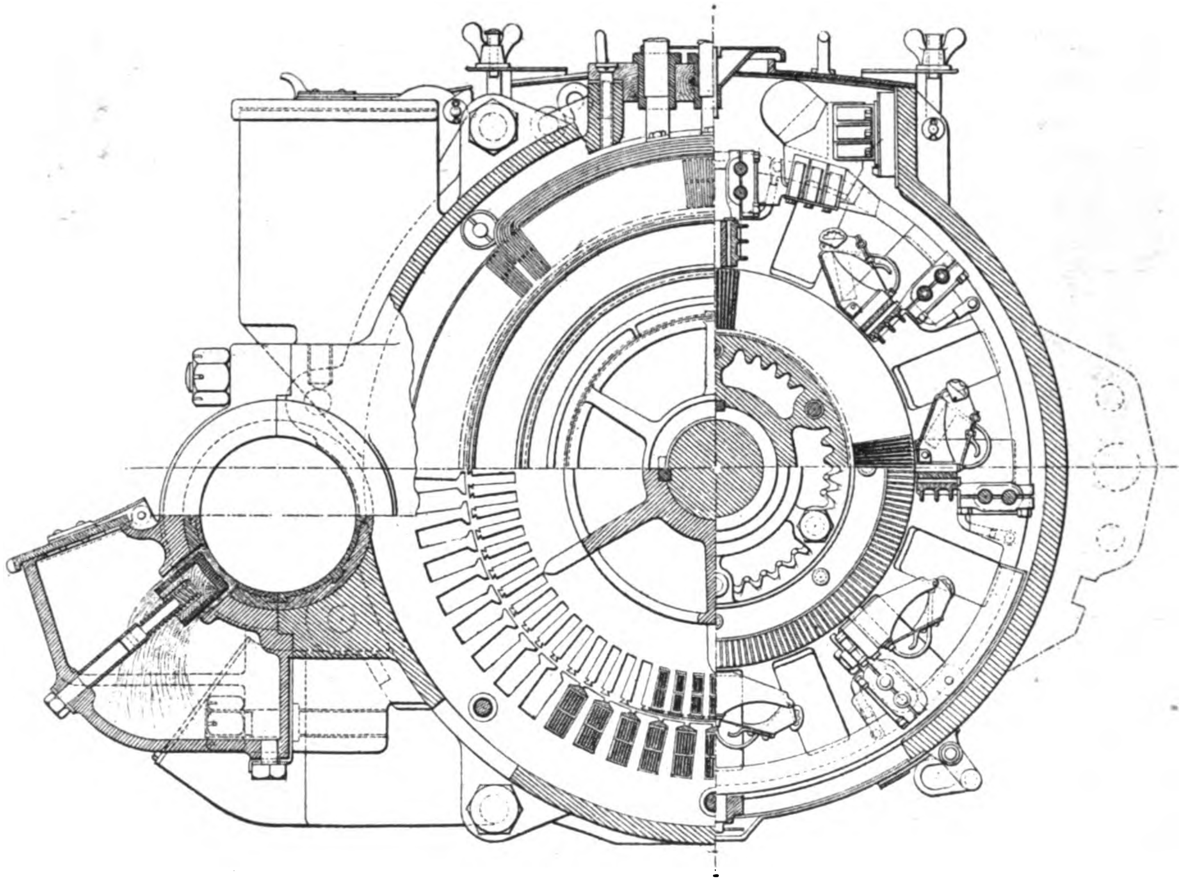


Fig. 13.—CROSS-SECTION OF SIEMENS MOTOR

theoretically three windings, the exciting winding, the compensating winding, and the commutation winding, though the motor is, like the Westinghouse, of series compensated type, and also has high-resistance commutation leads. It is claimed that these are in this case so embodied in the winding as to add to the torque of the motor. While the voltage generated in each of the two leads is in opposition to the main current passing through it, thus, as claimed, adding to the torque, so far as the circulating current of commutation is concerned these two voltages are opposed to each

For commutation purposes, with the intention both of counteracting the alternating flux, which is linked with the coils under commutation, and thus suppressing the circulating current in these coils and, as in the case of the commutating poles of direct-current machines, of counteracting the reactance voltage, there is also a special commutating circuit. Unlike direct-current commutating pole motors in which the commutating field is produced by a winding in series with the armature, however, these voltages are only counteracted accurately at one particular value of the armature current on each control notch, as the commutating field in this case bears no direct relation to the armature current. In practice, however, the arrangement gives a wide range of sparkless commutation. A commutating pole with a series winding would not give a commutating flux in proper phase-relation to the current to be commutated.

This commutating winding is fed from a special transformer, the primary of which, as will be seen from the diagram, receives its voltage partly from a few additional turns on one of the secondaries of the main transformer feeding the main motors, and partly from the secondary winding itself. The extra turns and what might be termed the fixed-pressure end of this primary winding are at the opposite end of the main secondary winding from the fixed-pressure end of the latter, which is coupled direct to the motor. The other end of the commutating transformer primary is coupled to the variable voltage feed to the main motor in question, and thus the pressure on it also is variable, with the difference, however, that as the pres-

*Institute Civil Engineers

sure across the motor is raised, the commutating pressure falls; the effect is for the latter pressure to be greatest on the control notches on which the highest currents and greatest armature flux are to be expected. As constructed, the commutation circuit is adjustable, there being a number of tappings on the commutating transformer.

The commutating circuit on the motor itself consists of those turns of the compensating winding on the stator lying at the suitable angle, and the commutating pressure from the transformer is fed into tappings from these turns. The transformer is necessary partly to give an independent circuit for the commutation—otherwise these connections could not be used, since part of the motor would be short-circuited—and partly, since the commutating winding forms part of the compensating winding, to bring the commutating pressure down to such a voltage as to enable a suitable number of turns to be used.

The commutating coils under some conditions give out power back to the circuit, and in testing care must be taken to allow for the power taken or given back by these coils.

Practically, in the actual construction of the Siemens stator, all three windings are embodied in one continuous one, the feed-point being, as it were, at what would be the resultant effective point of the exciting and compensating windings with the commutating winding connection tapped in. As the diagram shows, reversal is not effected in the usual way, but by tapping into the stator at a different point for each direction. There is thus a small proportion of the field winding corresponding to the excitation portion ineffective in each direction; but the compensating and commutation portions remain the same.

The stator winding has the good mechanical feature of its consisting of bars similar in dimensions throughout. These bars, however, are grouped sometimes in series and sometimes in parallel round the periphery, according to the particular purpose they serve at the different points, the exciting windings being those of small section.

The Siemens axle-lubrication is by pad; the motor lubrication was originally a circulating system, oil being siphoned from the tanks shown in the top left-hand corner of Fig. 13, by ordinary wick siphons, and collected again after passing through the bearings in another tank, from which it was pumped by a small pump into the top tanks again. This pump gave trouble in use, and the practice now is for the motorman to keep the top oil boxes full. It is occasionally also necessary to pour some oil direct into the pipes.

The Westinghouse lubrication, both on the axle bearings and on the bearings of the motor, is also by pad, which is very satisfactory and requires little or no attention; and the authors do not consider that anything better is required or anything more elaborate desirable. The simpler the lubrication and other apparatus of such motors is kept the better.

Control Gear.—This, on the Westinghouse car, is very similar to the firm's standard direct-current control gear, with the exception that the valve magnets are actuated by single-phase current at 150 volts instead of the usual low-voltage direct current from a battery or motor generator.

The switch group is a standard one of the unit-switch type as used on the Metropolitan and other railways, except that the interlocks are modified for the different sequence of operation and for the higher voltage. The contactors are shown in detail in Fig. 16.

The Siemens electric contactor is shown in Fig. 15. The magnetic circuit is built up of laminated iron, as is also the movable plunger. The drawing is self-explanatory as regards the mechanism. To obviate humming and chattering of the contactors a small coil is wound on the core, as shown in the Figure, the ends of this coil being connected across the coil of resistance wire which is shown on the top of the contactor.

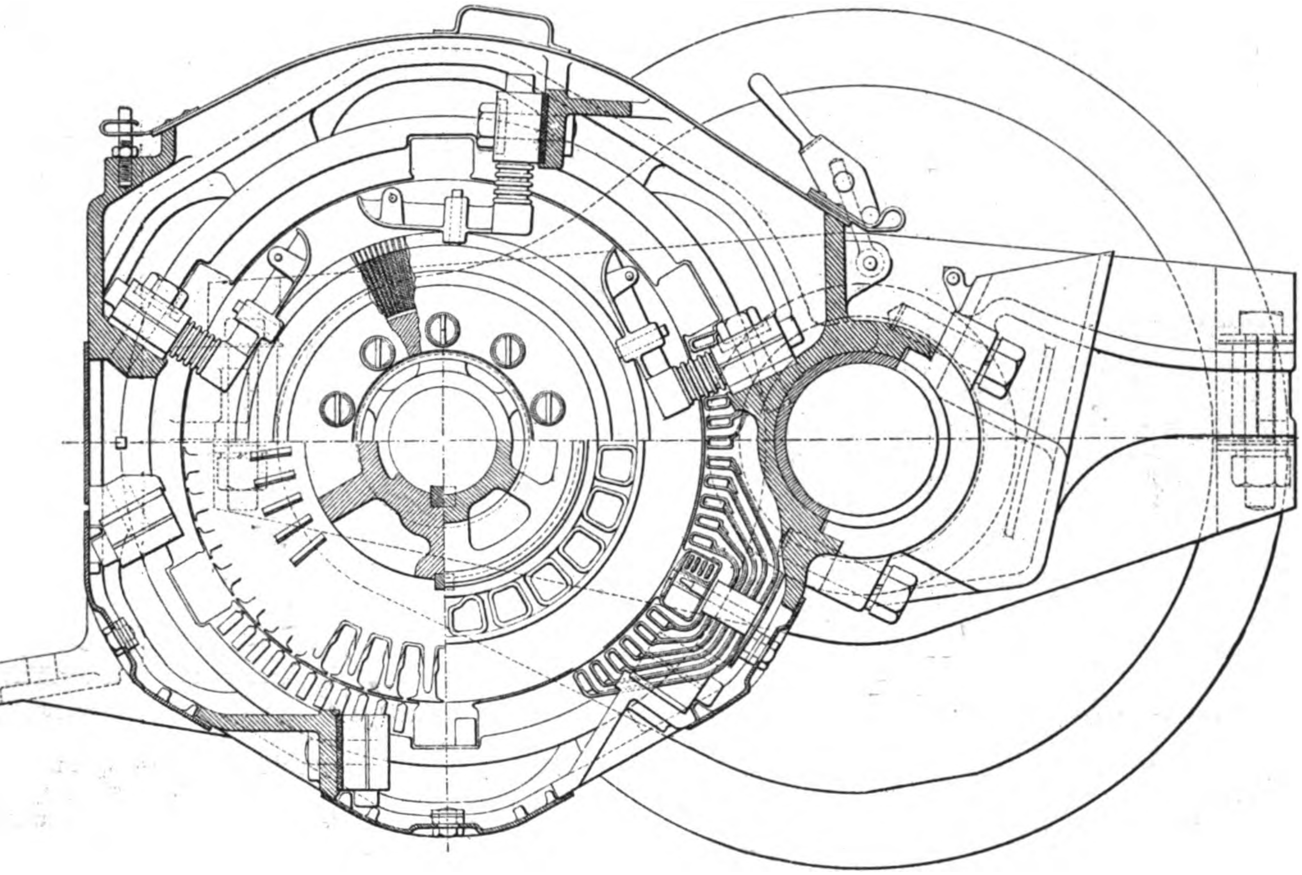


Fig. 14.—CROSS-SECTION OF WESTINGHOUSE MOTOR

The contact pieces consist of heavy copper bars pressed to shape and held in by springs in such a way that a bar can be readily withdrawn and re-inserted, or replaced by a fresh one. The reversers have three switch contact pieces; most of the other contactors have only two. The middle piece is intended to take all sparking, and is surrounded by an asbestos arcing shield, with a section of the blow-out coil on each side of it. The blow-out coil is not continuously in circuit, but the current begins to pass through it when the auxiliary contacts are opened before the spark-taking ones part from one another. These contactors weigh about 95 lb. each, and are very liberally designed. In a future case they will probably be considerably lightened. They work quite satisfactorily, and without humming or chattering.

The pump contactors are smaller, and of rather different design.

The master controllers are of "fly-back" or "dead-man-handle" type, the release of forward and downward pressure on the handle by the driver opening the circuit of No. 13 wire, and so tripping all the contactors. It is not necessary for the handle to come back to the "off" position, as a movement of about half a notch ensures this tripping taking place, so that the maximum amount of safety that can be obtained from a handle of this type is insured. It was not considered advisable to complicate the control gear by also fitting to these master controllers a means of putting on the brake in the event of the driver releasing the handle, ample safety being provided for by the vacuum-operated trip switch and the control of the brake by the guard.

The type of motor suspension adopted, while neither of the nose nor of the center of gravity type, resembles the latter more than the former. The suspension bar is heavy, weighing about 3 cwt., but the bringing of it round so as to allow of the type of spring support adopted, appears to give the bogie very good riding qualities.

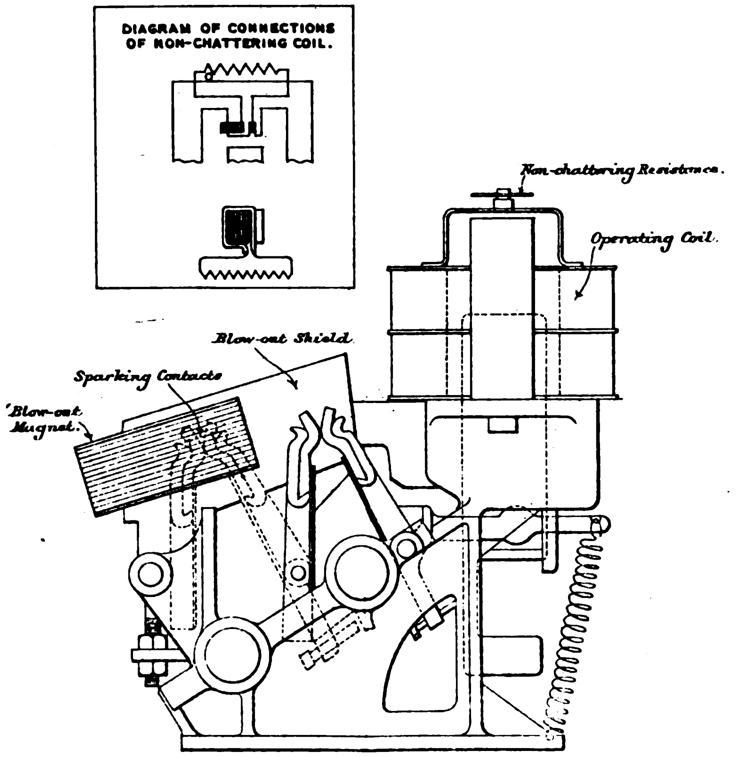


Fig. 15.—DETAIL OF SIEMENS CONTACTOR

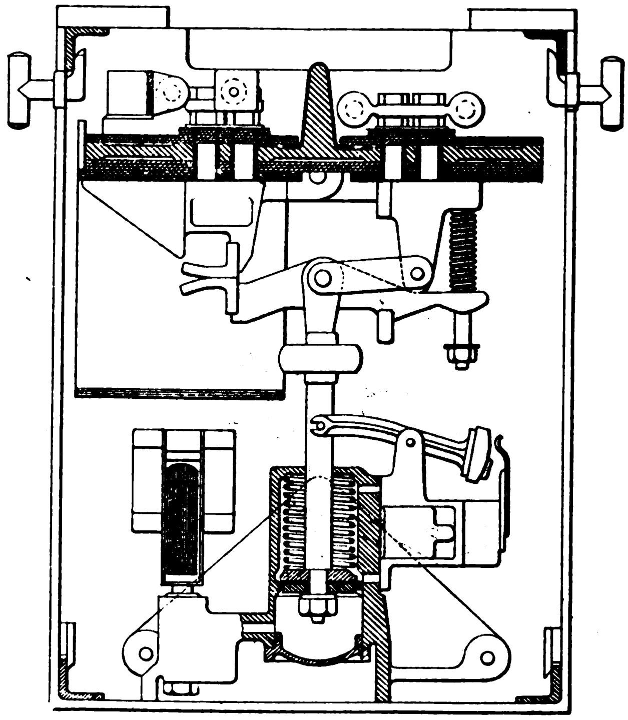


Fig. 16.—DETAIL OF WESTINGHOUSE CONTACTOR

Transformers, Casings, etc.—In neither case are the transformers in any way special in internal construction. The Westinghouse tanks are of cast iron. The Siemens tanks of the main and auxiliary transformers are built of corrugated iron plates and angles. The Westinghouse main transformer is entirely supported from its top plate, so that the tank with the oil can be lowered off bodily, leaving the top plate and the transformer exposed for inspection. In each case the transformers are supported by girders of channel section bolted to the main girders of the coach underframe. The Siemens preventive coil and commutating transformers are in cast-iron cases, and are also oil-cooled. The Westinghouse preventive coil is not cased, but is air-cooled, and is much lighter, though it has more work to do. Air-cooling appears to be perfectly satisfactory for a transformer of this capacity and type which, in particular, has no high-tension windings.

The high-tension apparatus and the contactors, etc., of the Siemens car are contained in sheet-iron cases, which were made by the railway company. These, and their supports, and the supporting of the transformers, preventive coil, and other apparatus, would be considerably lighter in any future case; and the necessary provision of a good deal of special girder-work on the underframe also added considerably more to the weight of the latter than would be the case again.

Though the Westinghouse apparatus is more self-contained, much the same remark applies to it.

It has been already indicated that the auxiliary and the Siemens commutating transformers could be dispensed with, while the Siemens control-gear and preventive-coil transformer could be lightened.

WEIGHT OF EQUIPMENT

For future similar work, the main transformers in both cases might be reduced in weight. Below are given not only the actual weights, but also the probable revised weights:

It will be seen that, taking the Siemens motors on their forced-draught rating of 210 h.p., the weight of the actual electrical equipment in this case amounts to 0.035 ton per h.p., the weight of the Westinghouse apparatus being 0.041 ton per h.p., while on the revised weights the figures are respectively 0.029 and 0.035 ton per h.p. This contrasts with the figures for direct-current equipments variously published at from 0.016 to 0.02 ton per h.p., and coming out in actual practice at about 0.020 and 0.025 ton per h.p.

for equipments with motors of similar rating. The 60-ft. single-phase 420-h.p. motor car, seating 72 passengers, weighs, on the revised figures, 36 tons, as against 32¼ tons for a direct-current motor car of similar length, horsepower and capacity.

Obviously, while the single-phase revised equipment is by itself about 40 per cent. heavier than direct-current equipments of similar horse power, the percentage by which the weight of a single-phase car exceeds that of a direct-current car of similar power is much less, namely, about 12 per cent., and still less is the percentage difference in the weights of the respective complete trains, *e.g.*, for the standard Heysham train 5½ per cent.

It will be seen from Fig. 1 that the distance from Heysham to Morecambe is about 4.7 miles, Lancaster to Morecambe about 3.4 miles, while Lancaster Green Ayre to Lancaster Castle is about ¾ mile. The last-named is the only portion of the route heavy in gradient, being 1 in 70 to 1 in 78 for about ½ mile, but there are speed restrictions at all three ends.

The services for which the motor cars were specified was a 20-min. one Morecambe to Heysham, and a 15-min. service Morecambe to Lancaster, each with a three-car train (trailer, motor car, trailer), the Siemens train weighing 77½ tons without, and 89½ tons with, 180 seated passengers, the corresponding Westinghouse weights being 74½ and 86½ tons. Two additional main-line coaches were also to be taken occasionally if required, but with an increased time allowance. It was considered by the railway company that two 150-h.p. motors per motor coach would satisfactorily carry out the work, and the respective contractors supplied motors of their nearest standard sizes to this, the Siemens motors being nominally of 180 h.p., and the Westinghouse motors of 150 h.p. The former are, however, now rated by their makers at 210 h.p. under forced draught.

The motors were specified for one hour's run with single-phase current at full load with a temperature rise not exceeding 135° F., and for a similar maximum temperature rise after having run the three-coach train for six complete double trips on the schedule above. They were also specified to be subjected to overloads up to 100 per cent. over full-load torque. The main transformers were specified for the same heating-test conditions.

	Siemens.			Siemens. Revised.			B. W. Co.			B. W. Co. Revised.		
	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
Motors with gear, gear-case, and suspension-bar......	6	5	0	6	5	0	5	11	0	5	11	0
Main transformer..................................	2	14	2	2	10	0	2	11	0	2	5	0
Auxiliary commutating transformer and preventive coil..		19	2		2	2		9	2		2	1
Pumps and compressors............................	0	9	2		9	2		16	0		10	2
Contactors and chambers..........................	1	2	2		14	2		9	3		9	3
Other sundries, including bows, blowers, controllers, cables, etc................................	3	7	0	1	19	0	2	9	3	1	15	0
	14	18	0	12	0	2	12	7	0	10	13	2
Carriage-body......................................	13	5	0	13	5	0	13	5	0	13	5	0
Special suppotrs...................................	1	6	0		15	0		17	0		15	0
Carriage-bogie.....................................	4	10	0	4	10	0	4	10	0	4	10	0
Motor-bogie..	6	11	0	5	10	0	6	11	0	5	10	0
	25	12	0	24	0	0	25	3	0	24	0	0
Grand Total......................................	40	10	0	36	0	2	37	10	0	34	13	2

TESTS OF MOTORS

The tests of the Siemens apparatus at the makers' works resulted as follows: With natural cooling at 180 h.p. for one hour the motors did not exceed their guaranteed temperature rise. With forced draught and with 300 volts at the terminals (the full voltage being 340 volts) they were tested at 200 h.p. without exceeding the specified temperature rise, this corresponding at full voltage with fully 225 h.p. They were also tested for continuous-service capacity, and from this test it is evident that with a temperature rise of 135° F. they can take loads corresponding with a continuous root-mean-square current of 405 amperes with a forced draught that requires about 1½ kw. for the man. At full voltage this is a power of about 150 h.p. Under 1100 ampers at 300 volts, which corresponds at full voltage with 350 h. p., and a torque of fully two and one-half times that at the rated power of 180 h.p., there was no injurious sparking whatever. The later rating of these motors at 210 h.p. is, in the authors' opinion, fully justified.

At the makers' works, under forced draught, the temperature rise of the Westinghouse motors at the end of one hour's full run at 150 h.p., with single-phase current, was well within the limit, while overloads up to 1200 amperes, corresponding with 195 h.p. at full voltage, and two and one-quarter times normal full-load torque, were applied without causing injurious sparking.

Fig. 17 shows the characteristic curves of the Siemens motors, and Fig. 18 those of the Westinghouse motors. The efficiencies, power factors, etc., given are obtained from the tests made on the test-stand and on the line. The speed, voltage, current and watt curves have been checked in service on the cars.

In actual service the trains, particularly in the winter, are not anything like so frequent as the specified schedule, nor are the specified running-times adhered to, as speeds have been further restricted on the curves since the electrification commenced. In test-

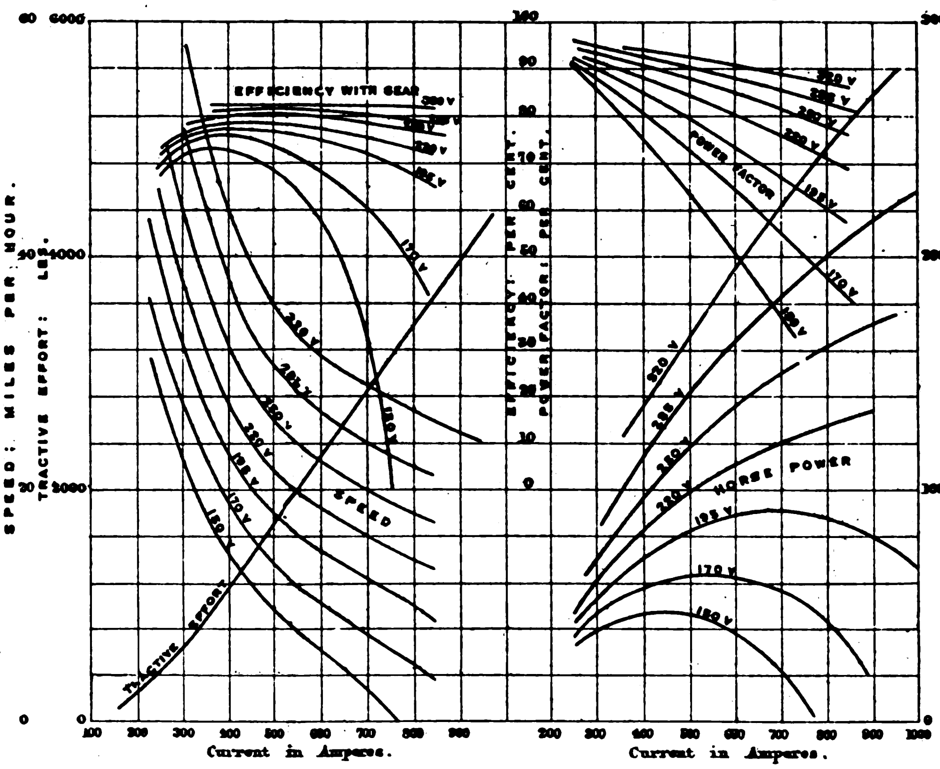


Fig. 17.—CHARACTERISTIC CURVES OF SIEMENS MOTOR. RATED CAPACITY, 210 HORSE POWER; GEAR RATIO, 30.88; WHEELS, 43½ INCHES DIAMETER

running without passengers, however, the running-times have been bettered, if anything. But, as regards loading, while traffic and trains are, of course, light at some parts of the day, not only do many of the trains taken daily

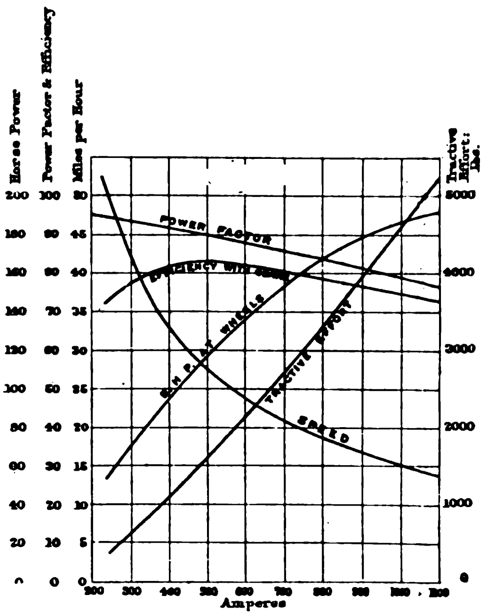


Fig. 18.—CHARACTERISTICS OF WESTINGHOUSE MOTOR: GEAR RATIO 19:70; WHEELS 43½ IN. DIAMETER.

come up fully to the specified loads, but several trains (main-line trains, for example, taken from or given up to steam locomotives at Lancaster, where the running-sheds are situated) daily exceed these loads up to a total train-weight of 165 tons, or 113 per cent. overload; while trains up to a total weight of 190 tons have been taken. The motor cars, in fact, do very much the work of locomotives.

[*To be continued.*]

Mexican Electrical News

The Mexican Light and Power Company has entered into a contract with the Compania Hidro-Electrica y Irrigadora of Pachuca to furnish the Irrigadora Company with 30,000 h.p. from the Necaxa plant. The Irrigadora Company already owns two plants in the Pachuca district and is erecting a third, which, when complete, will give the Company 15,000 h.p. of its own. The absorption of 45,000 h.p. by this mining district gives an idea of the possible demands for power from mining interests.

Another Pachuca company has obtained a grant from the government of the State of Hidalgo for the erection of a hydro-electric plant to utilize the waters of Lake Metzitlan for electric power and irrigation purposes. This Company will transmit power to the mining districts of El Chico and Real del Monte.

It is announced by Dr. F. S. Pearson, head of the Mexican Light and Power Company, that the great Necaxa dam will be finished about July 1. Next to the Gatun dam on the Isthmus of Panama it will be the largest dam of its kind in the world. It will bring the hydro-electric capacity of the Company up to 100,000 h.p. An additional 32,000 h.p. will be had by 1912. When the demand for power reaches this capacity a second power plant of 100,000 h.p. will be built below the Necaxa Falls.

The British firm of S. Pearson & Son, limited, has obtained the contract for constructing the $6,000,000 dam on the Nazos River in Northern Mexico. The object of this tremendous undertaking is mainly irrigation, but it is announced that the water will also be used to generate electric power, which will be transmitted to the Cities of Torreon, Durango, Lerdo, Gomez Palacia, Mapimi, San Pedro and many smaller places.

The construction of the electric railway that is to be built from Guadalajara to the pleasure resorts on Lake Chapala by the Compania Hidro-electrica y Irrigadora de Chapala, a Guadalajara concern, will start as soon as the government has approved the plans and surveys. The distance is about 35 miles. This Company is also projecting the construction of an electric railway from Guadalajara to Aguascalienties, a distance of some 120 miles.

Mr. D. E. Thompson, President of the Pan-American Railroad, has been granted a concession to utilize the waters of the Tonala River at a point near the town of Tonala, State of Chiapas, for generating electric power, and to furnish the town of Tonala with electric lights. The shops and general offices of the Pan American road will be removed to Tonala.

Southern Pacific Electrification

The Southern Pacific Railroad has announced that it is proposed to operate cars by electricity between San José, Meridian Corners, Monte Vista, Los Altos, Mayfield and Palo Alto. The line from Mayfield to Los Gatos will be affected, as steam trains will hereafter use only the east track of the double-track line between Mayfield and Congress Junction, the west track being turned over to the Peninsula Railway, which is now equiping the line for operation by electricity to Monte Vista, where the tracks connect with those of the Cupertino line to San José. Five multiple-unit cars for the new service have already been received from the St. Louis Car Company. The construction of the substation and power-house at Los Altos and the installation of the machinery remain to be completed.

Electric Traction in Russia

The Municipal Board of St. Petersburg, Russia, is planning to extend electric operation of the street-railway system in St. Petersburg by rebuilding immediately 43 miles of horse-car lines at an expenditure of more than $10,000,000. When this work is completed the entire street-railway system of the city will be operated electrically.

News Notes

The provision of storage batteries for emergency lighting on all subway cars in New York has been ordered by the Public Service Commission.

The Baltimore & Ohio Railroad has adopted the electric light for all sleeping-car and parlor-car equipment. Besides the general lighting in sleeping-cars, lights for each berth will be provided. Axle-driven generators and storage batteries will be used.

The Boonton, N. J., plant of the Westinghouse Storage Battery Company was almost entirely destroyed by fire on the 6th of February. Owing to bitter cold weather and a high wind the power house was the only building which could be saved. About 200 men were thrown out of employment, mostly inhabitants of the village, whose chief employment was thus interrupted. The loss is estimated at $240,000, of which about $180,000 is covered by insurance. The plant is to be rebuilt at once.

The New York Central Railroad's extension of its electrical service is proceeding apace. The work is now complete as far as Mt. Vernon on the Harlem division and Yonkers on the Hudson division. The electrical service to White Plains is to begin in the current month. The completion of the work beyond Yonkers is not so definitely fixed on account of its difficult character. Besides the electrical work, grade-crossing elimination and new stations play an important part. The Hudson division will also be four-tracked throughout the electric zone.

Recent returns indicate that the present fiscal year's business will be the next to the largest ever done by the Western Electric Company. Calculations based on the usual ratio point to a gross of about $60,000,000, which, if verified, will be only $9,000,000 below the banner record of 1906. January sales were 46 per cent. greater than those of the same month last year. Machinery, electric light, telephone and cable departments are all doing well. Extensions and improvement in the Company's producing-plant are under way, and more are contemplated.

Some Chemistry of Light

By W. R. WHITNEY, Ph. D.*

Director of General Electric Company's Research Laboratory

From the dawn of history, chemistry has had much to do with the production of artificial light, and I wish now to recall to your minds a few illustrations. I will not burden you with a long story on physics or mechanics of light, but intend treating the subject of artificial light so as to show you that it has always been largely a subject for chemical investigation. I want to impress upon your minds that it is still a most green and fertile field for the chemist. It should be borne in mind that I am trying to interest an audience of chemists from widely different fields, rather than to present a chronological record of recent experimental research.

I cannot tell just when chemistry was first scientifically applied to a study of artificial light. Most cardinal discoveries are made by accident and observation. The first artificial light was not made by design, nor was the first improvement the result of chemical analysis. It is supposed that the first lamps were made from the skulls of animals, in which oil was burned. Herodotus, describing events about three centuries before Christ, says of the Egyptians:

"At the times when they gather together at the city of Sais for their sacrifices, on a certain night they all kindle lamps many in number in the open air round about the houses; now the lamps are saucers full of salt and oil mixed and the wick floats of itself on the surface and this burns during the whole night."

This night was observed all over Egypt by the general lighting of lamps, and these lamps were probably the forerunners of the well-known Greek and Roman lamps of clay and of metal which are so common in our museums.

The candle and lamp were probably invented very much earlier. We know that both lamps and candles were used by the priests of the Jewish temple as early as 900 B. C. The light of those candles and lamps was due, as you know, to particles of carbon heated in a burning gas.

It is not fair to the chemists of our early candle-light to skip the fact that great chemical advances were made while candles were the source of light, and so I touch for a moment upon one of the early applications of chemical knowledge. The fats and waxes first used were greasy and the light was smoky and dull. They were capable of improvement and so the following chemical processes were developed and applied to the fats. They were first treated with lime, to separate the glycerol and produce a calcium soap. This was then treated with sulphuric acid, and the free stearic and palmitic acids separated. These acids were then made into candles and gave a much whiter light than those containing the glycerol ester previously used. Similar applications of chemical principles are probably known to you all in the refining of petroleum. The crude distillate from the rock oil is agitated with sulphuric acid and then washed with a solution of sodium hydroxide. This fact accounts, in considerable degree, for the advance of a number of other chemical processes. An oil refinery usually required the presence of a sulphuric acid plant in the immediate vicinity, and this often became a source of supply for other new chemical industries.

Very great advances have been made in the use of fats and oils for lighting purposes, but there is so much of greater interest in later discoveries that we will not consider many of them. The distillation of gas from coal or wood in 1739 was a chemical triumph, and a visit to a gas plant still forms one of the main attractions to the young chemist in an elementary course of applied chemistry. The first municipal gas plant was established in London, just about 100 years ago. The general plan, so apparently simple to us to-day, was at its inception judged impracticable by engineers.

In spite of other methods of illumination, the improvements in the making, purification and application of illumination gas have caused a steady increase in its use. Gas owes its illuminating power to the fact that a part of the carbon in it is heated to incandescence during the combustion of the gas. It must contain, therefore, such carbon compounds as yield a fair excess of carbon, and this knowledge has led to the schemes for the enrichment of gas and for the use of non-luminous water-gas as a base for illuminating gas.

Various schemes were devised in the early part of the nineteenth century for using gas to heat to incandescence, rods or surfaces of lime, zirconia and platinum. This was not at first very successful, owing to imperfect combustion of the gas. The discovery of the Bunsen-burner principle was made a little later. By thus giving a much higher temperature to the gas flame and insuring complete combustion, new impetus was given to this branch, and the development of suitably supported oxide mantles continued for a half a century.

Most prominent in this field is the work of Auer von Welsbach. It was a wonderful series of experiments which put the group of rare earth oxides into practical use and started a line of investigation which is still going on. The Welsbach mantle practically substitutes for the carbon of the simple gas flame, another solid in a finely divided shape capable of giving more efficient light. This allows all of the carbon of the gas to contribute to the production of a hotter flame. But more interesting than the mechanical process, to my mind, is the unforeseen or scientifically unexpected discovery of the effect of chemical composition. By experiment it was discovered that the intensity and color at incandescence of the various mixtures of difficultly fusible oxides varied over a wide range. Thus a broad field for unforeseen investigation was opened, and much advanced chemical work has been applied to this industry. The color and intensity of the light varies in an unexplained manner with slight differences in composition of the mantle. The following are the composition and candle-powers of some sample mantles:

CANDLE-POWER OF MANTLES, RANGING FROM PURE THORIA TO 10 PER CENT. CERIA

No.	Per Cent. Thoria	Per Cent. Ceria	Candle-Power
367	100.00	0.00	7
378	99.75	0.25	56
369	99.50	0.50	77
370	99.25	0.75	85
371	99.00	1.00	88
372	98.50	1.50	79
373	98.00	2.00	75
374	97.00	3.00	65
375	95.00	5.00	44
376	90.00	10.00	20
69	La, Zr, Ce	Oxides	30

The methods of making the present mantles were also a part of Dr. Auer's contribution to the art. Suitably woven fabrics are dipped into solutions of the rare earth salts; these are dried and the organic matter burned out, leaving a structure of the metal oxides.

The pure thoria gives a relative poor light. The addition of the ceria, up to a certain amount, increases the light. This added component is called the "excitant," and as the cause for this beneficial action of the excitant is not known, it is possible that further

*Address before the American Chemical Society.

discoveries along this line will yet be made.

There as hardly a prettier field for chemical speculation than is disclosed by the data on these light efficiencies. For some unknown reason, the change in composition by as little as one per cent. varies the luminosity over tenfold, and yet more than 1 per cent. of the excitant (ceria) reduces the light. Besides the temptation to speculation, such disclosures of nature encourage us to put greater trust in the value of new experiments, even when accumulated knowledge does not yield a blazed trail for the pioneer. By giving a discovery a name and attaching to it a mind-quieting theory, we are apt to close avenues of advance. Calling this small amount of ceria an "excitant" and guessing how it operates, is directly harmful unless our guess suggests trial of other substances.

One of the explanations proposed to cover the action of the ceria ought to be mentioned, because it involves catalysis. This is a term without which no chemical lecture is complete. Some think that the special mantle mixture causes a more rapid and localized combustion and, therefore, higher temperatare by condensation of gas in its material. Others think that this particular mixture permits of especially easy and rapid oxidation and reduction of its metal oxides themselves in the burning gas mixture. The power which catalyzers have of existing in two or more states of oxidation seems to apply also to the ceria of the Welsbach mantle.

Whatever the truth may be, it has been shown by Swinton* that when similar oxide mantles are heated to incandescence in vacuo by cathode rays, the presence of 1 per cent. ceria produces only a very small increase in the luminosity of thoria. It is interesting to note that in the gas flame *pure ceria* gives about the same light as *pure thoria,* while in the cathode rays of the Crookes tube, with conditions under which ceria gave almost no light, pure thoria gave an intense white light. These facts, which are still unexplained, illustrate how little is understood in this field.

I will merely refer to the fact that vapors of gasoline, kerosense, alcohol, etc., are now also used in conjunction with the Welsbach mantles. The field of acetylene I must also omit with a mere reference to the fact that the manufacture of calcium carbide was a chemical discovery; and the action of water upon it producing the brilliantly burning acetylene gas was another.

Turning now to electrical methods of generating light, we find the chemist early at work. Sir Humphrey Davy and others, at the dawn of the nineteenth century, showed the possibilities which since that time have been developed into our various types of incandescent and arc lamps. We naturally attach Mr. Edison's name to the development of the carbon incandescent lamp, because it was through his indefatigable efforts that a practicable lamp and illuminating system were both developed.

It had long been known that platinum, heated by the current, gave a fair light, but it melted too easily. A truly enormous amount of work was done in attempts to raise the melting-pot of the platinum, and the effect of occluded gases, of annealing, of crystalline condition, etc., were most carefully studied, but the results were unsatisfactory. He was, therefore, led to the element carbon as the next most promising conductor of high melting-point. Edison's persistent and finally successful attempts to get a dense, strong, practical filament of pure carbon for his lamps is one of the most encouraging lessons to the chemists of to-day.

This history needs to be read in the light of the knowledge of carbon at that time and the severe requirements of a commercially useful carbon filament. It illustrates the value of continued effort when it is based on knowledge or sound reasoning. The search was not the groping in the dark that some of us have imagined, but was a resourceful search for the most satisfactory among a multitude of possible materials. From our point of view, all subsequent changes in choice of material for incandescent lamp filaments have been dictated by the knowledge that high melting-point and low vapor tension were the first requirements. If you will consult the curve (Fig. 1) of the ***melting-points*** of all the ***elements,*** as plotted against their ***atomic weights,*** you will see at once that the desired property of high melting-point is a periodic function of the atomic weight. And it is this fact, which was independently disclosed as a general law by Meyer and Mendeljeff, in 1869, that has aided in the selection of all the new materials for this use. You will notice that the peaks of the curves are occupied by such elements as carbon, tantalum, tungsten, osmium, etc., which are all lamp materials.

A study of the laws of ***radiation*** also soon played a part in incandescent lamp-work. The early rough and black filament of bamboo was first replaced by a polished black carbon filament, and later by one which had a bright silver-gray coat of graphite. A black body at any temperature radiates the maximum possible energy in all wave-lengths. Heated to incandescence, it will ***radiate more invisible and useless infra-red rays than any other*** opaque material at the same temperature; a polished metal is,

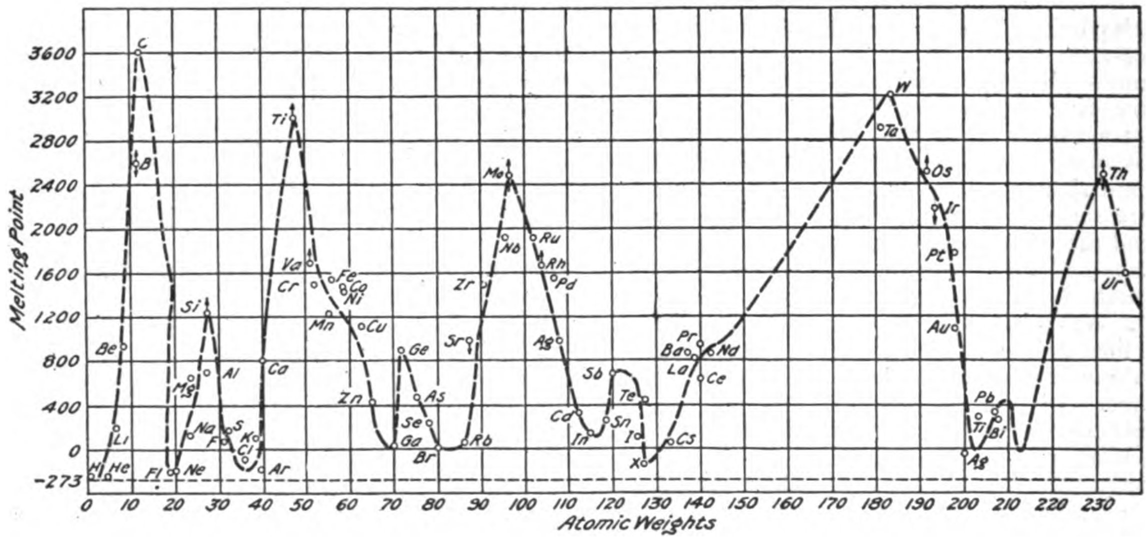


Fig. 1.—CURVE OF MELTING-POINT OF ALL ELEMENTS

*Proc. Roy Soc., 66, 115.

therefore, a more efficient light source than the same metal with a black, or even rough surface. This fact is derived from Kirchoff's law of radiation and absorption, which was early established.

It may seem like penetrating too far into details to consider for a moment the changes in structure and surface which the carbon filament of our incandescent lamps has undergone, but the development of such an apparently closed problem is instructive, because it has yielded to such simple methods of attack. The core, or body, of the carbon filament of today is made by some one of the processes based on dissolving and reprecipitating cellulose, such as are used in artificial silk manufacture. The cellulose solution is squirted through a die into a liquid when hardens it into dense fibres. These cellulose fibres are then carbonized by being heated, out of contact with the air, at as high a temperature as possible with gas furnaces. All of this is also merely the application of chemistry which was first worked out in some of the Germen chemical laboratories.

The plain carbon filament (the result of this simple process), which might have been satisfactory in the early days, would nowadays be useless in a lamp, as its practical life is only about 100 hr. 3 watts per candle. In a subsequent process of manufacture it is, therefore, covered with a steel-gray coating of graphite, which greatly improves the light emitting power. This coat is produced by heating the filament in an atmosphere of benzene or similar hydrocarbons. The electric current which heats the filament is of such an intensity that the decomposition of the hydrocarbon produces a smooth, dense deposit of graphite.

With this graphite-coat the filament now burns about 500 hours. But the simple graphite-coat is improved by being subjected, for a few moments, to a temperature of about 3500 degrees in the electric furnace; the life then becomes about 1500 hours under the same operating conditions as before. The product of this treatment is known as the metallized filament, because by this last step its temperature coefficient of resistance is made similar to that of the metals; *i. e.* 0.0037.

With an incandescent lamp containing a platinum wire filament, the intensity of its light is not very great, even when the current is sufficient to melt the wire. A much greater luminosity is produced by a plain carbon filament, and a still greater by the graphite-coated and metallized carbon before they are destroyed. In the case of carbon, the useful life of the lamp depends much more on the vaporization of the material than on its melting-point, and these lamps will operate for a short time at very much greater efficiencies or higher temperatures than is possible when a practical length of life is considered. Thus, besides the physical effect of surface quality, we have evidence of differences in the vapor pressure of different kinds of carbon. It looks as though carbonized organic matter yielded a carbon of much greater vapor pressure for given temperature than graphite, and that even graphite and metallized graphite are of quite distinctly different vapor pressures at high temperatures. It may be interesting to note here that if the carbon filament could withstand for 500 hr. the maximum temperature which it withstands for a few moments, the cost of operating incandescent lamps could be reduced to nearly a fifth of the present cost.

It was discovered by Auer von Welsbach that the metal osmium could be made into a filament, though it could not be drawn as a wire. The osmium lamp was the first of the recent trio of metallic filament incandescent lamps. The tantalum lamp, in which another high melting-point metal replaces the superior but more expensive osmium, has been in use six or eight years. This surpasses the carbon in its action, and on running up to its melting-point it shows still brighter light than carbon.

More recently the tungsten filament lamp has started to displace both of the others. At present this is the element which withstands the highest temperature without melting or vaporizing, and on being forced to its highest efficiency in a lamp it reaches higher luminosity; it is similar to carbon and tantalum in that an enormously greater efficiency may be produced for a very short time than can be utilized for a suitable length of life. The inherent changes at these temperatures, distillation or whatever they are, quickly destroy the lamp. The lamp will burn an appreciable time at an efficiency 15 times as great as that of the common operating carbon incandescent lamp (at 3 watts per candle). In other words, light may be produced for a short time at an energy cost of .1/15 of common practice, so that there is still a great field for further investigation directed toward merely making stationary those changing conditions which exist in the burning lamp.

While it is generally true that the light given by a heated body increases very rapidly with rise of temperature above 600 degrees, the regularity of the phenomenon is commonly overestimated. A certain simple law covering the relation between the temperature and the light emitted, has been found to apply to what we call a black body. This so-called Stefan-Boltzmann law states that "the total intensity of emission of a black body is proportional to the fourth power of the absolute temperature." There are, however, very few really black bodies in the sense of the law. The total emission from a hole in the wall of a heated sphere has been shown experimentally to follow the law rigidly, but most actual forms and sources of illumination do not. Most practical sources of artificial light are more efficient light producers than the simple law requires. This may be said to be due to the fact that these substances have characteristic powers of emitting relatively more useful energy as light than energy of longer wave-length (or heat rays). Most substances show a power of selective emission and we might say that an untried substance, heated to a temperature where it should be luminous, could exhibit almost any conceivable light effect. A simple illustration will serve to make this clear: If a piece of glass be heated to 600 degrees, it does not emit light; if some powder, such as clay, be sprinkled upon it, light is emitted, and the proportion of light at the same temperature will depend upon the composition of the powder. Coblentz has shown, both for the Auer mantle, and for the Nernst glower, that the emission spectra are really series emission bands in that portion of the energy curve which represents the larger part of the emitted energy. This is in the invisible infra-red part, and so the laws which govern the emission at a given temperature depend upon the *chemical composition* of the radiant source. Silicates, oxides, etc., show characteristic emission bands.

One of the most attractive fields of artificial light production has long been that of luminous gases or vapors. It has seemed as though this ought to be a most satisfactory method. The so-called Geissler tubes in which light is produced by the electrical discharge through gases at low pressure are familiar to all. The distribution of the energy emitted from gases is still further removed than that of solids from the laws of a black body, and a large proportion of the total electrical energy supplied to a rarefied gas may be emitted as lines and bands which are within the range of the visible spectrum. These lines, under definite conditions of pressure, etc., are characteristic of the different elements and compounds. The best known attempts to utilize this principle are the Moore system of lighting (in which long tubes of luminous gas are employed), and the mercury lamps, which, while more flexible on account of size, are still objectionable because of the color of the light.

It is rather interesting that the efficiencies of all of these various sources of electric light are not nearly so widely different as one would expect from a consideration of the widely divergent methods of light production employed.

From the light of a vapor or gas to that of an open arc is not a wide step, but the conditions in the arc are apparently quite complex and there is a great deal of room for interesting speculation in the phenomena of an arc. Briefly, there are two kinds of arcs to be considered in lighting. One has been in use for a century, the other for a few years only. The first is the successor to Sir Humphrey Davy's historical arc between charcoal points. In this kind of arc the current path itself is hardly luminous, and the light of the lamp is that given by the heated electrodes. In case of direct current it is the anode, or positive electrode, which gets the hotter and gives far the greater part of the light. In this carbon arc it can readily be seen that the light is emitted by the heated solid carbon of one electrode; this gives a steady source of light, but is not so efficient as an arc in which material in the arc stream itself is the source of light. The arc may be made to play upon rare earth oxides, and these, being heated to incandescence, increase the luminosity, but this has not proved useful. The more common way is to introduce into the carbon electrode certain salts which volatize into the arc and give a luminous effect. Here cerium fluoride, calcium fluoride, etc., are use, and the color of the arc, just as in the case of gas mantles, may be varied by varying the composition of the electrodes. This is seen in the arc from the carbon electrodes containing such salts.

In the case of the flaming arc, the greater part of the light is due to the incandescent metallic vapors in the space between the electrodes. Substitution of one chemical for another in such flaming arc electrodes has covered quite a wide range of chemical investigation. Salts are chosen which give the greatest luminosity without causing the formation of too much ash or slag. Some compounds of calcium, for example, are practical, while others are not, though all of these would, under suitable conditions, yield the calcium spectrum. If such salts as calcium fluoride were conductors at ordinary temperature, useful electrodes for flame arcs would probably be made from them. Such conducting materials as iron oxide, carbides, etc., have been used for flame arc electrodes, and a great many of the so-called magnetite arcs are now in use. The electrodes in this case are largely magnetic oxide of iron, with such other ingredients as titanium and chromium oxides, to increase the intensity of light, to raise the melting-point of the mixture, etc.

As will be seen from observing this arc, the light is very white and intense and is generated by the heated vapors of the arc proper. A great many modifications of this arc principle are possible. Titanium carbide and similar substances give characteristic arcs, and some of them are very intense and efficient.

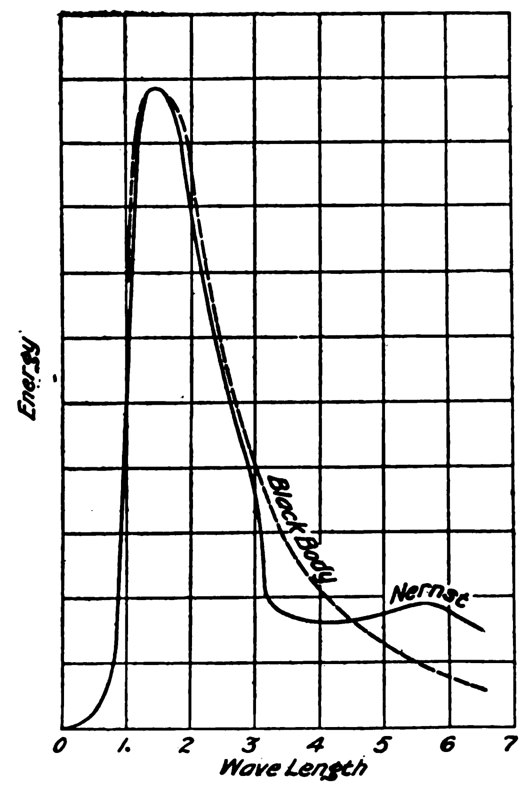


Fig. 2.—EMMISSION CURVES FOR NERNST BLOWER AND BLACK BODY

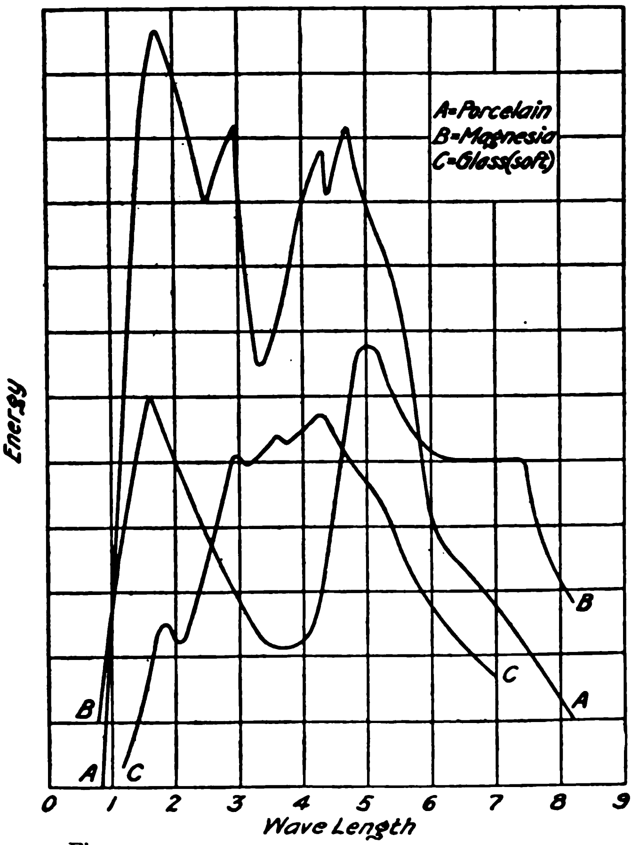


Fig. 3.—EMMISSION CURVES FOR REFRACTORY BODIES

THE NERNST LAMP

A distinct species of electric incandescent lamp is that invented about 10 years ago by the well-known physical chemist, Professor Nernst. This employs for filaments a class of bodies which are not electrical conductors at all at ordinary temperatures, and which, at their burning temperatures, do not conduct the current as metals and carbon, but as a solution does. This kind of conductivity, the electrolytic, involves electrochemical decomposition at the electrodes, and in the case of the Nernst filaments these otherwise destructive reactions are rendered harmless by the continual oxidizing action of the air. For this reason this type of lamp will not burn in vacuo.

For its most perfect utility the principle of the Nernst lamp seems to require a mixture of oxides, because a single one is not so good a conductor nor so luminous. It uses oxides becaüse these are the most stable compounds known, and it uses the rare earth oxides because they have higher melting-point than other oxides. As the efficiency rises very rapidly with temperature, there is a great advantage in using the most infusible base possible. For that reason, zirconia, thoria, etc., are usually employed.

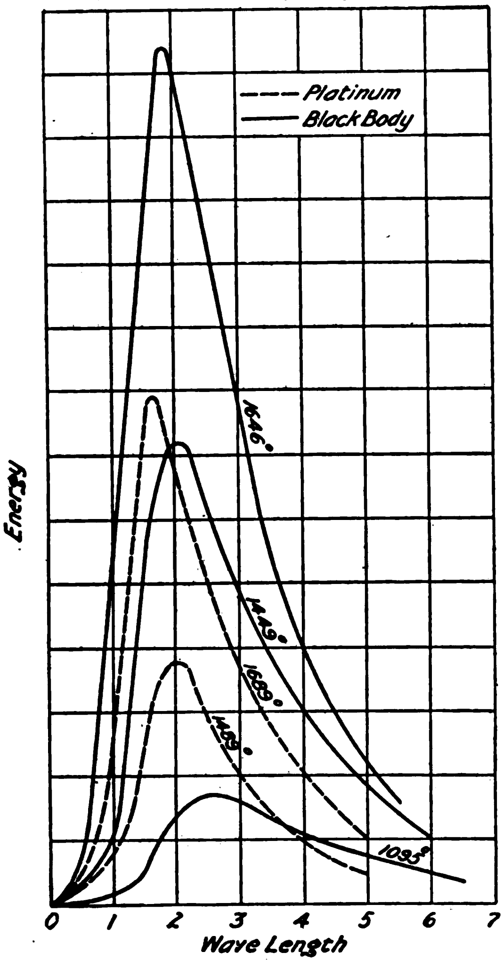


Fig. 4.—EMMISSION CURVES FOR PLATINUM AND BLACK BODY

In this lamp a rod or filament of an oxide mixture, much like those used in Welsbach mantles, is heated by the current, externally applied, until it reaches a temperature at which it becomes a good conductor itself. Here, again, the peculiar laws of light radiation are illustrated, the light emitted at a given temperature being determined by the nature of the substance. Just as the pure thoria gives a poor light compared to the mixture with 1 per cent. ceria, so a pure zirconia rod, heated by the current, gives much less light than a rod containing a little thoria, ceria or similar oxide. Work done by Coblentz on the energy-emission of such rods shows the emission spectra, at least in the infra-red, to vary with the nature of the substance. In general, the spectra are not continuous like the spectra of metals and black bodies, but seem to occupy an intermediate position between these and luminous gases, which we know have usually distinct line spectra.

This recalls the subject of selective emission. Coblentz has shown selective emission in the long wave-lengths for a Nernst glower. This is shown in comparison with the emission of a black body, in curve No. 2. The two sources, when compared at the temperatures where they exhibit the same wave-length for maximum emission, differ very considerably in emission in the infra-red, the black body giving more energy at the blue end, and less at the red end of the spectrum.

This is still more noticeable in the curves for such substances as porcelain, magnesia and glass, as shown by Coblentz's curves (Fig. 3).

The curves of wave-length and radiant energy which are shown are, with slight modifications, taken from work of Lummer and Pringshein and of Dr. Coblentz. The curve for the ideal, or black body radiator, gives a picture of the total energy and its distribution over the different wave-lengths. It is the peculiarity of the black body to radiate more energy of any given wave-length than does any other body at the same temperature. Therefore, in case of all substances acting as thermal radiators, the black body will always give the greatest brilliancy. Since this body at the same time radiates a maximum in *all* wave-lengths, it will be surpassed in light *efficiency* by any substance which is a relatively poor radiator in the invisible or non-luminous part of the spectrum.

In the energy curves shown it is to be noticed that the visible part of the energy is practically only that between 0.4 and 0.8 thousandths of a millimeter. Consider the solid lines in Fig. 4 for a moment. These show the emission of a black body at centigrade temperatures noted on the curves. Evidently the energy emitted rises very rapidly with the temperature; *i. e.*, as the fourth power of the absolute temperature. It will be noted also that the point of maximum energy or wave-length corresponding to maximum energy shifts gradually toward the left, or toward the visible wave-lengths.

It is this rapid shifting of the position of maximum energy which makes the search for substances which can withstand even only slightly higher temperatures of such great interest.

The curves for the black body and for platinum (dotted lines) are not greatly different in general appearance, but the total amount of energy emitted at a given temperature from the black body is shown to be more than for the platinum, and it can be seen that at about the same temperature the platinum is the more economical light source. Professor Lummer has said that at red heat, bright platinum does not radiate *one-tenth* the total energy which the ideal black body radiates at the same temperature, and at the highest temperature still less than one-half. The deviation of platinum from the black body law is a step in the direction of getting improved light-efficiency without corresponding increase of temperature. This method is practically without limit in its extension, for there seems to be no limit to the forms of energy curves which different substances may possess. The curves are apparently determined not only by physical state, but also by chemical composition of the emitting substance.

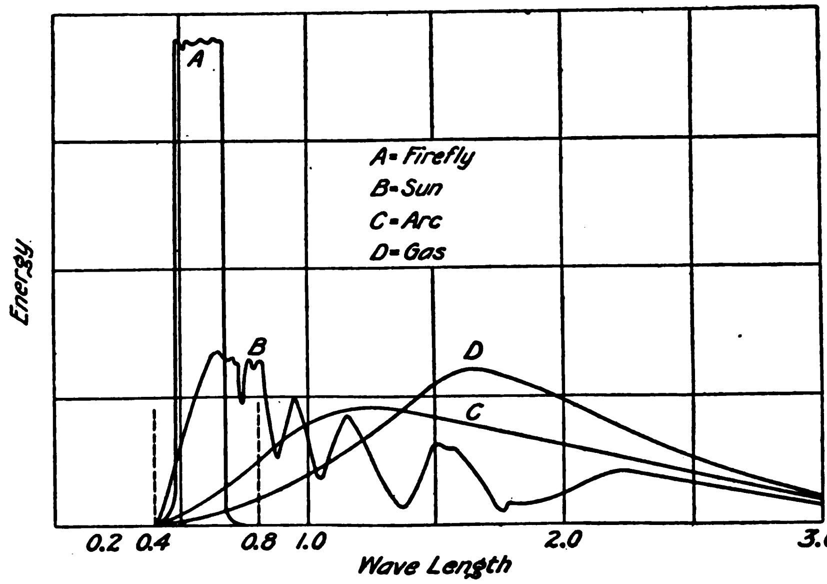


Fig. 5.—EMMISSION CURVE FOR DIFFERENT SOURCES OF LIGHT

In the production of artificial light, the tendency will always be in the direction of increasing the practical efficiency; *i. e.*, reducing the cost of light. We have seen that there is still much room for this. In the case of the kerosene oil lamp we know that much less than 1 per cent. of the energy of combustion of the oil is radiated as light from the flame. In the case of the most efficient source — the electric incandescent lamp at *highest* efficiency — we are still far from ideal efficiency. A still higher temperature would yield a yet higher efficiency. We do not know exactly how much light might possibly be yielded for a given consumption of energy, but one experimenter concludes that it is about 10 candles per watt. Fortunately, it is not now clear just how the chemist is to realize all the advances which he will make in more efficient lights.

No consideration of this part of the subject is complete without a brief reference to the efficiency of the firefly. The source of his illumination is evidently chemical. This much is known about the process:

The light-giving reaction is made to cease by the removal of the air, and to increase in intensity by presence of pure oxygen. It is extinguished in irrespirable gases, but persists in air some time after the death of the insect. Its production is accompanied by the formation of carbon dioxide. These all indicate a chemical combustion process. Professor Langley has shown that such a flame as the candle produces several hundred times as much useless heat as the total radiation of the firefly for equal luminosity. In other words, the firefly is the most efficient light source known. This is illustrated by the energy distribution curves from several light sources taken from Professor Langley's work (Fig. 5). The difficulties attendant upon the accurate determination of the curve for the firefly are so great that we ought not to expect very great accuracy in this case. These curves, which in each case refer to the energy after passing through glass, which cuts off energy of long wave-lengths, represent the same quantities of radiant energy. While the sun is much more efficient than the gas flame or carbon arc, it still presents far the largest part of its energy in the invisible long wave-lengths (above 0.8), while the firefly seems to have its radiant energy confined to a narrow part of the visible spectrum.

A New Type Of Pump

In the search for the solution of the gas turbine problem, Mr. H. A. Humphrey, a well-known English specialist on gas motor works, has invented a new type of gas-driven pump which contains so many departures from the ordinary practice of pump construction, and whose basic principles have such possibilities of development in wider fields, that we have abstracted the inventor's description of it, as read before the British Institute of Mechanical Engineers:

The pump, as shown in Fig. 1, is probably the simplest power pump ever devised. It works on the impulse principle and has no piston and exceedingly few parts. Essentially, it consists of a valve chamber provided with the usual inlet and exhaust openings, valves and a water-proof ignition device, together with a cone-shaped combustion chamber set on a water-box provided with check-valves opening inwardly from the supply tank. A number of these valves are used in the place of one large valve to lessen the inertia, and for other reasons. The entering water is in an annular chamber surrounding the water-box, and is admitted through these valves which close by springs of such strength as to permit them to normally open when suction occurs.

The principle details of the gas valve and explosion mechanism are shown in Fig. 2. The same device permits either two- or four-cycle operation simply by altering the arrangements. As may be noted, the exhaust and inlet valves are at different levels and the space above the exhaust valve level forms the "cushion chamber," which is also part of the combustion chamber or pump proper. The mechanism of the pawls, springs and collars as shown will be best understood by describing the operation of the pump.

At starting water will stand at the same level in the suction tank, the pump and the discharge pipe. This

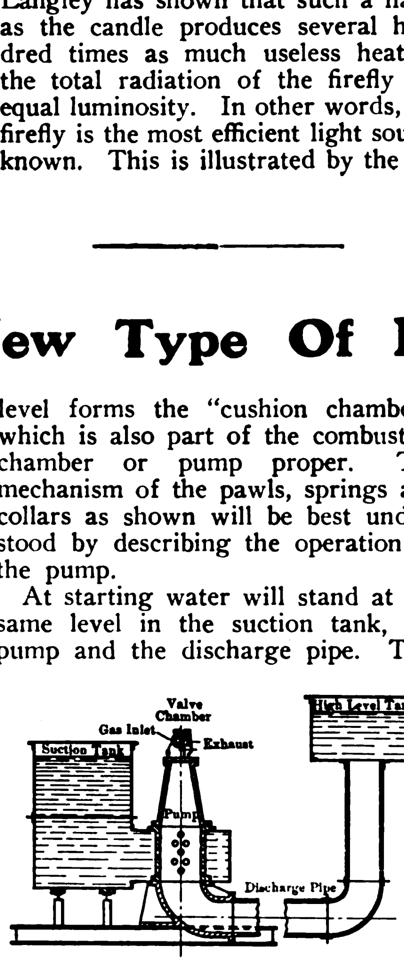


Fig. 1.—DIAGRAM OF PUMP

level may be controlled within desired limits by a float regulating the inlet to the suction tank. If now a charge of compressed air and gas is admitted into the combustion chamber over the surface of the water and fired, the following cycle of action occurs: The expanding charge forces the water downward and out of the combustion chamber, or pump, and along the discharge pipe. This mass of water must be such as to have a given amount of kinetic energy when thus set in motion. Its inertia will carry it forward to a point where it tends to form a partial vacuum in the explosion chamber, or pump, as we will hereafter term it. As soon as the pressure falls below the atmosphere the exhaust valve opens the combustion chamber, and the check-valves open, admitting more water to the water-box, which is added to the water that was already in the pump.

When the kinetic energy of the rising column of water is exhausted, the column has reached its highest level, and some of it has gone into the discharge tank, the remainder reverses its motion and starts to return with the water just admitted from the suction. Thus it rises in the pump, closing the check-valves and expelling the burnt charges through the open exhaust until its surface reaches the exhaust valve and closes it.

All of the burnt gas are now expelled, except those remaining in the cushion chamber, Fig. 2, which are now compressed, thus cushioning the shock of the returning column of water. These gases thus compressed, after receiving the impact of the water and bringing the column to rest, in turn expand again and start the water once more downward and outward. This second "stroke" has, of course, much less energy than the first. It does not go far enough to cause the water check-valves to open, but it reduces the pressure in the pump sufficiently to open the inlet valve and draw in a fresh supply of the charge. Returning for the second time, the water compresses the charge, which is automatically fired at the proper instant, and the cycle of operation begins anew.

The pump would be stopped by opening the circuit of the sparking coil. It comes to rest with a charge of unexploded mixture in it and can be started by switching on the current, thus admitting of distant control.

It will be seen that the gas inlet and exhaust valves require an interlocking mechanism to operate them alternately when the reductions of pressure take place in the pump. The arrangement, as shown in Fig. 2, comprises on each valve rod a collar *a* and *c*, beneath which the edges of the sliding plate *e* alternately catch. The movement of this plate is controlled by the springs and lever *l* attached to it, which are actuated by the bar *j* cross-connected between the pawls *f* and *h*. The pawls, in turn, are moved by the lower collars *b* and *d* on the valve rods.

As will be seen, the gear is shown with the exhaust valve open. As the rising water on the return "stroke" pushes this valve and rod up, the edge of the plate *e*, by reason of the tension in the attached spring, is drawn beneath the collar *c*. With the suction caused by the second oscillation of the water column, the inlet valve is now free to open, and in descending, through its lower collar *b* engaging the pawl *h*, throws the lever *l* over on its other position, being held there by the vertical spring *m*. This throws a tension on the plate *e*, tending to pull it away from the exhaust valve rod, but the collar *a* holds it in place until the second return of the water closing the inlet valve raises the rod and collar and the plate slips into place once more, unlocking the exhaust valve and locking the inlet valve. This completes the cycle of gas valve action.

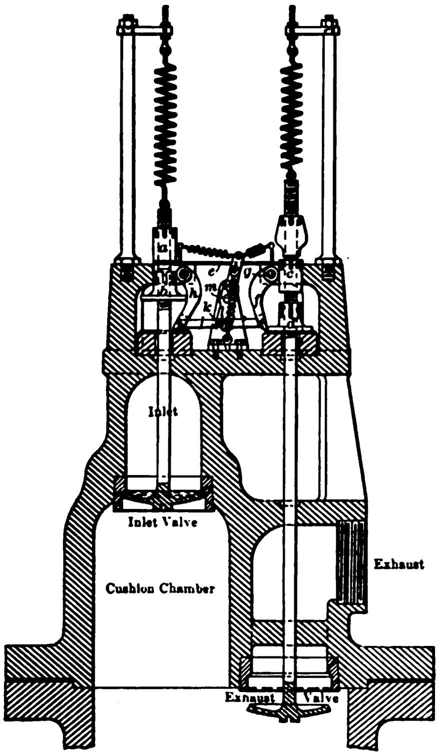


Fig. 2.—GAS VALVE MECHANISM

The ignition device is so designed as to be unaffected by immersion in water, and to have the movement of ignition timed, if desired, by the pressure in the explosion chamber.

From the description, it can be seen that in this pump water itself forms the piston. The fly-wheel for steadying and compression consists of the oscillating column of water which sucks in its fresh supply at the lower end and throws off its output at the upper end. The fewness and simplicity of its working parts and the fact that exhaust is carried down to atmospheric pressure, give it a very high operative efficiency, as may be seen from the following table, which gives a summary of tests conducted by Prof. W. C. Unwin, using Mond producer gas for operating the pump:

The very low consumption of gas per pump horse-power hour shown in this test summary, which represents the means of six tests on the highest lift, and three each on the intermediate and low lifts, as compared with other coal-operated pumps, is shown in Table II.

As compared with gas engine driven centrifugal pumps, Professor Unwin gives the respective gas consumptions as follows:

	Gas Engine and Centerfugal Pump	Humphrey Gas Pump
Cubic feet of gas per pump horse-power hour	120 to 127	83.1

This indicates relative efficiencies of 100 to 69.2, or a saving of nearly one-third, assuming gas and other conditions equal.

TABLE I. SUMMARY OF TESTS OF HUMPHREY GAS-PUMP.

Lift Feet.	Pump Horse-power.	Mond Gas Used per P. H. P.-Hour, at 760 mm. and 0 Deg. C., Cu. Ft.	Calorific Value of Gas per Cu. Ft. in B. t. u.	Heat expended per P. H. P.-Hour, B. t. u.	Lb. of Anthracite in Producer per P. H. P.-Hour.
32.87	16.15	83.12	147.3	12,243	1.063
25.95	12.32	90.93	143.5	13,037	1.132
20.73	10.99	93.61	145.3	13,596	1.180

TABLE II. COMPARATIVE TESTS OF RECIPROCATING AND GAS PUMPS.

	Worthington High Duty Engines.			Humphrey
	Compound Nov. 1888	Triple Dec. 1896	Triple Feb. 1897	Gas-Pump Sept. 1909
Lift in feet	53.7	92.3	129.1	32.9
Indicated horse-power hour	255.5	370.5	498.4	......
Pump, horse-power hour	217.1	320.3	449.8	16.15
Quantity pumped gallons per minute	13,407	11,450	11,497	1,621
Lbs. of Coal per indicated horse-power hour	1.696	1.402	1.530	......
Lbs. of Coal per pump horse-power hour	1.996	1.662	1.695	1.06

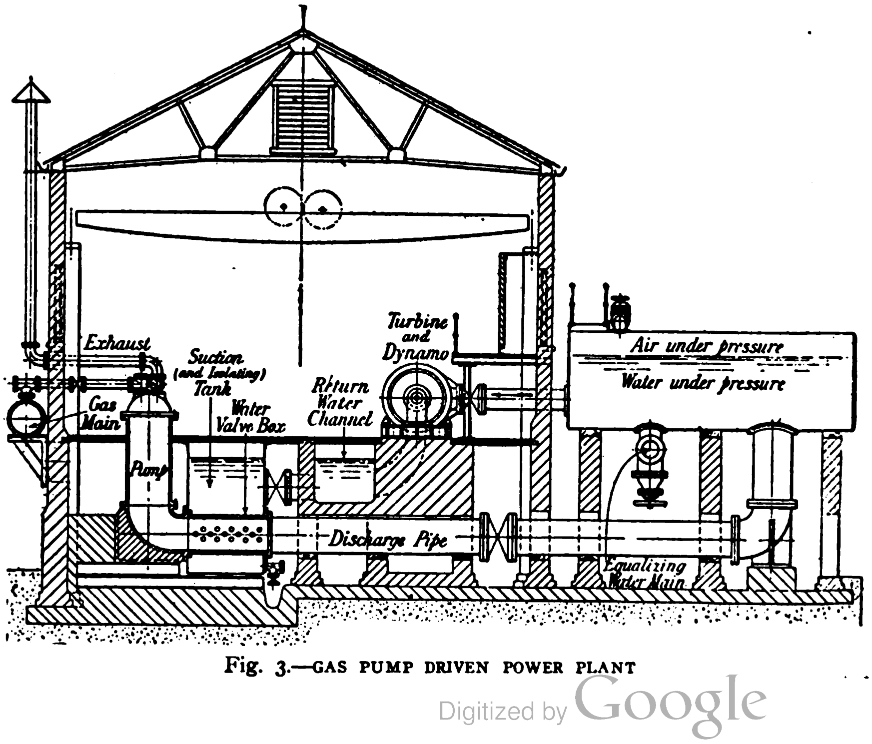


Fig. 3.—GAS PUMP DRIVEN POWER PLANT

The high operating efficiency is not the only advantage promised of this type of pump. The maintenance of such a machine must be very low as compared with a gas engine. As may be seen, the mechanism is conspicuous by its simplicity and few parts, except the small light and easily replaceable interlocking valve gear. The loss from mechanical friction and wear and tear must be very small. As the explosion chamber is flooded every cycle, there can be no danger from pre-ignition. Temperature strains are eliminated by internal water cooling.

From all these advantages it would appear that the pump represents a considerable advance in the construction of pumping apparatus.

Other application of the principles involved are set forth by the inventor. Of these, perhaps, the broadest is that shown in Fig. 3, which gives the diagram of a power plant operated by gas with these pumps as prime movers instead of gas engines.

The figure indicates one unit of such a plant. The pump discharges into a large air-vessel, which is connected with others of the same type, by a common water pipe at the bottom and air pipe at the top. The water pumped into this tank is turned on to a turbine-wheel direct-connected to generator and flows from the discharge to the suction tank, being used over and over again.

Among the advantages claimed for this arrangement are simplicity of working parts and low cost of maintenance. Assuming the losses in the turn in any generator to be less than the energy saved by the superior economy of the pump and transmission as compared with a direct-coupled gas engine, the fuel economy would be greater.

The first cost of such a plant might reasonably be expected to be less than that of a gas-driven plant of equal capacity.

General News

The first of two new freight electric locomotives, built for the New York, New Haven & Hartford Railroad by the Westinghouse Electric & Manufacturing Company, are being tested at the East Pittsburg shops. It is expected that they will be put into service between Stamford, Conn., and Mt. Vernon, N. Y., early in February. These locomotives are entirely different in construction from the electric locomotives now in service on the road. The center of gravity has been raised to save the wear on the tracks, and one of them has been equipped with side driving rods, like the Pennsylvania Railroad locomotives.

It is given out that the first electric trains through the East River tunnels on the Long Island Railroad will be run some time in April. They will be operated from the Pennsylvania Railroad station at Thirty-third Street and Seventh Avenue, Manhattan, to Jamaica. The Long Island Railroad is beginning to receive the steel cars which are to be used in its electric service. One hundred and forty of these cars will be delivered during the year, representing an investment of $1,250,000. In addition to this, repairs and extensions will have to be made to almost every station within the electric zone.

A working agreement has lately been arranged between the German electrical engineering company, Felten & Guilleaume-Lahmeyer, Mulheim-on-Rhine, and the French firm of Schneider & Company, Le Creusot. The agreement came into operation with the new year, and applies both to French and foreign electrical business. The agreement is the outcome of several large orders which have been executed jointly by the Schneider company and the French branch of the German concern, the Societe Anonyme d'Electricite Lahmeyer, Paris. These include the erection of a large rolling plant for heavy ship plate for the Italian firm, the Terri Iron Works, and a 1500-h.p. monophase locomotive for the Compagnie des Chemins de Fer du Midi, and it is thought that a definite business agreement will be of mutual benefit. An arrangement has existed for some time between the above two companies and the Escher-Wyss Company, Zurich, for the building of the Zoelly turbine for all three undertakings.

The General Electric Company has sold to the Southern Railway Company two of its latest type of gas-electric motor cars. These cars will be equipped with standard commutating pole railway motors of 100 h-p. Two of these motors are located on the forward truck, giving a motor capacity of 200 h-p. to each car. The current is supplied from a 600-volt generator, which is direct coupled to an 8-cylinder gas engine in the forward compartment.

The Southern Power Company expects to put its new power plant at Ninety-nine Islands in South Carolina into commission within 60 days. This plant will add 24,000 h.p. to the 80,000 h.p. now being generated in the other plants of the Company. By next fall the Greenville plant steam auxiliary plant of the Company will be ready for use, thus adding another 15,000 h.p. to the Company's power capacity.

Financial

The Public Service Commission has approved the issue of $2,500,000 of the $5,000,000 of new bonds which the Kings County Electric Light & Power Company asked permission. The question of the remainder is held under consideration. The above amount is needed for improvement and extensions.

The Pennsylvania Water & Power Company is the name of the new corporation organized by the bondholders of the late McCall's Ferry Power Company to take over the property of the latter. The Company has a capital stock of $8,500,000, and may issue bonds for $12,500,000. J. E. Aldred, receiver of the earlier company, is president of the new concern, which will push the completion of the dam, power house and transmission lines.

The Western Power Company, controlling the Great Western Power Company and the California Electric Generating Company, has issued a prospectus in which it claims that it can now develop 83,000 h.p., and will ultimately be able to develop 430,000 h.p. This Company has no bonded indebtedness, and $12,000,000 of common stock and $5,220,000 6 per cent. preferred.

Under the name of the Monterrey Railway Light & Power Company a group of Canadian capitalists have acquired the electric utilities of Monterrey, Mexico, from J. F. White & Co. and N. W. Halsey & Co. These comprise the street railways, electric lighting, water supply and sewage system of the city. The Company has $5,000,000 5 per cent. first mortgage debenture stock, $500,000 preferred and $4,100,000 of common stock.

Through Harvey Fisk & Sons the Hudson Companies have sold to J. P. Morgan & Co. $5,500,000 5 per cent. three-year notes, which are secured by the bonds of the Hudson and Manhattan Railroad. About $50,000,000 have already been spent on these properties, and the new loan is understood to be used for extending the tunnels up Sixth Avenue from their present terminus at Twenty-third Street to Thirty-third Street and to complete certain lines in Jersey City.

Questions and Answers

Question.—*Will you kindly explain why transformers must be larger for lower frequencies, such as 25 cycles, than for high frequencies, as, for instance, 125 cycles?*

Answer.—This is on the same principle that slow-speed machines must always be larger than high-speed ones of equal capacity. In any transformer the electromotive force of the secondary is always proportional to the rate at which the secondary coils are cut by the lines of the alternating magnetic field. To give a given amount of secondary electromotive force, therefore, so many lines must cut the coils at a given speed. Very well. If the speed is increased, *i.e.*, the field has a higher frequency, less lines are needed, so the cross-section of the iron can be reduced. If, on the other hand, the speed is lowered, *i.e.*, the field has a lower frequency, the number of lines must be increased, so more iron must be used. The same reasoning increases the number of turns in the coils of the secondary, so that a larger transformer is necessary to produce a given result.

Question.—*What is usually the resistance of a good voltmeter reading up to 600 or 700 volts?*

Answer.—The best voltmeters, if not of the induction type, have resistances running from about 60 ohms up to 200 ohms per volt of rated capacity. The figure varies with the design and the purpose for which the meter is to be used. The higher the capacity, the greater the resistance per volt.

Question.—*Can amperes be read on a watt-meter?*

Answer.—No. But if the meter is on a constant potential circuit of unity power factor, the amperes may be calculated from the watt-meter readings by dividing them by the voltage.

Question.—*What is the reason that low voltage on the trolley line causes the motors to heat more than normal voltage?*

Answer.—The reason is that with a voltage lower than that for which the motors are designed the speed decreases, and the time the current must be kept on to make a given run increases, so the ventilation is less, the current is on longer and the motor gets hotter than it would when running under proper voltage.

Question.—(*a*) *What is meant by "skin effect" in connection with alternating currents?*

(*b*) *How is it calculated.*

Answer.—(a) The name is given to that property of a conductor which causes an alternating current to flow mainly near the surface and not penetrate the interior at all. It depends on the nature of the conductor. It is greatest with iron of high magnetic quality. It also depends on the frequency of the current.

(b) The calculation is too complex to give here. Consult the papers of some of the electrical or physical societies.

Question.—*What is the record speed for electric cars?*

Answer.—On the Zossen road in Prussia, some years ago, a special electric train ran somewhat over 126 miles an hour for some minutes. Previous to that, a small motor car is said to have run at 120 miles an hour on a test track in Maryland in the early eighties.

Question.—*Are electrically welded rail joints preferable to banding from an electrical point of view?*

Answer.—They are preferable from every point of view wherever conditions justify installing them. The resistance of the joints is generally less than that of an equivalent length of rail, and it is maintained indefinitely. As for the mechanical feature, the great point is that the life of the joint is as long as that of the rail.

Question.—*What is the best make of governor for water turbines that is to be had?*

Answer.—This column cannot undertake to give the names of manufacturers making what we consider the best. The devices that we have seen give the best results are of Swiss make, and in turbine work the Swiss and Germans seem at present to be somewhat ahead of our American manufacturers.

Question.—*What is the mechanical equivalent of Ohm's law?*

Answer.—We suppose you mean the mechanical analogy. It would be written: Effect = force ÷ resistance to force; just as current = e.m.f. ÷ resistance to e.m.f. This is a great general law and holds true in all fields of which we can conceive.

Question.—(*a*) *When two or more compound-wound generators are operating in parallel how much may the voltage of one of them drop below that of the other before it will reverse and run as a motor?*

(*b*) *What determines the division of the load between generators in parallel when the voltages are equal?*

Answer.—(a) On compound-wound generators running in parallel, if the difference in voltage of any machine gets far enough below that of the others to enable the latter to force current back through the armature, the lower voltage machine will be "reversed" as to direction of current and will be receiving it, not giving it. Hence it will run as a motor, but in the same direction as when running as a generator, and if the driving force of the machine is still being applied, the effect of the two forces will be to run it faster. There would be no reversal of the direction of rotation in this case. The amount of difference in voltage to work this effect depends on the resistance of the connections between the machines, the bus bar and the armature resistances, and also on the position of the brushes on the machine that is being "overpowered." Usually, if the brushes are in the right position, the difference in voltage necessary to reverse the current will be very small.

(b) With equal voltages on all the machines, the load, that is, the current factor of it, divides among the machines in proportion to the resistances of the different armature circuits and connections from bus to bus. As these are proportional to the output as a rule, the load tends to divide itself among the generators in proportion to their capacity.

Question.—*Please define exactly what is meant by a polyphase current.*

Answer.—Nothing. There is no such thing. You probably mean polyphase *currents.* These are alternating currents that differ in phase, which is to say, currents that do not reach their maximum or minimum values at the same instant. If you have two single-phase alternating-current generators exactly alike and running at the same speed, but started up so that the armature coils of one are passing before a field-pole at the instant when the armature coils of the other are between two poles, you have two simple single-phase currents which differ in phase in this case 180 deg., or exactly oppose each other. If they had been started so that they were just half so far apart in the rotation of the armature, you would have a difference of 90 deg. between the two machines, which would together give "two-phase" currents. If there were three generators so arranged, and the difference in the rotation was two-thirds that of the first instance, you would have 120 deg., or "three-phase" currents, from them. When the two or three sets of coils are wound on one armature properly spaced, you have a two-phase or three-phase generator.

The February Technical Press

Leading Articles of General Technical Interest

Commercial

"Financial Aspect of the Application of Electric Motive Power to Railroads," F. Darlington. An extended analysis of the traffic and other conditions that determine the advisability of electrifying trunk lines. Some results of the relatively limited experience of trunk-line sections that already operate electrically are given, and their bearing on the problem is discussed. The writer thinks that there are many cases in which great net economies could be made by installing electricity as the motive power.—*Eng. Mag.*

"Industrial Engineering," J. C. Parker. A vigorous practical paper taking up the commercial end of central station operation dealing with the modern methods of power-selling and rate-making, and giving many typical instances of methods of central station power applications.—*Elec. Jour.*

"Rates for Hydro-electric Service," Alton D. Adams. A study of conditions determining the rates quoted by ten different companies for hydro-electric power. The annual output of these ten companies ranged from 260,000 kw-hr. to 362,000,000, and the prices charged varied from 0.28 cent to 2.48 cent. The largest of these companies had only 33 customers who used energy mainly for electro-chemical purposes. A table slightly changed gives the complete list or outputs and rates, as follows:

Annual Sales and Average Rates for Hydro-Electric Power

Company	Annual Output Kilowatt hour	Average Price Cents per kw.-hr.
I	260,000	2.05
II	1,600,000	1.70
III	2,400,000	1.88
IV	2,900,000	1.42
V	3,700,000	2.48
VI	18,200,000	0.82
VII	53,700,000	0.77
VIII	84,800,000	0.68
IX	149,000,000	0.704
X	362,000,000	0.2786

Only the first five of these plants do any general lighting business, and the figures throughout cover energy sold for power purposes only. They are obtained by dividing the total revenue from the sale of power by the total output for power.—*Elec. Wld.*

Detail Apparatus

"A Large Industrial Plant Switchboard," Warren H. Miller. A description of the switch and central devices of the gas-engine-driven plant of the Bayway refinery of the Standard Oil Company. A well-illustrated account of a plant representative of up-to-date practice in this class of work. Out of a total of over $225,000 spent for electrical equipment, the board cost only $8,200, of which about $1,000 was for foundations, connections and accessories.—*Elec. Wld.*

Electric Railways

"New Electric Locomotives for the New Haven Road," N. W. Storer. A description of the new geared locomotives made for the N. Y., N. H. & H. R. R., giving the principal features and a few figures resulting from the preliminary test of these machines.—*Elec. Jour.*

"Re-Equipped Elevated Instruction Car of Brooklyn Rapid Transit Company." A profusely illustrated account of a new car for the instruction of motormen operating elevated trains that shows what pains and expense experience has shown to be worth while in order to properly train men for this important and responsible work.—*Elec. Ry. Jour.*

"Reinforced Concrete in Railway Work," F. W. Scheidenhelm. A useful and well-illustrated discussion of the application of reinforced concrete to power and substation buildings and to galleries, foundations, bunks and roofs thereon, as well as to stringers, girders, bridges and poles.—*Elec. Jour.*

"The Bellinzona-Mesocco 1500-Volt Railway." An account of a high-voltage direct-current Swiss mountain railway about 20 miles long, with a maximum grade of about 6 per cent. The motor equipment is Siemens-Schuckert, and multiple unit control with 60-volt current from storage batteries is used. This line has been in operation since 1907.—*Elec. Ry. Jour.*

Management

"Power Plant Wastes," Percival Robert Moses. A study of various practical instances of preventable waste in the power-making departments of various office buildings, stores, hotels, manufacturing establishments and other concerns that have come under the author's notice. Some of these wastes have run as high as 50 per cent. of the total cost of operating the establishments in question. That is, by proper design and operation, the cost of running the plants might be cut in half. The cause is almost always unintelligent engineering.—*Cass. Mag.*

Measurements and Tests

"Commercial Electrical Testing," E. F. Collins. Continues the description of factory and other tests of electrical machinery and gives numerous tables and curves showing results of such tests.—*Gen. Elec. Rev.*

"Tests of Turbine Alternators," Howard M. Nichols. A detailed description of the testing of alternating-current turbines as done in the shops of one of the large manufacturing companies. Some fifteen different tests are described and curves are given for two or three of the more important, as well as a table of voltage tests for machines of rated terminal volts of 800 to 23,000.—*Elec. Wld.*

Power Plants

"Electrical Generators for the Rjukanfoos Water-power Development." A short account of what are probably the largest water-driven turbo-generators yet built. They are designed to furnish power for electrochemical purposes and are double. Each generator is stated to be capable of "generating 17,000 kw-amperes at a pressure of 10,000 to 11,000 volts, a frequency of 50 cycles, and a power factor of 0.6, this at a speed of 350 rev. per min., with each machine consuming about 14,450 h.p." The description states that the full-load efficiency will be about 95 per cent., but according to the figures just quoted the efficiency must be more than 150 per cent. The weight is given as about 226 tons, of which the revolving element is about 101 tons.—*Elec. Rev.*

"The Castel Nuovo-Valdorno Transmission Plant." The description of an Italian plant which generates its power from lignite burned under boilers and transmits some 4500 kw. at 33,000 volts to Florence, Siena and other places in the Arno valley. The plant has American boilers, Italian engines and British 6000-volt, 50-cycle alternators. The longest transmission is 33 miles.—*Elec. Wld.*

"The Coltness Iron Company's New Cement Plant." This is a description of an iron works in Scotland in which, by the use of electrically operated machinery, the slag from the blast furnaces is crushed and treated so that it is turned into first quality Portland cement. The power for operating the machinery comes from gas-engine-driven generators operating on waste gases from the furnaces.—*Elec. Rev.* (London).

"The New Berlin-Rummelsburg Power Plant," F. Koester. Tells of a recently completed turbo-generator plant in the suburbs of Berlin which is interesting as being representative of the latest German practice.—*Elec. Rev.*

Prime Movers

"Elementary Theory of the Steam Turbine," W. E. Snow. This is a copiously illustrated serial paper dealing with the history and development of the various types of steam turbine from the practical standpoint. The different classes are discussed and their modes of operation shown.—*Power.*

"Mixed Pressure Turbine and Engine Plants," H. Y. Haden. A practical paper on the performance of mixed power equipment worked out for several cases, with curves given showing the performance of the combined plants. The advantages claimed are: 1, a large range of high efficiency operation; 2, greater reliability of operation; 3, a better maintenance of initial efficiency under working conditions; 4, flexibility.—*Power.*

"Specifications for Engines and Boilers," C. H. Benjamin. Some practical notes on drawing up specifications and contracts for the furnishing of engines and boilers for electrical plants.—*Elec. Rev.*

Theory

"Economies of Synchronous Condensers," B. F. Jakobsen. A mathematical treatment of the problem of calculating the most economical capacity of this kind of condensing effect, whether for the purpose of increasing the output of a given installation, or for decreasing its losses. *Elec. Wld.*

"The Design of Constant Potential Transformers," W. T. Ryan. This is a series of illustrated articles dealing with this problem. The matter is treated in a clear and simple way.—*Elec. Rev.*

"Transmission Line Calculations," M. W. Franklin. Continues the presentation of the calculation of various properties of a transmission line. This chapter deals with capacity, reactance and charging current.—*Gen. Elec. Rev.*

Transmission

"Engelberg-Lucerne Transmission System," Francis M. Weldon. An illustrated description of a long-distance plant transmitting 6000 h.p. with an ultimate capacity of 15,000. An extended description of this plant was published in the ELECTRICAL AGE for October, 1909.—*Elec. Wld.*

Utilization

"A Motor-Operated Rail Mill," B. E. Semple. An illustrated description of the electrically operated rail mill of the Gary plant of the Indiana Steel Company. The mill, which is the largest in the world and the only one of its kind that can roll 166 tons per hour direct from the ingot without reheating, requires some 30,000 h.p. of motor for its operation, of which all but 5000 are furnished by alternating-current induction motors. Three of these are 6000-h.p., 6600-volt, 25-cycle motors of 75, 83 and 88 rev. per min. respectively. These motors, which are the largest so far built, all have tremendous fly-wheel effects and pull-out torques. The 75 rev. per min. motor, for example, pulls out at 20,600 h.p. They weigh in the neighborhood of 374 tons apiece, and have been in regular operation since November, 1908.—*Gen. Elec. Rev.*

"Electricity for Mine Operation and the Electric Hoist." This is an illustrated sketch of the more general features of electrical applications to mine work. Diagrams and general data for selecting apparatus are given.—*Ind. Prog.*

"The Effect of Rotary Condensers on Power Factor," J. Liston. Gives an analysis of the effect of power factors on station economy and output, and the improvements to be obtained by the use of properly selected rotary condensers.—*Gen. Elec. Rev.*

"The Electric Grill," P. A. Bates. A paper giving the general features of the electric grill as now made, and the time required for various cooking operations. It states that at 10 cents a kw-hr. the cost of cooking the breakfast chop or steak is from 3 to 8 cents. —*Elec. Wld.*

Miscellaneous

"Atmospheric Electricity," Elihu Thomson. This well-known writer discusses the various kinds of lightning and the problem of lightning protection.—*Gen. Elec. Rev.*

"Railless Electric Traction," R. Lonneman. A short illustrated account of "trackless" trolleys as operated in a few European cities. Power consumption and operating expenses are given for a line at Neuenahr, in which the tire expenses run about two-thirds of the power bill. These cars are supposed to occupy a place driven generators operating on waste the gasolene-driven omnibus.—*Cass. Mag.*

"Sunlight and Artificial Light," A. C. Morrison. An instructive comparison on the various kinds of artificial light with the ideal light, and their chemical and physical effects.—*Illum. Eng.*

Copper Production in 1909

Statistics and estimates received by the United States Geological Survey from all plants known to produce blister copper from domestic ores and from all lake mines indicate that the copper output from mines in the United States in 1909 surpassed all previous records.

The figures represent the actual production of each company for 11 months and include an estimate of its December output. The November figures for a few companies were not available and these companies furnished estimates for the last two months of the year. According to the statistics and estimates received the output of blister and lake copper was 1,117,800,000 lb, as against 942,570,-721 lb. in 1908, an increase of over 18 per cent. This not only exceeds the increase of any previous year, but it is considerably greater than the total yearly increase since 1904.

Mine development has been active in most of the important camps, but especially so in the deposits of disseminated ore in Arizona and Nevada.

The Boston News Bureau, basing its figures on reports from mines, gives the estimated production of copper on the American continent, based upon mine and smelter figures of output for 1909, compared with 1908, as follows:

	1909	1908
Arizona	325,622,000	262,200 000
Montana	312,000,000	293,800,000
Lake	237,000,000	224,500,000
Utah	117,000,000	87,750,000
California	65,000,000	27,750,000
Nevada	53,700,000	7,500,000
Other States	45,000,000	37,000,000
Mexico-Canada	162,000,000	125,000,000
Total	1,317,322,000	1,065,500,000

Production of copper on the American continent is now at the rate of about 1,400,000,000 lb. per annum.

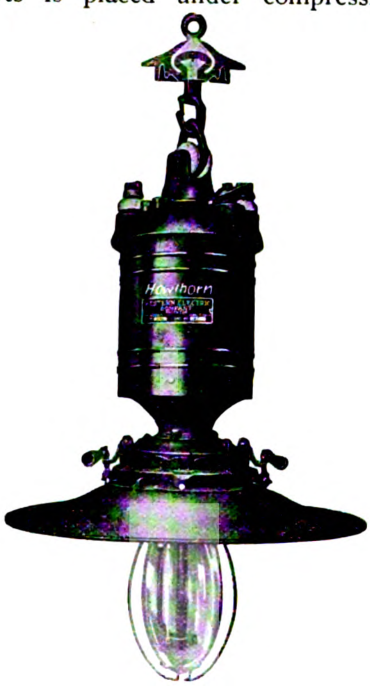
Even allowing that there will be no restriction in production, even though the big copper merger becomes a fact, it is evident that copper production in 1910 cannot reasonably be expected to show an increase over 1909 of over 5 per cent. It is reasonable to suppose, however, that in future production will be kept more in line with consumption than in the past.

An Improved Arc-Lamp Suspension Insulator

Experience has demonstrated the necessity of employing a high-potential insulator for the suspension of series arc lamps, thereby preventing grounding of the lamp or line, and at the same time protecting the trimmer or other person who might come in contact with the suspension rope.

To supply this need, the Western Electric Company has placed on the market a high-potential strain and suspension insulator for arc lamps and cut-outs.

These insulators, which are made from the well-known "Electrose" material, are constructed in such a way that with the lamp suspended the insulating material between the metal parts is placed under compression,



thereby making the strength of the insulator far in excess of ordinary requirements.

The novel construction also makes the dropping of the lamp impossible in the event of the insulator becoming destroyed.

The disc-type arc-lamp insulators possess all of the important features embodied in the well-known "Electrose" disc-type suspension line and strain insulators which possess great mechanical strength, combined with the highest form of electrical insulation.

The merits of the insulators have received immediate acknowledgment from some of the foremost electrical engineers in the country.

The arc-lamp insulators are provided with detachable bronze eyes and sister hooks, clevis or other forms of hangers, and are made sufficiently large to accommodate the steel cables.

Projected Steam Road Electrification in Germany

In a report recently submitted to the Bavarian Parliament by the Minister of transportation the question of the electrification of the state-owned railways of that country was pre- engineer connected with the study, has contributed an abstract of this report to the Bulletin of International Railway Congress, published at Brussels.

In the report the trains were divided into four classes: Freight trains, suburban trains, express trains and local trains, and power-speed-distance curves were prepared for each line. The total consumption and ton mileage of the system estimated upon are shown in the accompanying table, which is based on an average day in July, 1906. To the figures for energy therein shown an allowance was made of 10 per cent. for contingencies, 15 per cent. for transformer losses based on a transmission voltage of 10,000 and 25 per cent. for transmission losses. This gives for the average daily demand 3,400,000 h.p., equivalent to an average daily load of 142,000 h.p. With a load factor of 33 per cent. and a further allowance for extensions probable before 1920, the engineers estimate that there should be provided a maximum power station capacity of 606,000 h.p. The largest output of energy is required in November, because at that time power is needed for light and heat and the traffic is greater than during any other winter month. The least energy is required in April. The figures for July are a close average of those for the year.

A study of different electrical systems resulted in the recommendation for single-phase operation with transmission voltage of 50,000 and a trolley voltage of 10,000 with low frequency.

The report then considered the financial aspect of the proposition. This was based on a cost of coal per ton in the northern sections of $5.12 and in the southern sections of $5.48, and a cost per kilowatt-hour from water-power in the northern sections at from 0.8 cent to 1.2 cents, and in the southern section, where water-power is more abundant, from 0.4 cent to 0.8 cent. The conclusion is reached that electric power would be cheaper than steam on the southern lines and ward. The tons given are English (long) tons of 2240 lb.

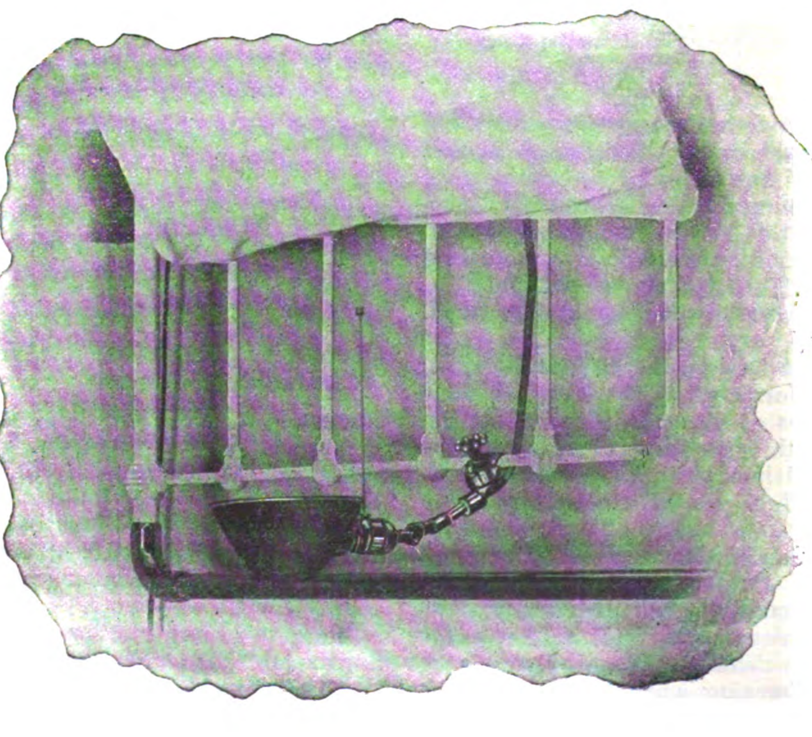
DISTRIBUTION OF ENERGY CONSUMPTION ON BAVARIAN STATE RAILWAYS

	Ton, miles.	Kw. hours.	Watt hrs per ton mile
Main lines—			
Passenger trains.....	8,416,813	578,890	68.27
Freight trains.......	14,542,236	646,010	44.48
Branch lines—			
Passenger and freight	1,433,976	78,525	54.61
Miscellaneous—			
Switching.........	....	135,400	....
Local lines.........	197,359	12,270	62.46
Total............	24,590,384	1,447,095	58.87

A Convenient Eye-Saving Device

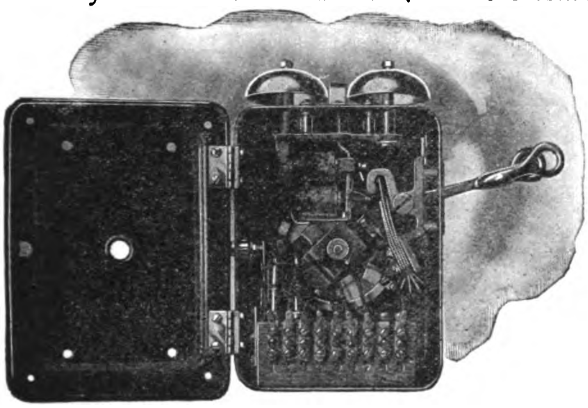
The extension of the domestic uses of electricity is one of the striking features of the present time. One of the many new wrinkles is the adaption of a special lighting fixture for reading in bed shown below.

This device is made by the O. C. White Company, Worcester, Mass., and is only one of a number of useful and handy electrical house and office fixtures turned out by them.



New Connecticut Interchangeable Telephone

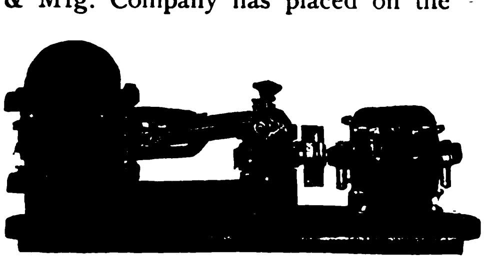
The Connecticut Telephone & Electric Company, of Meriden, Conn., have just placed on the market a new type, which will be known as their interchangeable telephone. In all telephone installations it has been necessary in the past to have systems wired for the particular service for which they are to be used. At last a battery telephone has been placed on the market which can be carried in stock by electrical dealers and jobbers



which can be used for practically all systems. The Connecticut Company furnish a bulletin showing connections which correspond to the lettering of their wiring diagrams in their catalogue No. 20 covering interior telethe phone. This telephone is equipped by adding one or two jumper wires to these connections in the inside of the phote. This telephone is equipped with the very best long-distance parts throughout. It is also made up in a stamped metal case, and is without any question a most desirable article in view of its high quality and interchangeable features.

A Neat Electric Pump

In places where there is no water service under pressure the small electrically driven house pump has come to be indispensible. Realizing the demand for a thoroughly reliable article, the Fort Wayne Engineering & Mfg. Company has placed on the



market the ingenious pump shown below.

As may be seen, it is double-acting with the piston operated from a crank shaft driven by a worm gear. Thus the advantage of a high-speed motor and a low-speed pump are realized.

Business Notes

Meetz & Weiss, of New York, who make oil engines, are having a brisk demand for small units for electric lighting plants. The Navy Department has also been placing orders with this firm for oil engines to operate generators for wireless.

The National Carbon Company, of Cleveland, report for its year ending January 31st shows the largest business in its history. The outlook for the coming year is even better.

The Edison Storage Battery Company, of Orange, N. J., is having a rush of orders for their new battery, and large volumes of business are reported by the Electric Storage Battery Company, of Philadelphia, and also by the Westinghouse Storage Battery Company, which will at once rebuild the Boonton, N. J., plant, destroyed by fire on the night of February 6th.

The Kelman Electric and Manufacturing Company, of Los Angeles, Cal., and Pierson, Roeding & Company, of San Francisco, have completed arrangements whereby the latter firm acquire the Pacific Coast agency for the Kelman high voltage oil switches and circuit breakers.

The Westinghouse Electric & Manufacturing Companies report a lively business in January, with orders amounting to nearly $3,000,000. In the railway division 1200 motors were ordered by five companies alone, and the detail and supply department is busier than ever before. It is stated that the Newark shops are now turning out about 30,000 motors a month. More men are now employed than at any time since 1906.

The H. T. Paiste Co., Philadelphia, Pa., added to its line of standard sign receptacles a new one having the holding screws in a right-angled position to the two-line contacts.

The H. W. Johns-Manville Company, manufacturer of electric lamps and fuses, among other products, has leased the building at 27-29 Michigan Avenue in Chicago and will concentrate at that point the supply business at 171-173 Randolph Street, and also the warehouse now on Erie Street. The building has been leased for a term of 10 years and is near South Water Street. The Baltimore branch has moved to new quarters at 30 Light Street.

The Allis-Chalmers Company has been experiencing a strong demand for the many different lines of its output, particularly in the lighter power and mining fields. Among the recent electrical orders placed is the entire hydraulic and electric equipment of the James White Power Company of Athens, Ga.; and also the power plants of the New River & Pocahontas Consolidated Coal Company, Berwind, W. Va.,; the Interurban Electric Company, Cartersville, Ill.; the Wisconsin Traction, Light, Heat & Power Company, Appleton, Wis., and the San Diego Electric Railway Company.

J. G. White & Company, New York, have been awarded the contract for the double tracking of the Albany Southern Railroad between Rensselaer and Kinderhook Lake, N. Y., as well as the straightening of curves and the rehabilitation of a large amount of the present track of that Company. In addition to the operation of its third rail electric road between Albany and Hudson, N. Y., the Railroad Company furnishes electric light to the following towns: Rensselaer, East Greenbush, East Schodack, Nassau, North Chatham, Niverville, Valatie, Kinderhook, Stuyvesant Falls, Stottville, and also owns and operates gas plants in Hudson and Rensselaer, N. Y. The above properties are under the management of J. G. White & Company, Inc.

Foreign Trade Opportunities

4144. Electric-light Plant and Equipment.—An American consul in Latin America has forwarded the name of a business man who has recently been granted a concession by the local government for the establishment of an electric-light plant. The concessionaire undertakes to supply light to certain cities, also power for machinery, tramways, railroads, etc. No duty will be charged on the machinery and materials imported for this plant.

4149. Electrical Machinery and Equipment for Power Buildings.—An American consular officer in Canada reports that a power company in his district has begun the erection of a plant for the development of electrical power for industrial purposes. The company will be able to develop between 40,000 and 50,000 h.p. when required, but at present the intention is to develop about 25,000. The general manager states that the plans for the power buildings and machinery are nearing completion.

Further particulars are obtainable by addressing the Bureau of Manufacturers, Washington, D. C., referring to the file numbers given above.

Legal Notes

A case of joint liability of two companies for damages recently came up in Atlanta, when a horse was killed by contact with a telephone wire which had broken and fallen across an electric railway company's wire. Negligence as to insulation and other points was charged against both companies, and both were held responsible.

In a Pennsylvania case, where an electric light company made a special written contract to supply certain parties with electric current at a rate less than that made to other parties in the same business, discrimination was charged. The court found that the plaintiff had never applied for and had no special contract as to price, and therefore there was not necessarily any discrimination.

In South Carolina a wire hanging from a pole shocked a woman and her son. It was testified that the company, having had repeated warnings as to the condition of the wire, had failed to take any measure to remedy it or to prevent accident, and the company was found negligent, judgment being given for $17,000 damages to the mother and $8,000 to the son. The court of appeals confirmed the judgment.

The old Lange-Lamme patent upon a controlling switch for electric railways issued in 1894 and which has about a year and a half to run is again the subject of litigation. It was upheld against the Electric Controller & Mfg. Co. of Cleveland, and is now upheld by Judge Knappen in the Circuit Court for the southern district of Ohio against the Allis-Chalmers Co., notwithstanding their contention that if the patent were upheld it would likely deprive them of railway orders for motors.

Boiler Data

In reckoning the heating surface of a boiler, all tubes, flues and the part of the boiler-shell covered by water and exposed to hot gases is to be measured.

The efficiency of a boiler is given by the ratio of the heat absorbed by the boiler per pound of dry coal put on the grate to the calorific value of that poud of coal.

The best-set and best-fired boilers will give from 7 to 10 pounds of water per pound of good quality coal. The average results are from 25 to 60 per cent. higher than this. The ratio between heating surface and evaporation is about 150 sq. ft. to the nominal horse power.

Alternating-Current Portable Drill

In the present day of skilled labor, high-speed machinery and plants of vast size, the minutes become a question of great moment. Fortunes have been made from the scrap heap, the profits of manufacturing plants have been enormously increased by the discovery of a method of turning waste into valuable by-products. Will the moments wasted slip by unnoticed? Time is money. Profits depend upon the amount of business done. Economy of time must become a question of supreme importance to the large manufacturer, or moments wasted will total an appalling amount.

The practice of taking heavy castings to a stationary drill, of spending much valuable time in adjusting them in order that a few brief moments may be spent in drilling, is an instance of the wasteful methods that eat into the profits.

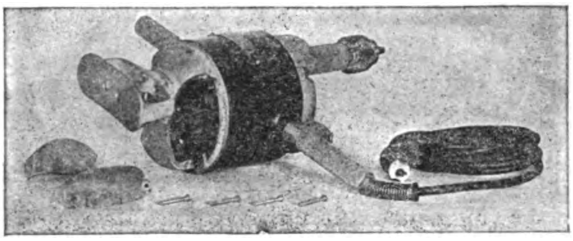
The direct-current portable breast drill designed by the General Electric Company has met with great favor and has so satisfactorily demonstrated its ability to do the work for which it was designed that they are now manufacturing an alternating-current one which possesses all the superior features of their direct-current drill and permits the use of this device where alternating current only is available.

It possesses the ruggedness of design required to withstand the hard usage incidental to its service, yet its weight has been reduced to a minimum, being but 21 lb., ensuring that the device may be handled by one person with great ease and rapidity.

The drill is fitted with a Jacob's chuck which will take drills up to and including 3/8 in. diameter. An idea of the great saving of time made possible by its use may be gained from the following approximate data. It will drill a 3/8-in. hole 1 in. deep in cast iron in 27 sec.; in machine steel in 95 sec. It will also satisfactorily operate a 3/4-in. wood bit.

It is designed for operation on a 110- or 220-volt 60-cycle circuit, to which it is connected by screwing the attaching plug into a standard lamp socket.

The illustration shows the alternating-current portable drill with cover removed.



Boston Terminal

Speaking before the Massachusetts Legislature's railroad committee, Mr. T. E. Byrnes, vice-president of the New York, New Haven & Hartford Railroad, stated that that company expected to spend $50,000,000 during the next ten years in developing its transportation facilities in Massachusetts. He said that the attitude of the legislature toward his company had held up an expenditure of $25,000,000 in the vicinity of Boston. The company desires to build a tunnel between the North and South station. The estimated cost of electrifying the Boston suburban line of the New York, New Haven & Hartford and the Boston & Maine is between $25,000,000 and $40,000,000.

Books Received

"Illumination and Photometry," by William E. Wickenden, B. S., Assistant Professor of Electrical Engineering, Massachusetts Institute Technology; McGraw-Hill Book Company, New York. Cloth; 195 pages; illustrated; 6 by 9¼ in. Price $2.00.

A text-book designed primarily for the use of colleges of engineering. The presentation of the subject is most compact and well arranged, and the whole volume is one of the best we have seen on this, one of the youngest developments of engineering.

"Direct and Alternating Current Testing," by Frederick Bedell, Ph. D., Professor of Applied Electricity, Cornell University, and C. A. Pierce, Ph. D.; D. Van Nostrand Company, New York. Cloth; 265 pages; illustrated; 5½ by 8½ in. Price $2.00.

A manual detailing the theory of a line of tests selected with reference to their practical usefulness and instructive value. While primarily intended for the use of students, it is also of general valve. Of the seven chapters in the book, five are devoted to alternating-current machinery and apparatus. The book is particularly rich in diagrams and sketches of typical testing arrangements.

Personals

Mr. Bion J. Arnold has been appointed chief engineer of the Chicago subways and will organize the subway construction work in that city.

Mr. H. G. Hetzler, until lately president of the Metropolitan West Side Elevated Railway, has become president of the Chicago & Western Indiana Railroad Company and of the Belt Railway of Chicago.

Mr. B. I. Budd, lately general manager of the Metropolitan West Side Elevated Railway of Chicago, has been elected president of that company.

Mr. F. D. Nims, who for several years has been chief operating engineer of the Mexican Light and Power Company, has been appointed electrical engineer for the Western Canada Power Company at Vancouver, B. C.

Prof. H. C. Parker, of Columbia University, New York, who was connected with the invention of the helion lamp, will leave the university to devote all his time to research work.

Mr. Albert Spies has resigned the editorship of the *Electrical Record* to devote himself to *Foundry News,* a new paper whose first number will come out in April.

Mr. H. W. Young, who recently severed his connection with the Central Electric Company of Chicago, is now president of the Delta-Star Electric Company. Mr. Young has had an extended experience in electrical work with both the Westinghouse and General Electric Companies, as well as with other concerns. The Delta-Star Company will devote itself to the development and manufacture of high- and low-tension specialties.

Mr. J. D. Mortimer has succeeded Mr. C. D. Wetmore as vice-president, and Mr. S. W. Burt as secretary of the Milwaukee Electric Railway & Light Company and the Milwaukee Light, Heat and Traction Company.

Mr. B. A. Behrend has been elected a foreign member of the Elektrotechnischer Verein of Berlin.

Mr. Frank S. Smith has recently completed a special mission in Europe for the Adams-Bagnall Electric Company.

Mr. E. B. Raymond, who was general superintendent of the Schenectady works of the General Electric Company, has been appointed second vice-president and chief engineer of the Pittsburg Plate Glass Company.

Mr. L. H. Thullen, who has been practising as consulting engineer in New York, has become chief engineer of the Triumph Electric Company, Cincinnati.

Mr. P. D. Wagoner has been elected president of the General Vehicle Company, Long Island City, succeeding Mr. J. Howard Hanson, who has withdrawn from the company. Mr. Wagoner brings to his new work a wide experience in engineering and commercial affairs, and under his administration the outlook for the future of the General Vehicle Company appears very bright.

Mr. J. N. Carlisle, of Watertown, N. Y., has been appointed a member of the Second District Public Service Commission of New York, to fill the vacancy caused by the resignation of Mr. T. M. Osborne.

Obituary

Mr. H. H. Buddy, Manager of the Power, Mining and Lighting Departments, Philadelphia District Offices of the General Electric Company, died suddenly on the 15th of January, after a brief illness in the 43d year of his age.

Mr. Elmer Gillmer, long well known in the lamp industry and president of the Warren Electric & Specialty Company and the Peerless Electric Company, of Warren, Ohio, as well as of the National Electric Lamp Association, died suddenly of acute indigestion, February 19th, aged 48. He was a pioneer in the commercial manufacture of incandescent lamps.

MR. E. GILLMER

Prof. Amos Dolbear, who did important work in the development of the writing telegraph, died at West Somerville, Mass., in the 73d year of his age. He was Professor of Physics at Tufts College from 1874 to 1906.

Mr. Charles M. Hobbs, manager of the Nevada, California Power Company, died at Danville, N. Y., where he was under treatment for an organic disease, January 27th. He was 55 years old and lived long in Colorado.

Prof. Friedrich Kohlrausch, who died in January at Marburg, was one of the great scientists who have brought Germany to her commanding position in the scientific world. He was born in 1840, and came from a family in the field of physical research. His electrical work was mostly quantative and included the investigation of the density and conductivity of pure water and of many aqueous solutions; the migrations of ions; the resistance of mercury; thermo-electricity; the electromotive force of standard cells and of the thin gas films that form on electrodes; electro-chemical equivalents; electro- and magnetic measurements in general, and studies of the earth's magnetic field. His work underlies much of the present-day theories of electricity. He also published some important works, of which the best known is his "Guide to Practical Physics," a book of some 650 pages. He was a genius in experimental work.

Among the Associations

The Iowa Electrical Association and the Iowa Street and Interurban Railway will hold their tenth annual meeting at Sioux City, April 20th and 21st. At the same time an electrical exhibition will be held, lasting until April 21st.

The annual convention of the National Electric Light Association will be held at St. Louis during the week beginning May 23d. The Coliseum, an immense new steel and concrete structure, will be used for meetings and exhibitions. The last time the Association met at St. Louis was in 1893.

The South African Institute of Electric Engineers, having affiliation with the parent body in England, held its first meeting in the Transvaal Universiti College, at Johannesburg, in November. C. W. R. Campbell was elected president, W. Elsdon-Dew and M. Rahmann, vice-presidents, and Friederich Rowland, secretary.

Trade Publications

The Northern Equipment Company, Chicago, has put out a very well gotten up catalogue telling about the Copes boiler feed regulator and the Copes pump governor. Very complete descriptions and illustrative matter set for the merits of these devices.

The Benjamin Electric Mfg. Company, Chicago, has distributed leaflets describing its improved line of tungsten fixtures and reflector sockets.

Kerr Turbine Company, Wellsville, N. Y., has just issued two new bulletin, No. 9, "Turbo-Blower Units," and No. 10, "Steam Turbine Generators, Steam Turbine Centrifugal Pumps." The first bulletin illustrates practical outfits for forced and induced draft, gas works service and for furnishing blast for cupolas. The other bulletin includes generating sets for electric power and lighting, and pumping units for boiler feeding, fire, service, water supply, circulating condenser water, draining pumps, and for other service where water must be delivered at moderate or high pressure, or against considerable head.

The Western Electric Company has issued its bulletin No. 5352 giving complete information on its line of Hawthorne fan motors for 1910. A larger and better assortment than has ever been placed on the market by this company is listed. The company has also issued their bulletin 5230, devoted to the Hawthorne type SL induction motor. This bulletin is well illustrated and includes a description of all the essential parts of the motor.

"Ad Book No. 10" is the title of a set of 12 live advertising suggestions for central station managers which has just been sent out by the Westinghouse Electric & Mfg. Company.

The Delta Star Electric Company of Chicago has begun the distribution of a new loose-leaf price list. The line covered in Nos. 1 and 2 comprises descriptions and price lists of the company's high-tension specialties, and also considerable technical information regarding high-tension lines, sparking distances, critical voltages at which the corona effect begins, and connections for generators and transformers, as well as current calculations for three-phase and other systems.

"Common Sense," the monthly publication of the Electric Controller & Mfg. Company of Cleveland, has a few pages of descriptive matter and lots of philosophy in the February issue.

The Buckeye Electric Company, Cleveland, has issued a forceful folder for the central stations, entitled, "The Lamp Problem as Your Customer Sees It."

H. W. Johns-Manville Company, in the second issue of "The J-M Packing Expert," its new house monthly, feature the story of asbestos, and many practical notes.

The National Brake & Electric Company of Milwaukee is out with a handsome catalogue, No. 387, giving complete illustrated descriptions of its line of motor-driven air compressors.

"Paistery," the house organ of the H. T. Paiste Company, for February, carried a full description of the latest Paiste specialties and a picture of the company's Philadelphia factory.

Bulletin No. 1098 of the Pittsburg Transformer Company is devoted to its well-known line of oil-insulated self-cooled transformer. The many merits of this type, which is made in capacities up to 500 kva., are well brought out.

The General Electric Company has just issued pamphlet No. 3907, entitled "A Revolution in Lighting," which is descriptive of the G. E. Mazda lamp. This lamp is the most recent and improved development in high efficiency metal filament lamps. It represents the result of the combined research work and manufacturing experience of the laboratories and factories of the most important lamp manufacturers and inventors in the world, secured through the acquisition of the most improved processes. The company also has distributed a pamphlet on the subject of "Building Lighting," which should be not only of interest but of service to managers of hotels, apartment houses, and all large buildings of either a public or private nature. This pamphlet is No. 3890.

Recent bulletins of the company are: No. 4714, Railway Signal Volt-Ammeters; No. 4715, The G. E. 210 Railway Motor.

H. M. Byllesby & Company have issued, for the use of their construction men, the first section of a practical loose-leaf pocketbook giving data on various classes of electrical line construction work. The first section, which has been issued, relates to overhead construction and specifications for materials for medium and low-tension distribution. This will be followed by two other sections, to be bound in the same cover, relating to long-distance transmission and to underground distribution. One purpose of the book is to standardize construction in the different undertakings in various parts of the country in which the company is engaged. The existing section treats of such subjects as poles, cross-arms, brackets, pins, the setting of poles, sag in wires, standard systems of guying, arrangement of circuits, etc. The book is illustrated by diagrams and includes a number of tables.

The firm Roth Brothers & Company of Chicago have issued bulletin No. 193, in which are described the type "T" machines which have been manufactured by the company now for a number of years. The line embraces four sizes of frames for machines rated from 4 h.p. to 30 h.p. All parts of the apparatus are interchangeable, and no details of construction are embodied which are of an experimental nature.

"Storage Batteries in Signal and Car Lighting" is the most useful bulletin lately issued by the Electric Storage Battery Co., Philadelphia.

The Deming Pump Company, Salem, Ohio, has issued a useful diary for 1910. It is of pocket size, with leather cover, and bears the title "Every Day's Doings," as well as the catch phrase, "When Water Flows Up Hill." Aside from the diary there are many pages of maps and useful statistical matter. The pages devoted to descriptions and illustrations of pumps for all purposes are very interesting and contain information about this kind of machinery which adds greatly to the value of the publication.

The Bristol Company, Waterbury, Conn., has issued a 48-page catalogue listing the most complete line of recording pressure gauges ever put on the market. The company's recording instruments are coming more and more into use for classes of work in which their advantages have heretofore been neglected. Particularly is this the case with the temperature recording devices that are now making their way in metallurgical work.

The Westinghouse Diary for 1910, which contains some 36 pages of well-arranged and useful information, is the sixth of its series. While the size and arrangement are much the same as last year, considerable new information has been added to this year's addition. The diary is to be found in the pockets of thousands of engineers and operating men all over the country. Its presence there is the best witness of its utility.

Classified Directory of Manufacturers

ADJUSTERS
- Morse, Frank W., Boston, Mass.

AIR AND GAS COMPRESSORS
- Allis-Chalmers Co., Milwaukee.
- American Air Compressor Works, N. Y.
- Blake Mfg. Co., Geo. F., New York.
- Chicago Pneumatic Tool Co., Chicago.
- Clayton Air Compressor Works, N. Y.
- Curtis & Co., Mfg. Co., St. Louis.
- Dean Bros. Steam Pump Wks., Indianapolis.
- Emerson Elec. Mfg. Co., St. Louis, Mo.
- Hall Steam Pump Co., Pittsburg.
- Ingersoll-Rand Co., New York.
- Knowles Steam Pump Works, New York
- Laidlaw-Dunn-Gordon Co., New York.
- McGowan Co., John H., Cincinnati.
- National Brake & Elec. Co., Milwaukee.
- Norwalk Iron Works, Norwalk, Conn
- Platt Iron Works Co., Dayton
- Providence Engine Works, Providence
- Snow Steam Pump Works, New York.
- Sullivan Machinery Co., Chicago
- Worthington, Henry R., New York.

ALTERNATORS
- Allis-Chalmers Co., Milwaukee, Wis.
- Crocker-Wheeler Co., Ampere, N. J.
- Fort Wayne Elec. Works, Indianapolis.
- General Electric Co., Schenectady, N. Y.
- National Brake & Elec. Co., Milwaukee
- Wesco Supply Co., St. Louis
- Western Electric Co., Chicago
- Westinghouse Elec. & Mfg. Co., Pittsburg

ANCHORS (GUY)
- Holden Anchor Co., Des Moines, Ia.
- Matthews & Bro., W. N., St. Louis, Mo

ANNUNCIATORS
- Central Electric Co., Chicago, Ill.
- Doubleday-Hill Electric Co., Pittsburg.
- Electric Appliance Co., Chicago.
- Haines, J. Allen, Inc., Chicago.
- Manhattan Elec. Supply Co., New York
- Ostrander & Co., W. R., Chicago.
- Van Dorn-Elliott Elec. Co., Cleveland.
- Wesco Supply Co., St. Louis.
- Western Electric Co., Chicago.

ATTACHMENT PLUGS
- Hubbell, Harvey, Bridgeport, Conn.

BATTERIES—PRIMARY
- Bunnell & Co., J. H., New York.
- Burnley Battery & Mfg. Co., Painesville, Ohio.
- Central Electric Co., Chicago
- Doubleday-Hill Elec. Co., Pittsburg.
- Eastern Carbon Works, Jersey City, N. J.
- Edison Mfg. Co., New York.
- Elec. Motor & Equipment Co., Newark. N. J
- French Battery Co., Madison, Wis.
- Gordon Battery Co. New York.
- Lawrence Elec. Co., F. D., Cincinnati, O.
- Leclanche Battery Co., New York.
- Manhattan Electrical Supply Co., Chicago.
- Waterbury Battery Co., Waterbury, Conn.
- Wesco Supply Co., St. Louis, Mo.
- Western Electric Co., Chicago.

BATTERIES—STORAGE
- American Battery Co., Chicago.
- Doubleday-Hill Electric Co., Pittsburg.
- Electric Storage Battery Co., Philadelphia.
- General Storage Battery Co., New York.
- Gould Storage Battery Co., New York.
- National Battery Co., Buffalo, N. Y.
- Railway Safety Service Co., Springfield, Mass.
- Universal Electric Storage Battery Co., Chicago.
- Willard Storage Battery Co., Cleveland.

Classified Directory of Manufacturers—Cont'd

BELLS
Central Electric Co., Chicago.
Manhattan Electrical Supply Co., New York and Chicago.
Ostrander & Co., W. R., New York
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.

BELT DRESSING
Cling Surface Mfg. Co., Buffalo
Dixon Crucible Co., Jos., Jersey City, N. J.

BELTING
Boston Belting Co., Boston.
Eureka Fire Hose Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Philadelphia.
Pittsburg Gage & Supply Co., Pittsburg.
Robins Conveying Belt Co. New York.

BLOWERS
Allis-Chalmers Co., Milwaukee.
American Blower Co., Detroit.
American Gas Furnace Co., New York.
Buffalo Forge Co., Buffalo.
Chicago Flexible Shaft Co., Chicago.
Crocker-Wheeler Co., Ampere, N. J.
Dean Bros. Steam Pump Works, Indianapolis.
Green Fuel Economizer Co., Matteawan, N. Y.
Platt Iron Works, Dayton, O.
Smith, J D., Fdy. Supply Co., Cleveland.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

BLUE PRINT MACHINERY
Buckeye Engine Co., Salem, O.
Keuffel & Esser Co., New York.
Kolesch & Co., New York
Resolute Machine Co., New York.
Wagenhorst & Co., J. H., Pittsburg.

BOILERS
Atlantic Works, East Boston, Mass.
Babcock & Wilcox Co., New York.
Harrison Safety Boiler Works, Phila.
Heine Safety Boiler Co., St. Louis.
Platt Iron Works, Dayton, O.
Riter-Conley Mfg. Co., Pittsburg.
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.
Walsh's Holyoke Steam Boiler Co., Holyoke, Mass.
Wetherill & Co., Robt., Chester, Pa.

BOXES—JUNCTION
Bossert Electric Construction Co., Utica.
D. & W. Fuse Co., Providence. R. I.
Steel City Electric Co., Pittsburgh

BOXES—OUTLET
Bossert Electric Const. Co., Utica, N. Y.
Steel City Electric Co., Pittsburgh

BRUSHES—CARBON
Central Electric Co., Chicago.
Eastern Carbon Works, Jersey City, N. J
Holmes Fibre-Graphite Mfg. Co., Germantown, Pa.
Le Valley Carbon Brush Co., New York.
National Carbon Co., Cleveland.
Speer Carbon Co., St. Mary's, Pa.
Western Electric Co., Chicago.

BUSHINGS-OUTLET
Steel City Electric Co., Pittsburgh

CABLE HANGERS
Barron & Co., Jas. S., New York.
Bissell Co., F., Toledo, O.
Standard Underground Cable Co., Pittsburg
Steel City Electric Co., Pittsburg.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co.. Chicago.

CABLE JOINTS
Dossert & Co., Inc., New York

CARBONS
Central Electric Co., Chicago.
Eastern Carbon Works, Jersey City, N. J.
National Carbon Co., Cleveland.
Reisinger, Hugo, New York.
Speer Carbon Co., St. Marys, Pa.
Wesco Supply Co., St. Louis.

CASTINGS
American Steel Foundries, Chicago.
Aiton Machine Co., New York.

Classified Directory of Manufacturers—Cont'd

Lunkenheimer Co. Cincinnati.
New England Butt Co., Providence, R. I.
Phosphor-Bronze Smelting Co., Ltd., Philadelphia.

CHAINS FOR ARC LAMPS
Oneida Community, Ltd., Oneida N. Y

CIRCUIT BREAKERS
Cutler-Hammer Mfg. Co., Milwaukee.
Cutter Electrical Mfg. Co., Philadelphia
Doubleday-Hill Electric Co., Pittsburg.
Fort Wayne Electric Works, Fort Wayne, Indiana
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
La Roche Co., F. A., New York.
Sundh Electric Co., New York.
Switchboard Equip. Co., Bethlehem, Pa
Ward Leonard Electric Co., Bronxville, N. Y.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co. Pittsburg.

CLAMPS—CABLE
Matthews, W. N., & Bros., St. Louis.

CLEATS
Blake Signal & Mfg. Co., Boston, Mass.
Imperial Porcelain Works, Trenton, N. J
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.

CLIMBERS
Klein & Co., Mathias, Chicago.

CLUSTERS
Benjamin Elec. Mfg. Co., Chicago
Hubbel, Harvey, Bridgeport, Conn.

COAL AND ASH-HANDLING MACHINERY
Brown Hoisting Machinery Co. land.
Case Mfg. Co., Columbus, O.
Hunt Co., C. W., New York.
Jeffrey Mfg. Co., Columbus, O.
Link Belt Co., Philadelphia.
Mead-Morrison Mfg. Co., Boston.
Northern Engineering Works, Detroit
Robins Conveying Belt Co., New York.

COILS—INDUCTION
Ostrander, W. R., & Co., New York.
Splitdorf, C. F., New York.

COMMUTATOR LUBRICANT
Allen & Co., L. B., Chicago.
Dixon Crucible Co., Jos., Jersey City.

COMMUTATORS
Homer Commutator Co., Cleveland, O.

CONDENSERS—ELECTRIC
Marshall, William, New York.

CONDUIT RODS
Barron & Co., Jas. S., New York.
Cope, T. J., Philadelphia.
Doubleday-Hill Electric Co., Pittsburg

CONDUITS
American Circular Loom Co., Chelsea, Mass.
The Gillette-Vibber Co., New London, Conn.
American Conduit Co., Chicago.
American Vitrified Conduit Co., N. Y.
Camp Co., H. B., New York.
Doubleday-Hill Electric Co., Pittsburg
Gest, G. M., New York.
National Conduit & Cable Co., N. Y.
National Metal Molding Co., Pittsburg
Orangeburg Fibre Conduit Co., Orangeburg, N. Y
Sprague Electric Co., New York.

CONDUIT FITTINGS
Steel City Electric Co., Pittsburgh

CONDUIT REAMERS
Steel City Electric Co., Pittsburg.

CONDUIT TOOLS
Cope, T. J., Philadelphia
Steel City Electric Co., Pittsburg.

CONTROLLERS
Allis-Chalmers Co., Milwaukee.
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Cutler-Hammer Mfg. Co., Milwaukee.
Elec. Controller & Supply Co., Clevelan

Classified Directory of Manufacturers—Cont'd

Standard Prices for Hydroelectric Power

"Is there any standard price for electric power delivered?" This question is answered by Charles T. Main and F. M. Gunby in their paper "Cost of Power for Various Industries under Ordinary Conditions." Read before the Boston Society of Civil Engineers, this paper answers as follows: There does not appear to be any standard, the prices varying largely according to the amount taken. For small amounts large prices can be obtained. The price, of course, must have a close relation to that at which power from a steam station would be sold. The prices for power from the Edison Electric Illuminating Company of Boston, Mass., will give a good idea of this, and these are given in part below:

EDISON RATES

Let us first follow through the cost of power for lighting in various sized amounts. We will assume that the demand will be required for 50 hr. a month. For a demand of 1 kw. the rate would be 10.4 cents per kw. hr.; for 5 kw. demand the rate would be 9.8 cents; while for 25 kw. demand the rate would be 7.5 cents per kw. hr.

The prices for this same demand of 25 kw. for 300 hr. a month would be only 2.4 cents per kw. hr.

The permanent rate for a demand of 100 kw., with lamps and care, would be 7.8 cents per kw. hr. for a use of the demand 800 hr. per year; 3.18 cents for 3000 hr., and 2.34 cents for 6000 hr. use of the demand.

The same rates without lamps and care would be 7.3 cents; 2.68 cents; and 1.84 cents, respectively.

It must be remembered, however, that these are the selling prices of this current and include all kinds of charges. Probably the selling and office charges are a very great part of the cost. The company made the statement recently, that it cost more to meter the current for tis smallest customers than it did to generate it.

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Classified Directory of Manufacturers—Cont'd

ENGINES—GAS AND GASOLINE
Allis-Chalmers Co., Milwaukee.
Buckeye Engine Co., Salem, O.
Carlisle & Finch Co., Cincinnati, O.
De La Vergne Machine Co., New York.
Elbridge Engine Co., Rochester, N. Y.
Marine Engine & Machine Co., N. Y.
Mietz, A., N. Y.
Otto Gas Engine Works, Philadelphia.
Power & Mining Machinery Co., Cudahy, Wis.
Westinghouse Machine Co., Pittsburg.
Wood & Co., R. D., Philadelphia.

ENGINES—STEAM
Allis-Chalmers Co., Milwaukee.
American Blower Co., Detroit.
Am. Engine Co., Bound Brook, N. J.
Ball Engine Co. Erie, Pa.
Blake Mfg. Co., Geo F., New York.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo.
Frick Co., Waynesboro, Pa.
Hooven, Owens, Rentschler Co., Hamilton, Ohio.
Mecklenburg Iron Wks., Charlotte, N. C.
Providence Eng'g Works, Providence.
Shepherd Eng'g Co., Franklin, Pa.
Southwark Fdy. & Mch. Co., Philadelphia.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Watertown Eng. Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg.
Wetherill, Robert & Co., Chester, Pa.

EXHAUST HEADS
American Spiral Pipe Works, Chicago.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Pittsburg Gage & Supply Co., Pittsburg.
Sturtevant Co., B. F., Hyde Park, Mass.
Watson & McDaniel Co., Philadelphia.
Wright Mfg. Co. Detroit.

FANS AND MOTORS
Century Electric Co., St. Louis.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Elec. Co., Pittsburg.
Eck Dynamo & Motor Wks, Belleville, N. J.
Elec. Motor & Equip. Co., Newark, N. J.
Emerson Electric Mfg. Co., St. Louis.
Ft. Wayne Elec. Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Wesco Supply Co., St. Louis.
Western Electric Co. Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg.

FANS—EXHAUST AND VENTILATING
Allen Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Emerson Elec. Mfg. Co., St. Louis.
Green Fuel Economizer Co., Matteawan.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Boston.
Western Electric Co., Chicago.

FIXTURES—GAS AND ELECTRIC
Benjamin Elec. Mfg. Co., Chicago.
Cleveland Gas & Fixture Co., Cleveland
Gail-Webb Mfg. Co., Buffalo.
Goodwin & Kintz, Winsted, Conn
Wells Light Mfg. Co., New York.

FLASHERS
Advertising Mirrograph Co., Brooklyn
Campbell Electric Co., Lynn, Mass.
Elec. Motor & Equip. Co., Newark, N. J
Haller Machine Co., Chicago.
Reynolds Elec. Flasher Mfg. Co., Chicago

FLEXIBLE SHAFTS
Chicago Flexible Shaft Co., Chicago.
Stow Flexible Shaft Co., Philadelphia.
Stow Mfg. Co., Binghamton, N. Y

FRICTION TAPE AND CLOTHS
Massachusetts Chemical Co.

FUSES
Arknot Co., Hartford, Conn.
Chase-Shawmut Co.
Chicago Fuse Wire & Mfg. Co.
D. & W. Fuse, Providence, R. I.
Johns-Manville Co., H. W., New York.

Classified Directory of Manufacturers—*Cont'd*

GAS ENGINE SPECIALTIES
Lunkenheimer Co.

GAUGES—PRESSURE, STEAM, WATER
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston.
Bristol Co., Waterbury, Co., Conn.
Hohmann & Maurer Mfg. Co., Rochester.
Manning, Maxwell & Moore, New York.
Pittsburg, Gauge & Supply Co., Pittsburg.
Star Brass Mfg. Co., Boston.
Walworth Mfg. Co., Boston.

GEARS
New Process., Rawhide. Co.
Nuttal Co., R. D. Pittsburg.

GERMAN SILVER
Seymour Mfg. Co Seymour, Conn.

GLASS
Phoenix Glass Co., New York.

GLOBES, SHADES, ETC.
Holophane Glass Co., New York.
Phoenix Glass Co., New York.

GRAPHITE
Dixon Cruc. Co., Jos., Jersey City, N. J.

GUARDS—INC. LAMPS
Gail-Webb Mfg. Co., Buffalo.
Hubbell, Harvey, Bridgeport.
Matthews & Bro., W. N., St. Louis.

HANGER BOARDS
Ft. Wayne Elec. Works, Ft. Wayne, Ind-

HANGERS—CABLE
Chase-Shawmut Co., Newburyport, Mass.
Standard Underground Cable Co., Pittsburg.

HEATING DEVICES, ELECTRIC
American Elec'l Heater Co., Detroit.
Barr Elec. Mfg. Co., W. J., Cleveland.
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Electric Heating Co., Chicago.

HEATING—EXHAUST STEAM
Am. District Steam Co., Lockport, N. Y.
Diamond State Fibre Co., Elsemere, Del.
Mica Insulator Co. New York.

HOISTS AND CONVEYORS
Hunt, C. W., Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Northern Engineering Works, Detroit.

HYDRAULIC MACHINERY
Dayton Globe Iron Works Co., Dayton.
Dean Bros. Steam Pump Wks., Indianapolis.
Leffel & Co., James, Springfield, O.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co., Dayton, O.
Risdon-Alcott Turbine Co., Mount Holly, N. J.
Smith Co., S. Morgan, York, Pa.

IMPREGNATING APPARATUS
Buffalo Foundry & Machine Co., Buffalo
Devine Co., J. P., Buffalo.
Hubbard's Sons, Norman, Brooklyn.

INDICATORS
American Steam Gauge & Valve Mfg Co.

INSTRUMENTS—ELECTRICAL
American Instrument Co., Philadelphia.
Atwater Kent Mfg. Co., Philadelphia.
Baillard, E. V., New York.
Biddle, James G., Philadelphia.
Bristol Co., Waterbury, Conn.
Clark Electric Meter Co., Chicago.
Connecticut Telephone & Electric Co., Meriden, Conn.
Cutter Elec. & Mfg. Co., Philadelphia.
Dongan Instrument Co., Albany, N. Y.
Duncan Elec. Mfg. Co., Lafayette, Ind.
Eldredge Elec. Mfg. Co., Springfield, Mass.
Foote-Pierson & Co., New York.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady.
Keystone Elec. Instrument Co., Phila.
Leeds & Northrup, Philadelphia.
Machado & Roller, New York.
Pignolet, Louis M., New York.
Queen & Co., Philadelphia.
Robert Instrument Co., Detroit.
Sangamo Electric Co., Springfield, Ill.

For power in larger amounts, as for textile mills, the prices for permanent power seem to vary between $20 and $25 per h.p. delivered for 10-hr. power, and for 24-hr. power $30 to $40 per h.p.

For surplus or secondary power, which can be furnished for more than six months but less than twelve months a year, the charges cannot be more than at a rate of $10 to $15 a year; in large amounts a horse power for 10-hr. power for the time it is delivered, or, say, about one dollar a month a horse power. For about all that is usually saved in coal, as the fixed charges are going on all the time in the steam plant; and possibly a portion of it may be run all the time, and engineers and firemen cannot be discharged and hired at will.

If the saving in coal is 2 lb. per electric h.p. an hour for 250 hr. a month, equals 500 lb. a horse power per month, at $3 a long ton, this is 67 cents; at $4 a long ton, equals 89 cents. Other possible savings in supplies, etc., might make it worth while to pay one dollar a month for this kind of power.

In a recent case it was estimated that some colored mills could afford to pay about $15 per yr. for secondary power, where the power could be obtained about 10 months a year.

This case represents fairly average conditions, where coal costs about $4 per ton, and where the power is fairly steady from day to day, so that it is not necessary to keep a full force of steam-plant help.

Care of Tungsten Street Lamps

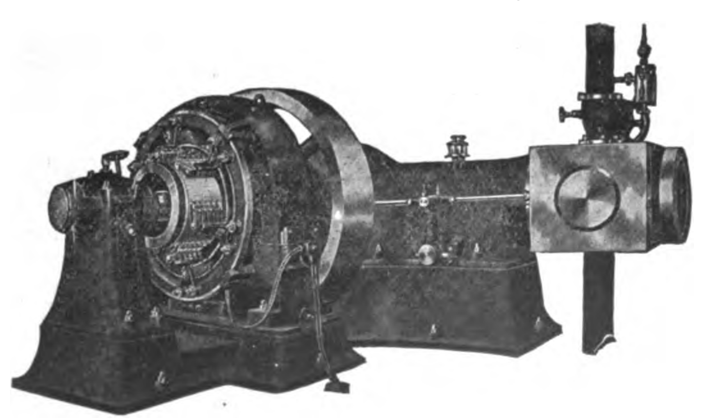
At the 1908 meeting of the Michigan Electric Association a system of street lighting which had recently been installed in Grand Rapids was described. At that time the lighting had been in operation but two months, and it was impossible to give any definite information as to the cost of maintenance. However, since that time we have collected considerable data which has been of great service to us in subsequent installations.

The first installation consisted of 270 60-c-p. 6.6-amp. series tungsten lamps operated eighteen in series across 220 volts. Each series of lamps was suspended from a messenger wire stretched across the street. These messenger wires were placed about one hundred feet apart. The distance between lamps is five feet, and the distance of each lamp below the messenger wire was regulated so as to give an arch effect. This system of lighting for business streets has become so popular in Grand Rapids that at the present time we have 1103 of these lamps in service and contracts for 270 more, making a total of 1373. The contract price for each lamp is $7.00, which makes an income of $9611.00 per year.

Considerable trouble was experienced at first in renewing burned-out lamps, as it was necessary to draw the arches to one side of the street so that the lamps could be reached from a ladder placed against the building. This system was quite expensive, as it required the services of four men to handle the extension ladders. It also shortened the life of the lamps and did considerable damage to the wiring of the arch.

Some time ago the power company

[*Continued on page 22.*]



Classified Directory of Manufacturers—Cont'd

Schaeffer & Budenberg, New York
Simplex Co., Newark, N. J.
Wagner Electric Mfg. Co., St. Louis.
Westinghouse Elec. & Mfg. Co., Pittsburg
Weston Elec. Instr. Co., Newark, N. J.
Whitney Elec'l Instr. Co., New York.

INSULATING MACHINERY
Aiton Machine Co., New York.
New England Butt Co., Providence. R. I

INSULATING MATERIAL COMPOUNDS—CLOTH AND PAPER
Anderson Mfg. Co., A. & J. M., Boston.
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—COMPOUNDS PAINTS AND VARNISHES
Macon-Evans Varnish Co., Pittsburg.
Massachusetts Chem. Co., Walpole, Mass
Standard Paint Co., New York.
Sterling Varnish Co., Pittsburg.

INSULATING MATERIAL—FIBRE
Am. Vulcanized Fibre Co., Wilmington.
Diamond State Fibre Co., Elsmere, Del
Kartavert Mfg. Co., Wilmington, Del.
Morris Elec. Co., Wilmington, Del.
United Indurated Fibre Spec. Co., Lockport, N. Y.
Wilmington Fibre Spec. Co., Wilmington.

INSULATING MATERIAL—LAVA
American Lava Co., Chattanooga, Tenn.
Kruesi, P. J., Chattanooga.
Steward Mfg. Co., D. M., Chattanooga.

INSULATING MATERIAL—MICA
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—PORCELAIN
Imperial Porcelain Works, Trenton, N. J.
Locke Insulator Mfg. Co., Victor, N. Y.
National Porcelain Co., Trenton, N. J.
Pass & Seymour, Inc., Solvay, N Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATING MATERIAL—TAPE
Amer. Electrical Wks., Philipsdale, R. I.
Massachusetts Chem. Co., Walpole, Mass
Morgan & Wright, Detroit
New York Insulated Wire Co., N. Y.
Okonite Co., Ltd., New York
Schott, W. H., Chicago.
Standard Underground Cable Co., Pittsburg.

INSULATORS—GLASS
Hemingway Glass Co., Louisville
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.

INSULATORS—PORCELAIN AND COMPOSITION
Anderson Mfg. Co., A. & J. M., Boston.
Imperial Porcelain Works, Trenton, N. J.
Johns-Manville Co., H. W., New York.
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O

INSULATOR SUPPORTS
Steel City Electric Co., Pittsburgh

JACKS
Watson-Stillman Co., New York.
Henderer's Sons, A. L., Wilmington, Del.

JUNCTION BOXES
Standard Underground Cable Co., Pittsburg, Pa.
Bossert Elec. Const. Co., Utica, N. Y

KNIFE SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

LAMPS—ARC
Adams-Bagnall Elec. Co., Cleveland.
Am. Arc Lamp Co., Kalamazoo, Mich.
Anderson Mfg. Co., A. & J. M., Boston.
Beck Flaming Lamp Co., New York.
Excello Arc Lamp Co., New York.
Ft. Wayne Electric Works, Ft. Wayne.
General Electric Co., Schenectady.
Hamburger, Felix, New York.
Helios Mfg. Co., Philadelphia.
Marquette Elec. Mfg. Co., Chicago.
Tucuring Co., C. J., Philadelphia.
Warner Arc Lamp Co., Muncie, Ind

Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg

LAMPS—INCANDESCENT
American Electric Lamp Co., Phila., Pa.
Banner Electric Co., Youngstown, O.
Bay State Lamp Co., Danvers, Mass
Boston Incandescent Lamp Co., Danvers, Mass.
Brilliant Electric Lamp Co., Cleveland.
Bryan-Marsh Co., New York.
Buckeye Electric Co., Cleveland.
Columbia Inc. Lamp Co., St. Louis.
Economy Electric Co., Warren.
Edison Dec. & Min. Lamp Co., Harrison, N. J.
General Electric Co., Harrison, N. J.
New York & Ohio Co., Warren.
Novelty Incandescent Lamp Co., Emporium, Pa.
Rooney Elec. Lamp Co., New York
Shelby Electric Co., Shelby, O
Stuart Howland Co., Boston.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg.

LIGHTNING ARRESTERS
Anderson Mfg. Co., A. & J. M., Boston.
D. & W. Fuse Co., Providence, R. I.
Electric Service Supplies Co., Phila.
Lord Electric Co., New York.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LINE MATERIAL
Anderson Mfg Co A & J. M., Boston.

LOCKERS
Edward Darby & Sons Co., Philadelphia
Merritt & Co., Philadelphia.

LOCOMOTIVES—INDUSTRIAL
Goodman & Co, Chicago

had a wagon built for use in renewing these lamps. It consists of an ordinary one-horse dray with a tower built on it. The top of this tower is fifteen feet from the ground, and a three-piece extension ladder is fastened to the side of it. All that is necessary is to drive this wagon below the lamps, raise the extension ladder and change the burned-out lamps. This operation requires about five minutes for each lamp and is handled by two men, one to drive the horse and the other to raise the ladder and change the lamps. This wagon has been the means of saving the company considerable money, both for labor, lamps and repairs to the wiring.

On June 8th of last year, the first installation of 270 lamps had been in operation one year. During this time the lamps burned 1920 hours and consumed 41,000 kw-hr. of energy. The number of lamps renewed was 196, which cost the company $225.00. This

[*Continued on page* 24.]

Classified Directory of Manufacturers—*Cont'd.*

Jeffrey Mfg. Co., Columbus, O.
Porter Co., H. K., Pittsburg.
Vulcan Iron Works, Wilkesbarre, Pa.

LUBRICANTS
Dixon Cruc. Co., Jos., Jersey City, N. J

MAGNET WIRE
Acme Wire Co., New Haven, Conn
Griffin, Frank B., Oshkosh, Wis.
Roebling & Sons, Trenton, N. J.
Seymons Mfg. Co., Seymons, Conn

MALLEABLE CASTINGS
Jeffrey Mfg. Co., Columbus, O.

METAL POLISH
Hoffman, George W., Indianapolis, Ind.

METALS
American Platinum Wks., Newark. N. J.
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

MICA—(See Insulating Material.)

MINING MACHINERY
Allis-Chalmers Co., Milwaukee
Dean Bros. Steam Pump Wks., Indianapolis.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
Power & Mining Machinery Co., Cudahy.

PINS—STEEL
Locke Insulator Mfg. Co., Victor, N. Y.

PLATINUM
American Platinum Wks., Newark. N. J.
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

PLUGS
Dickinson Mfg. Co., Springfield, Mass.
Freeman Elec. Co., E. H., Trenton, N. J.
General Mfg. & Sup. Co., Trenton. N J.
Paiste Co., H. T., Philadelphia.

PLUGS—ATTACHMENT
Hubbell Harvey, Bridgeport, Conn.

POLES—ARC LAMP
Mott Iron Works, J. L., New York.

POLES, BRACKETS, PINS, ETC.
Bissell Co., F., Toledo, O.
Cresap Co., The, Bristol, Tenn.
Humbird Lumber Co., Sandpoint, Ida.
Kellogg Switchboard & Sup. Co.. Chicago.
Sand Point Cedar Co., Sandpoint, Ida.
Southern Exchange Co.. New York.
Worcester Co., C. H., Chicago.

PORCELAIN—(See Insulating Machinery).

POWER TRANSMISSION MACHINERY
Case Mfg. Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co. Phila., Pa
Mead-Morrison Mfg. Co., Boston, Mass.
Robins Conveying Belt Co., New York.

DRESSES, DIES AND SPECIAL MACHINERY
Watson-Stillman Co., New York.

PULLEYS
Rockwood Mfg. Co, Indianapolis, Ind.

PUMPS—ELECTRIC
Allen Electric Co., Chicago, Ill.
Allis-Chalmers Co., Milwaukee, Wis.
Conover Condenser Co., Paterson, N. J.
Dean Bros. Steam Pump Wks., Indianapolis.

PUMPS—STEAM
Dean Bros. Steam Pump Wks., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Platt Iron Works Co., Dayton, O.
Quimby, Wm. E., New York.
Watson Machine Co., Paterson, N. J.
Worthington, H. R., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Deming Co., Salem, O.
Morris Company, I. P., Philadelphia, Pa.
Platt Iron Works Co., Dayton, O.

PUMPS—VACUUM
Alberger Condenser Co., New York.
Dean Bros. Steam Pump Wks., Indianapolis.
Hubbard's Sons, Norman, Bklyn., N. Y.
Platt Iron Works Co., Dayton, O

Classified Directory of Manufacturers—Cont'd

PUSH BUTTONS
Dunbar Bros., Bristol, Conn.
Sarco Company, New York.

RAIL-BONDS
Chase-Shawmut Co., Newburyport, Mass
Lord Electric Co., New York.
Roebling's Sons Co., J. A., Trenton, N. J.

RECEPTACLES
Benjamin Electric Mfg. Co., Chicago, Ill.
Freeman Elec. Co., E. H., Trenton, N. J.
Paiste Co., H. T., Philadelphia, Pa.

RECORDING INSTRUMENTS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.

REFLECTORS
Frink, I. P., New York.
Goodwin & Kintz, Winsted, Conn.
National X Ray Reflector Co., Chicago, Ill.
Phoenix Glass Co., New York.

REPAIRING
Gregory Electric Co., Chicago, Ill.
Heck, Louis, Newark, N. J.
Van Dorn-Elliott Electric Co., Cleveland, Ohio.
Ward, Leonard Electric Co., Bronxville, N. Y.

RESISTANCE UNITS
Cutler-Hammer Mfg. Co., Milwaukee.
Simplex Electric Heating Co., Cambridge, Mass.

RHEOSTATS
Automatic Electric Co., Chicago, Ill.
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman & Co., J. L., Chicago, Ill.
Sundh Electric Co., New York.
Ward Leonard Electric Co., Bronxville, N. Y.

ROSETTES
General Mfg. & Supply Co., Trenton.
Hart Mfg. Co., Hartford, Conn.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston, Mass
Trumbull Elec. Mfg. Co., Plainville, Conn.

RUBBER MACHINERY
Aiton Machine Co., New York.

SEARCHLIGHTS
Bogue Elec. Co., C. J., New York.
Carlisle & Finch Co., Cincinnati, O.

SECOND-HAND APPARATUS
Bender, George, New York.
Chicago House Wrecking Co., Chicago.
Dustin Co., Chas. E., New York.
Gas & Electric Development Co., N. Y.
Gregory Electric Co., Chicago, Ill.
Linder, H. J., New York.
Richter, Eugene, Philadelphia, Pa.
Station Equipment Co., Chicago, Ill.
Thompson, Joseph H., Jr., New York.
Toomey, Frank, Philadelphia, Pa.
Yearsley & Levene, Philadelphia, Pa.

SHADE HOLDERS
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SHADES
Holophane Co., New York.
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SIGNS—ELECTRIC
A. & W. Sign Co., Cleveland, O.
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C., Parkersburg, W. Va.
Metropolitan Engineering Co., N. Y.
Reynolds Elec. Flasher Mfg. Co., Chicago, Ill.

SIGN LETTERS
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C., Parkersburg, W. Va.
Matthews & Bro., W. N., St. Louis, Mo.

makes the cost of renewals $0.0055 per kilowatt-hour for lamps only. The labor necessary to care for 1100 lamps will not exceed $200.00 per year, or $50.00 for 270 lamps, which makes the total cost of lamp renewals $275.00 per year, or $0.0067 per kilowatt-hour.

The one drawback to the series tungsten lamp operating from a constant potential circuit is the extinguishing of all the lamps in the arch when one lamp burns out. This, however, is not very serious if the lamps are inspected each morning, as the defective lamps can be immediately re-

[*Continued on page 26.*]

Classified Directory of Manufacturers—Cont'd

SLEEVING
Belden Mfg. Co., Chicago, Ill.
Benjamin Electric Mfg. Co., Chicago, Ill.
Bryant Electric Co., Bridgeport, Conn.
Connecticut Electric Mfg. Co., Bantam, Conn.
Crescent Electrical Mfg. Co., Rochester.
Crouse-Hinds Co., Syracuse, N. Y.
Dunton & Co., M. W., Providence, R. I.
Federal Electric Co., Chicago, Ill.
Freeman Electric Co., E. H., Trenton.
General Mfg. & Supply Co., Trenton.
Johns-Manville Co., H. W., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Pass & Seymour, Solvay, N. Y.
Peru Electric Mfg. Co., Peru, Ind.
Porcelain Electrical Mfg. Co., Trenton.
Stanley & Patterson, New York.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Weber Electric Co. (Henry D. Sears, General Sales Agent, Boston, Mass.).
Yost Electric Mfg. Co., Toledo, O.

SOLDER
Belden Mfg. Co., Chicago, Ill.
Walworth Mfg. Co., Boston, Mass.
Western Electric Co., Chicago, Ill.

SOLDERING FLUX
Allen Co., L. B., New York.
Dunton & Co., M. W., Providence.
Uebelmesser, Chas. R., Bayside, N. Y.

SOLDERING IRONS
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Elec. Heating Co., Chicago, Ill.

SOLENOIDS
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman, J. L., Co., Chicago, Ill.

SPEED INDICATORS
Schaeffer & Budenberg, New York.

SPRINGS
Barnes Co., Wallace, Bristol, Conn.
Dunbar Bros. Co., Bristol, Conn.
Manross, F. N., Forestville, Conn.

SUPPLIES—ELECTRICAL
Am. Elec'l Supply Co., Chicago, Ill.
Central Electric Co., Chicago, Ill.
Central Electric Supply Co., New York.
Cobb, H. E., Chicago, Ill.
Commercial Electrical Supply Co., St. Louis, Mo.
Dearborn, Electric Co., Chicago, Ill.
Doubleday-Hill Elec. Co., Pittsburg, Pa.
Electric Appliance Co., Chicago, Ill.
Electrical Material Co., Baltimore, Md.
Erner & Hopkins Co., Columbus, O.
Ewing-Merkle Elec. Co., St. Louis, Mo.

Classified Directory of Manufacturers—Cont'd

Garton Co., W. R., Chicago, Ill.
Hudson Electric Supply Co., New York.
Latham & Co., E. B. New York.
Machado & Roller, New York.
Manhattan Elec'l Supply Co., New York.
Metropolitan Elec'l Supply Co., Chicago.
Nagel Electric Co., W. G., Toledo, O.
Novelty Electric Co., Philadelphia, Pa.
Ostrander & Co., W. R., New York.
Patrick, Carter & Wilkins Co., Phila., Pa.
Pettingell-Andrews Co., Boston, Mass.
Robertson Electric Co., Buffalo, N. Y.
Sherman-Brown-Clements Co., N. Y.
Stuart-Howland Co., Boston, Mass.
Union Electric Co., Pittsburg.
United Electric & Apparatus Co., Boston
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.

SUPPLIES—TELEPHONE
Am. Elec. Telephone Co.
International Teleph. Mfg. Co.
Kellogg Switchboard & Supply Co., Chicago.
Western Electric Co., Chicago.

SWITCHBOARDS
Adam Electric Co., Frank, St. Louis, Mo.
Anderson Mfg. Co., A. & J. M., Boston, Mass.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Chase-Shawmut Co., Newburyport, Mass.
Cleveland Switchboard & Electric Co., Cleveland, O.
Condit Elec'l Mfg. Co., Boston, Mass.
Crescent Elec'l Mfg. Co., Rochester, N.Y.
Crocker-Wheeler Co., Ampere, N. J.
Crouse-Hinds Co., Syracuse, N. Y.
D'Olier, Jr., Co., Henry, Philadelphia.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Grady Co., S. S., Cambridge, Mass.
Hill Electric Co., W. S., New Bedford, Mass
Ideal Elec. & Mfg. Co., Mansfield, O
Jones Electrical Co., New York
La Roche Co., F. A., New York.
Trumbull Elec. Mfg. Co., Plainville, Conn
Westinghouse Elec. & Mfg. Co., Pittsburg.

SWITCHES
Anderson Mfg. Co., A. & J. M., Boston
Dickinson Mfg. Co.

ARC LIGHTS
Sarco Co., New York.

CANOPY
Sarco Co., New York.

CEILING
Jones Electrical Co., New York.
Krantz Mfg. Co., H., Brooklyn, N. Y.
Sorensen, P., Brooklyn, N. Y.

CLOCK
A. & W. Electric Sign Co., Cleveland, O.
Campbell Electric Co., Lynn, Mass.
Elec. Motor & Equip. Co., Newark, N. J.
General Electric Co., Schenectady, N. Y.
Hartford Time Switch Co., Hartford.
Manhattan Elec'l Supply Co., New York.
Prentiss Clock Improvement Co., N. Y.
Specialty Mfg. Co., Youngstown, O.
Sorensen, P., Brooklyn, N. Y.
Trumbull Elec. Mfg. Co. Trumbull, Conn.

SWITCHES— KNIFE
Adam Electric Co., Frank, St. Louis Mo.
Anderson Mfg. Co., A. & J. M., Boston, Mass.
Chase-Shawmut Co., Newburyport, Mass.
Cleveland Switchboard & Electric Mfg. Co., Cleveland, O.
Condit Elec'l Mfg. Co., Boston, Mass.
Connecticut Electric Mfg. Co., Bantam, Conn.
Crescent Elec'l Mfg. Co., Rochester, N. Y.
Crouse-Hinds Co., Syracuse, N. Y.
Garton Co., W. R., Chicago, Ill
General Electric Co., Schenectady, N. Y.
Hill Electric Co., W. S., New Bedford, Mass.

THE ELECTRICAL AGE will pay 30 cents for copies of November and December, 1906.

Classified Directory of Manufacturers—Cont'd

Ideal Elec. & Mfg. Co., Mansfield, O.
La Roche Co., F. A., New York
Lang Electric Co., J., Chicago, Ill
Lundin Electric & Machine Co., Boston.
Manhattan Elec'l Supply Co., New York.
Marshall Elec. Mfg. Co., Boston, Mass
Mutual Electric & Machine Co., Wheeling, W. Va.
Ohio Brass Co., Mansfield, O.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Solvay, N. Y.
Trumbull Elec. Mfg. Co., Plainville Conn.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

OIL

Adam Electric Co., Frank, St. Louis, Mo
Condit Elec'l Mfg. Co., Boston, Mass.
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
Helios Mfg. Co , Philadelphia, Pa.
Hill Electric Co W. S., New Bedford, Mass.
Pettingell-Andrews Co., Boston, Mass.
Trumbull Elec. Mfg. Co. Plainville, Conn.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

SNAP

Bissell Co., F., Toledo, O.
General Electric Co., Schenectady N. Y.
Hart Mfg. Co., Hartford, Conn
Sarco Company, New York.

PENDANT

Sarco Company, New York

TACHOMETERS

Schaeffer & Budenberg, New York.

TAPE

American Elec'l Wks., Philipsdale, R. I.
Boston Woven Hose & Rubber Co. Cambridge, Mass.
Brixey, W. R., New York.
Diamond Rubber Co., Akron, O.
Dunton & Co., M. W., Providence.
Electric Appliance Co., Chicago.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goodrich Co., B. F., Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
Hartford Rubber Works, Co., Hartford, Conn.
Johns-Manville Co., H. W., New York
Knowles, C. S., Boston, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
Massachusetts Chem. Co., Walpole, Mass.
Mica Insulator Co., New York.
Morgan & Wright, Chicago, Ill.
National Insulator Co., Boston, Mass.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Pennsylvania Rubber Co., Jeannette, Pa.
Republic Rubber Co., Youngstown, O.
Revere Rubber Co., Boston, Mass.
Standard Paint Co., New York.

TELEPHONES

American Bell Telephone Co., Boston.
Connecticut Telephone & Electric Co., Meriden, Conn.
Couch Co., S. H., Boston, Mass.
Electric Goods Mfg. Co., Boston, Mass.
Gail-Webb Mfg. Co., Buffalo, N. Y.
Manhattan Elec'l Supply Co., New York.
Novelty Electric Co., Philadelphia, Pa.
Russell Electric Co., Danbury, Conn.
Schmidt-Wilckes Elec. Co., Weehawken, N. J.
Stromberg-Carlson Telephone Mfg. Co Rochester, N. Y.
Vote-Berger Co., La Crosse, Wis.
Wesco Supply Co., St. Louis, Mo
Western Electric Co.

THEATER DIMMER

Campbell Electric Co., Lynn, Mass.
Cutler-Hammer Mfg. Co., Milwaukee

placed, and it is very seldom that an arch has been out two nights in succession.

On one street in Grand Rapids we have tried the multiple tungsten lamps with very good results. This installation consists of 6100 watt lamps which have been in operation six weeks, burning on an average of three hours per night, and so far only two lamps have been renewed. This, I believe, speaks very well for the multiple lamp, as during that time there were two quite severe wind storms.

F. T. MASTERSON,
Michigan Electric Association.

The Crocker-Wheeler Co. has established an office in Detroit with C. W. Cross as manager.

A new bulletin (No. 1105) has just been issued by the Western Electric Company describing in minute detail their Intercommunicating Telephone Systems. The bulletin contains 40 pages of descriptive matter, showing the different combinations of systems on which the new Western Electric metal intercommunicating telephones may be used. It also contains the wiring diagrams necessary for the installation of these systems.

A new portable dry battery, for which is claimed a current capacity of from 30 to 35 amperes, and an exceptional degree of recuperative power, is being placed on the market by the Longlife Battery Company, 808 E. Fifth Street, New York.

Classified Directory of Manufacturers—Cont'd

Simplex Electric Heating Co., Cambridgeport, Mass.
Union Elec. Mfg. Co., Milwaukee, Wis.
Universal Electric Stage Lighting Co. New York.
Ward Leonard Electric Co., Bronxville, N. Y.
Wirt Electric Co., Philadelphia, Pa.

TIME SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

TRANSFORMERS
Am. Transformer Co., Newark, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Irwin & Co., O. C., Crawfordsville, Ind.
Kuhlman Electric Co., Elkhart, Ind.
Lafayette Electrical Mfg. Co., Lafayette, Ind.
Moloney Electric Co., St. Louis, Mo.
Packard Electric Co., Warren, O.
Peerless Transformer Co., Warren, O
Pittsburg Transformer Co., Allegheny, Pa
Wagner Elec. Mfg. Co., St. Louis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

TROLLEY WHEELS
Anderson Mfg. Co., A. & J. M., Boston.

TURBINES—STEAM
Allis-Chalmers Co., Milwaukee, Wis.
Am. Turbine Eng. Co., Washington, D. C.
Ball & Wood Co., New York.
De Laval Steam Turbine Co., Trenton
General Electric Co., Schenectady, N. Y.
Hooven, Owens, Rentschler Co., Hamilton, O.
Morris Co., I P., Philadelphia, Pa.
Westinghouse Mach. Co., Pittsburg Pa

VALVES
Am. District Steam Co., Lockport, N. Y.
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston, Mass.
Crane Co., Chicago, Ill.
Crosby Steam Gauge & Valve Co., Boston.
Fairbanks Co., New York.
Homestead Valve Mfg. Co., Homestead, Pa
Jarecki Mfg. Co., Erie, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Valve and Fitting Co. Pittsburg, Pa.
Powell Co., W. M., Cincinnati, O.
Schutte & Koerting Co., Philadelphia.
Walworth Mfg. Co., Boston, Mass.

VARNISH—ARMATURE AND COIL
Calman & Co., Emil, New York.
Eagle Paint & Varnish Co., Pittsburg.
Growthwell, A., New York.
Macon-Evans Varnish Co., Pittsburg, Pa.
Massachusetts Chem. Co., Walpole, Mass.
Sherwin-Williams Co., Cleveland.
Standard Paint Co., New York.
Standard Varnish Works New York.
Sterling Varnish Co., Pittsburg, Pa.

WATER WHEELS
Allis-Chambers Co., Milwaukee, Wis.
Dayton Globe Iron Works, Dayton, O.
Doble & Co., Abner, San Francisco, Cal.
Leffel & Co., James, Springfield, O.
Lombard Governor Co., Ashland, Mass.
Morris Co., I. P., Philadelphia, Pa.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co. Dayton, O.
Risdon-Alcott Turbine Co. Mt. Holly, N. J.
Smith Co., S. Morgan, York, Pa.
Trump Mfg. Co., Springfield, O.

WATTMETERS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.
Diamond Meter Co., Peoria, Ill.
Duncan Electric Mfg. Co., Lafayette, Ind.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Helios Mfg. Co., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
Keystone Electrical Inst. Co., Phila., Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Classified Directory of Manufacturers—*Cont'd*

Weston Elec'l Inst. Co., Newark, N. J.
Whitney Electrical Inst., Co., New York.

WIRE—

COPPER

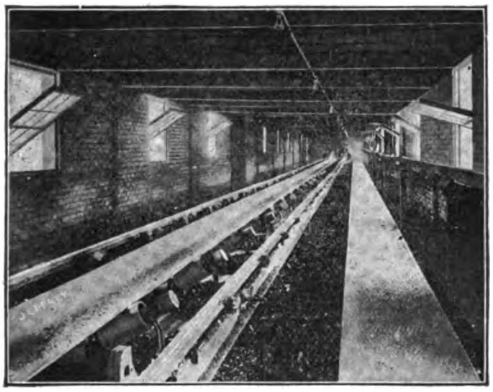
Am. Electrical Heater Co., Detroit, Mich.
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill
Ansonia Brass & Copper Co., New York
Bishop Gutta Percha Co., New York.
Chicago Insulated Wire Co., Chicago.
Crescent Insulated Wire & Cable Co., Trenton, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Monarch Electric & Wire Co., Chicago.
Moore, Alfred F., Philadelphia, Pa.
National Conduit & Cable Co., New York
Phillips Insulated Wire Co., Pawtucket R. I.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg, Pa
Western Electric Co., Chicago.
Wire & Telephone Co. of America, Rome, N. Y.

MAGNET

Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill.
Ansonia Brass & Copper Co., New York.
Belden Mfg. Co., Chicago, Ill.
Chicago Insulated Wire Co., Chicago.
D. & W. Fuse Co., Providence, R. I.
Driver-Harris Wire Co., Harrison, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago. Ill.
Moore Alfred F., Philadelphia, Pa.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg. Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg. Pa
Stuart-Howland Co., Boston, Mass.
Washburn Mfg. Co., Phillipsdale, R. I.
Waterbury Brass Co., Waterbury, Conn.
Western Electric Co., Chicago, Ill.
Wire & Telephone Co. of America, Rome.

RUBBER COVERED

Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago.
Atlantic Ins. Wire & Cable Co., New York.
Bishop Gutta Percha Co., New York
Boston Insulated Wire & Cable Co., Boston, Mass.
Brixey, W. R., New York
Crescent Insulated Wire & Cable Co., Trenton, N. J.
General Electric Co., Schenectady, N. Y.
Hazard Mfg. Co., Wilkesbarre, Pa.
India Rubber & Gutta Percha Insulating Co., New York.
Indiana Rubber & Insulated Wire Co., Jonesboro, Ind
Lowell Insulated Wire Co., Lowell, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
National India Rubber Co., Bristol, R. I.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Phillips Insulated Wire Co. Pawtucket, R. I.
Reed Electrical Cordage Co., Syracuse, N. Y.
Roebling's Sons Co., John A., Trenton.
Safety Ins. Wire & Cable Co., New York.
Simplex Electrical Co., Boston, Mass.
Standard Underground Cable Co., Pittsburg.
Waterbury Co., New York.
Wire & Telephone Co. of America, Rome



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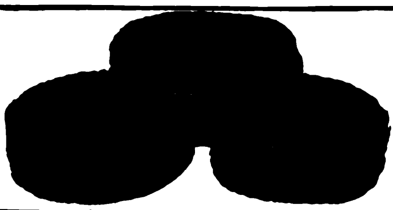

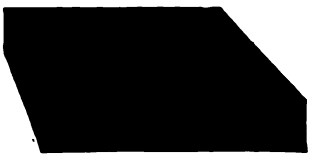

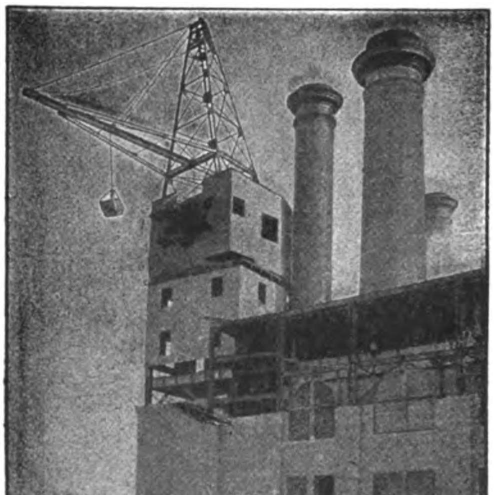

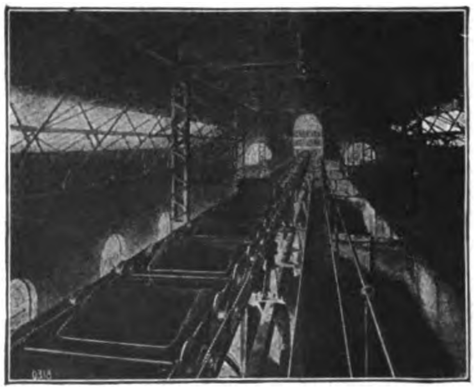

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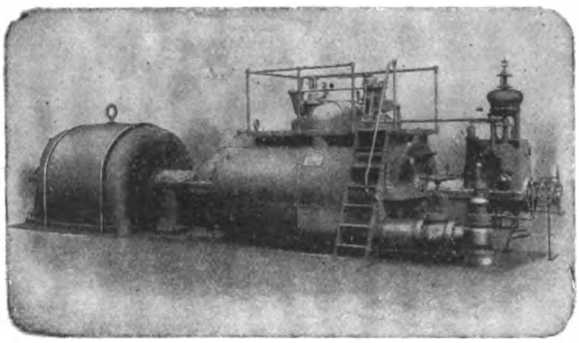

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CONTENTS

The Traction Tangle

Once more the country has been treated to the spectacle of a state of virtual war in the streets of one of its great cities. Once more a traction company has come to differences with its employees that have resulted in the partial breaking down of the social order on which our civilization is founded, and in bloodshed, arson and anarchy. Unfortunately, it is all an old story: the gathering of mobs, the wrecking and burning of cars and car-barns, the attacks on inoffensive passengers and non-striking carmen, the infliction of untold suffering on innocent women and children, of enormous inconvenience and financial loss on the public of all ranks and conditions, from the millionaire merchant, who sees his business income temporarily wiped out, to the humblest laborer who stumbles through the streets to his work.

How many times it has all been gone through with since the development of electric traction in the United States. It is easy to recall that in the last 20 years nearly all of our principal cities have had to endure this evil to a greater or less degree. Chicago, St. Louis, New Orleans, San Francisco, Brooklyn, Philadelphia, Cleveland, Pittsburg, and so the sinister roll-call runs even down to smaller cities, like Albany and Chester. A table embracing the vital, economic and financial loss, both to the disputants and to the general public, can be made to show that in the last 20 years, starting with New Orleans and ending with Philadelphia, the barbarous street railway conflicts have cost the country not less than 50 lives and $50,000,000.

Enormous as these figures are, appalling, as to unnecessary destruction of life and property, as they appear, they do not represent the most serious feature of the matter. Far worse than the lives lost and the millions wasted are the indirect effects on the community. Greater injury than even the misery, sickness and death, or the indirect financial losses—amounting to more, perhaps, than those in any other industry; with the exception of mining and metal working—is the moral damage resulting from loosening of the social bonds, the embitterment of men's minds, the uprousing of prejudice and passion, and the lowering of the public moral tone. Years after the cause is all but forgotten these baneful effects linger on, lying dormant or festering beneath the surface of our social and industrial life until another occasion arises to favor their awakening, and they water anew the springs of tumult and riot, battle and murder, and sudden death.

The deplorable picture represented by this phase of the electric traction industry is one of the far-too-numerous blots on the fair fame of this people. The past is past, but its heritage of evil remains. The burning questions confronting us now are: How long shall these things endure? What are the basic causes? What the remedies?

In attempting to answer these questions within necessarily narrow limits, we would present a brief survey of some of the general conditions obtaining in the traction quarrels, and of the causes that brought them into being.

The storm center of all the traction strikes has been around the "platform men." Of the more than 200 strikes that have occurred since electric traction came into general use, an overwhelming proportion hinges directly on the motormen and conductors; their hours, their wages, and the status and position of their union. Now, of the total 210,000 wage-earners in the employ of the companies at the beginning of 1908, motormen and conductors may be estimated to number about 130,000, or about 62 per cent. of the whole. The average pay of these men ranges from 25 cents an hour on the Pacific Coast to as lowa s 10 cents in the Southern States; but out of about 40,000 carmen in the great cities, the rate varies from 18 to 25 cents. However, the long hours involved bring up the average yearly earnings to a figure somewhat greater than the $658 of all the street railway companies' wage-earners taken together. In fact, the motormen and conductors stand always a little above the average on account of low-priced clerical and absolutely unskilled employees depressing the mean wage more than the highly paid engineers and other upper-grade employees raise it.

Now, these wages are by no means liberal, but neither are they starvation wages. The chief cause of traction strikes is hardly ever the absolute amount of wages paid. It lies deeper. The highly paid carmen on the Pacific have caused more trouble and violence than those in Southern cities. The most significant points in connection with the present scale of wages are, first, the actual inadequacy for reasons given later, and, second, in the memory of the fact that in too many cases the increases have had to be wrung from a reluctant management by measures that have likened the history of the traction industry unto the annals of war.

The mainspring of traction strikes is therefore deeper than the matter of the pay of carmen. Like most other evils, it is the result of a complex tangle of older evils, and its roots may be sought in the origin of modern traction, which seems to have had a somewhat tainted ancestry. Let us glance at this feature for a moment.

THE OLD HORSE-CAR DAYS

In the old days of horse traction, and relatively smaller city populations, the street railway business played a rather small part in the life of the city. The industry was thus of small proportions, but a study of the conditions prevailing in it shows them to have been astonishingly bad. The unskilled nature of the labor required to operate so simple and primitive a vehicle caused it to be a sort of a last resort for those who could do no better.

Accordingly we find that the labor, being what it was, was exploited to the limit. Low pay and overwork strained the endurance of the human unit to the breaking point. In most of the larger cities the normal working day ranged from 12 to 14, and even to 18, hours. The average for Philadelphia and Pittsburg, in 1885, was over 15 hours. A report of the commissioner of bureau of labor statistics in New York, in 1885, states that "in no other trade or occupation at which men work for a livelihood do I believe there exist grievances approximating in the slightest degree in number and gravity those resulting from the general mismanagement of the street railroads in this State." This a pretty strong expression for an official.

It appears, however, to be entirely justified. In addition to the excessive hours of labor, there were numerous and exacting rules, and the men were bullied by petty bosses. Dirty city politics played its part along with stingy practices of the companies regarding caps, uniforms, fare registers, matches, kindling wood, shovels, lamp chimneys, etc., all or part of which were sometimes charged to the horse-carman, frequently at outrageous prices. For enduring all of this sort of thing, for from 12 to 18 hours a day, the pay in eastern cities was generally not over $1.75, and very rarely over $2.00 a day. The average for Pittsburg in 1884 was $1.75 for 15½ hours' work.

This sort of grinding led to its usual result. Bad relations existed almost everywhere; strikes were frequent and relatively as fierce in character as the latter day. But there was no material betterment despite the complaints of the public, and even of the courts, until the Knights of Labor were appealed to in 1886 by the long-suffering carmen. This appeal was general in all the large cities.

The relief then came reluctantly. In March of that year the carmen of Philadelphia, being secretly organized and ready to strike, demanded of the companies a 12-hr. working day, a standard rate of pay of $2.00, the granting of an allowance of 30 minutes for dinner, and 15 minutes each for breakfast and supper, and relief from the rule requiring them to buy uniforms except the cap and badge. It took the companies a week's consideration to grant these requests.

Later, efforts were made in various States to legislate for the relief of carmen, but the success was only partial. The truth is that in most cases all the relief they got was fought for, and torn by threats or force from the traction companies. Outside circumstances enforced the rest.

This record of greed and oppression of violence and fraud throws a sinister light on the forerunning of present-day conditions. The traditions are distinctly bad.

THE COMING OF ELECTRICITY

With the introduction of electrical operation a vast change came over the whole industry. The era of wonderful expansion began. Also that of overcapitalization. The street railways grew and grew from year to year, until, at the beginning of 1908, over two and one-half billions of capital were—or supposed to be—invested, and gross earnings of traction companies were nearly $430,000,000. In the space of 20 years all the conditions of the business were practically changed. Of all the changes, the significant ones for our present purposes are those involving the much-abused platform man. What do we find them to be?

In many ways the introduction of electrical power has been of great benefit to him. In others, far from it. Looking at the best side first, we saw above that he has come to number 130,000 men. That is one point that ought to be useful to him. Moreover, we find that by this time his hours, for the most part, have been materially shortened. Instead of 15 or more hours per day for an average, the day's work is now nearer 10. In the good city of Philadelphia, for example, the average day has come down from 15 hours and 11 minutes for about 1000 men in 1885 to 10½ hours for 5000 men in 1910. This may be classed as one great benefit. Another is the improvement in the character and morale of the men themselves. The carman is now at least semi-skilled. The man who could successfully handle a car whose motive power consisted of two tired-out horses is not necessarily the man who is capable of handling cars of 50 to 150 horse power in streets that are many times more crowded than in horse-car days. The inevitable result of the increase in the value and complexity of the car is a more careful selection of the men on whom its safety depended. But as the handling of an electric car is essentially a young man's job on account of the physical and nervous endurance involved, the occupation has always been of a temporary nature. No one stays at it any longer than he can help. The shortening of hours and the rise of wages that have come in with electric traction have, to a certain extent, been made inevitable by the requirements of modern conditions. There was no other way to get the proper kind of men. This result has brought with it the betterment in morale.

Turning now to the disadvantages to carmen that are the results of the adoption of electric traction, the first thing that impresses is the enormous increase in the stress and strain of his occupation caused by the crowded streets, large cars and comparatively high speeds now involved. The fatigue and exposure to serious mishaps are greater in a 10-hr. day on a city trolley car than in a 15-hr. day on an old-fashioned horse-car. The consequences of a lapse from attention are far more serious, and the penalty of suspension is always hanging over motormen and conductors alike.

Another bad effect of the electrical régime on the carman has been the influence of the so-called overcapitalization of traction properties. Rightly or wrongly, the impression is widespread among the men themselves that too much of the companies' revenue is absorbed in meeting, or attempting to meet, obligations on capital that represents nothing of public benefit, but only enormous personal fortunes. We will not attempt here to discuss the painful subject of traction finance. We merely repeat that the public and the men alike, having had much to endure and having heard much of the reasons therefore, are led into an attitude toward the companies that goes far toward accounting for that bitter intensity of feeling that nearly all traction strikes have displayed.

Still more striking, as an illustration of the complexity of causes involved in the traction situation, is the analysis of the wage question. If traction statistics prove anything at all, they prove that there has been a considerable increase in wages during the last decade for reasons indicated above. But the effect of this increase has been very largely offset by the reduction in hours. Thus, for example, if the average carman who worked 15 hr. a day at 12 cents in 1885 now gets 22 cents for 10 hr. work, while his hourly pay has increased over 80 per cent, his actual daily earnings have increased only 40 cents, or 22 per cent. Against this increase in pay is the net increase in the cost of living, which is certainly over 30 per cent. for the class to which the carman belongs. It is therefore very doubtful if the platform man to-day is relatively as well paid as he was in the horse-car days. But he is younger, stronger in numbers, more intelligent and has more time to think over his real and fancied grievances.

Then, too, since a much larger proportion of the public use the cars than formerly, the crew have a larger personal acquaintance and are in a better position to reach the public ear, and the public, for reasons of its own, tends to make common cause with him.

AS THINGS NOW ARE.

Summing up the situation, the following conclusions impress themselves:

1. The country suffers a tremendous vital, economic and moral injury in its all too numerous traction strikes.

2. The injury falls first on the employees, second, and more heavily, on the companies, and thirdly, and most of all, on the public.

3. The chief cause of the disturbances is the conditions surrounding the carman.

4. As between the companies and the carman, the facts appear as follows:

(a) The companies are suffering from many economic causes, of which the chief are the results; first, of the reckless overcapitalization in forming the existing mergers; second, of the limits imposed by the fixed character of the unit fare and the difficulties in raising these charges; third, by the general increase in the cost of living, labor and material.

(b) The carman is likewise suffering from many causes, of which the chief seem to be; first, an evil inheritance from the memory of the outrages of the old horse-car companies; second, from the fact that to-day he is relatively little, if any, better paid than in the past; third, from the conviction that the companies might and should do better by him than they do; fourth, from much foolish and impracticable counsel from socialists and professional and semi-professional labor agitators.

THE REMEDY

In conclusion it may be said that the remedy for all these evils, and the means of placing the relations between the carmen and their employers on at least as good a footing as those obtaining in other industries, seems to us to lie along the line of straight, simple, common honesty and fair dealing on both sides. Both have sown the wind; both have reaped the whirlwind. Let the past be forgotten, and new policies laid out, based on mutual candor, consideration and forbearance, in the many difficulties in which each party is placed. It is a pleasure to note that there are many instances that show this solution is coming to be realized as the only sound and enduring one. In many systems it is a long distance under way. When all shall have come round to it, the disgraceful chapter of American traction strikes may be relegated to the company of events that will one day be regarded as belonging to the Dark Ages of industrial evolution.

Engine-Turbine Performance

The possibilities of the low-pressure turbine as a means of increasing the output capacity of large steam engine-driven electric plants has been much before the engineering public for some years past. There have been many calculations and discussions before the various societies, and a good many claims, some of which were difficult to follow, have been made for it. The inevitable amount of controversy has had to be gone through with, and, in fact, is still under way. It is, therefore, with particular pleasure that we present elsewhere in this issue an abstract of the paper presented recently before a joint meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, by Messrs. H. G. Stott and W. R. Pigott, entitled "Tests of a 15,000-kw. Steam Engine-Turbine Unit."

In this paper are presented the actual results of the installation of low-pressure turbines on a large scale. It is a record of the preliminary considerations and tests which led to the choice of the means of enlarging one of the best-known power plants in the country and of the results so far obtained. In the plant, the four-cylinder compound engines, which have been in use for some years, have given fair satisfaction in operation and a good economy at and around two-thirds load. The water-rate curve shows, however, the well-known loop indicating the relatively narrow range of highest efficiency characteristic of compound engines. The difficulty of keeping units in a traction plant, working in this region of maximum economy, which for the units here involved is between 3300 and 6300 kw., is one of the main points of plant operation. As the peak tends to go beyond the limits of the rated capacity, the difficulty of getting good operating conditions increases, as more units must be operated at uneconomical overloads.

In addition to this disadvantage, as pointed out by the authors, the total capacity of the station was becoming inadequate to the demands on it. This is, of course, due to the increase in the traction traffic of the lines served.

The problem was, therefore, twofold: First, to increase the total output of the plant; second, to improve the operating efficiency, particularly at fractional and over loads.

A valuable feature of the paper is the concise description of the line of reasoning that led to the rejection of the various methods that might have been employed to accomplish these results in a more or less satisfactory manner, and to the adoption of the low-pressure turbine. It must be confessed that all the conditions were particularly favorable to the conclusion reached. The presence of an enormous and relatively undeteriorated equipment, having in it a latent possibility of power capacity expansion forbade the idea of following any plan involving its rejection. Given that condition, the means of attaining the desired result narrowed down to increasing the number of expansions, or installing the low-pressure turbine.

The results of the choosing of the latter alternative, as announced at the conclusion of the paper, are a splendid vindication of the course adopted. The flat water-rate curve of the turbine end of the unit comes to the help of the engine and the resultant shows a striking widening of the limits of economical operation. The effect is clearly shown in the curves attached to the paper. The capacity of the combined unit is double that of the original engine unit, thus doubling the output of the larger units of the plant without increasing the size of the building. The increase in the amount and maximum efficiency range of the unit meets both the requirements of the case. The average efficiency of the combination is stated to be 25 per cent. greater than that of the engine unit alone. The total average thermal efficiency is given as 20.6 per cent., which is certainly a high figure for steam-operated units, especially under such conditions.

One result of the installation is stated to be the raising of the net economy to a figure 13 per cent. better than could be accomplished with the best high-pressure turbine operated alone. There is nothing in the paper itself to prove this, and it will probably be considered as open to question. If the comparison is between a 7500-kw. high-pressure turbine and a 7500-kw. low-pressure turbine it might be more generally received, but if it is between the combined 15,000-kw. unit and a 15,000-kw. high-pressure turbine, operated under the same high vacuums and other favorable operating conditions, which is manifestly the fitting comparison, it becomes a little hard to follow. But, in any event, the merit of the achievement as a feat of sound and skilful engineering is none the less admirable and noteworthy.

An interesting feature of the installation is the adoption of the induction generator for the electric end of the low-pressure addition. This machine has inherited its name from the well-known induction motor which it exactly resembles, and its characteristics are such as to fit in nicely with the special conditions of this problem. This generator is about the simplest possible type, and certainly one of the most hardy. The fact that it generates energy current only, and that its short-circuit current, like that of a direct-current shunt dynamo is zero, make it singularly adopted to fulfil the rôle of an auxiliary generator, which simply adds so much power capacity without interfering in the least with the regulation, and which admits of connection in the simplest possible manner. It would be interesting to know just what the efficiency of the generator is.

As the authors make the calculation of the short-circuit energy of this plant, with nine 15,000-kw. combined units, figured at twice their rating, and synchronous turbine units aggregating 7500 kw. at six times their rating, there would be at least 315,000 kw. of energy turned loose for destructive purposes. The adoption of induction generators reduces the estimated destructive energy on short circuit, calculated on the same basis from a total of 720,000 kw. to the figure given above. These figures are easy to write, but hard to realize. But the mere fact that the use of the inductor generator reduces the short-circuit energy to less than half of what it might have been with synchronous turbo-alternators, was an excellent reason for their selection, aside from the other considerations adduced.

The results shown in this particular instance of the use of the engine-turbine confirm the idea that in certain special cases it is admirably adopted to solve the problem of increasing the capacity and efficiency of large existing reciprocating-engine plants. We think it unlikely that its use, aside from this field, will ever be very extended, though it is being much discussed for certain classes of new construction, as, for instance, in marine work. The simplicity of the induction generator is not the least of the advantages possible. But it must always be borne in mind that only in plants of considerable capacity and subject to well-defined conditions can the hybrid unit make a showing approaching that reported for the Interborough Rapid Transit Company.

The Exploitation of Water-Power

A few months ago a well-known engineer, in a paper before the national body, sounded a note of warning on the manner in which so-called securities covering supposedly valuable water-power properties had been and are being distributed to the investing public. Attracted by the apparently certain earning powers of a waterfall, the ignorant or unscrupulous draw up a prospectus based on insufficient or mishandled data as to the cost of development and the probable earnings of the property, and unload their shares on a public which too often wakes from its dream of steady dividends to the realization that no return is possible on its investment for perhaps many years, if ever.

It is this sort of transaction that has given water-power development a bad name in the financial world. The volume of worthless or semi-worthless bonds and shares of stock in water-power properties compared with the really valuable securities is larger than is generally suspected. Comparisons of the total capitalization of water-power transmission companies that have been, or actually are, through receiverships, when made with that of solvent and profitable concerns, is not very reassuring, but this does not tell the whole story. Many small companies have had no such experience, but they are dragging along year after year, either losing money or merely partly paying expenses, a disappointment to all connected with them.

This being the state of affairs, it is certainly well to keep before the public the need for caution in water-power transmission undertakings. We are glad to note that, in a paper before the last meeting of the Institute, the chief engineer and up-builder of one of the country's largest water-power companies, although discussing specifically the parallel operation of plants, has taken occasion to say a word on the subject.

Second to none in point of experience in this special line, the following, which we take the liberty of quoting, comes with special authority on the risks involved in this alluring field of investment:

> I know of no business in which as much money has been invested as in hydroelectric developments that has made such a poor return on the investment. Seventy-five per cent. of the reports made on proposed hydroelectric developments are jokes. Moreover, the local papers, when a development is proposed or started, are eager to magnify the amount of power, the cost of construction and the value of the investment. The result is that the entire country has been trained to believe in a general condition that does not exist. Promoters have taken advantage of this condition, and many plants have been built or started that have proved failures.
>
> The investigation of a proposed hydroelectric development requires a great deal of work and study by trained and experienced men, as there are more varying features entering into consideration than in any other branch of engineering. Most reports are made hurriedly without proper investigation, hence disappointment follows. The engineers who make these reports are not wholly to blame, for they are seldom allowed the necessary time or facilities to make proper investigation on account of the cost involved.
>
> The standard for determining the cost of power to-day is based upon the cost of power produced from coal. As the supply of coal is consumed the cost of power will necessarily increase and a new standard of cost will be established. Any tendency to block or interfere with the development of water power is necessarily forcing the consumption of coal and hastening the day when the price of power must increase according to the law of supply and demand. I fear that many of our conservation advocates who are endeavoring to prevent the destruction of our natural resources are really hastening it.

The fundamental statement that "the standard for determining the cost of power to-day is based on the cost of power produced from coal" holds true for all localities. It might be made wider by putting it, "The standard of the cost of power production at any point is based upon the cost of power produced from the cheapest available fuel at that point."

This fact, which should be self-evident, is precisely one which is most frequently lost sight of in the numerous erratic small power developments that make up the unfortunate total of unsuccessful properties.

In a case that has come under notice quite recently, an investment of $1,800 per kilowatt of power available from minimum flow was made for a small plant in a locality where an investment of one-tenth of that sum would have provided a plant that could have been operated on coal or fuel oil at a net annual saving of many hundreds of dollars when operating with any load factor that the plant could ever command.

If it were clearly grasped that the question of a water-power development as compared with a fuel-using plant, speaking broadly, is usually a matter of the fixed charges on the excess cost of the water-power plant over that of an equivalent fuel-using plant *versus* the fuel bills of the latter plant, the number of unfortunate hydroelectric investments would be much reduced, and the business would take on a better tone.

Energy Consumption of Storage Battery Car

The car equipped with the Edison nickel-iron storage batteries, described in one of our recent issues, has been operating on the 28th and 29th Street crosstown lines in New York for some time. There are few grades on the line, but stops are frequent, and there are some short double curves.

Recent tests of the power consumption showed that in 10 hr. and 5 min. the car made 11 round trips, aggregating 52.47 miles. The weight of the car with an average load would be about six tons. The test showed a watt-hour consumption of 35,925, being 684.5 watt-hours per car mile and 114.1 watt-hours per ton mile.

Some Considerations In Selecting Equipment For Hydro-Electric Plants

M. H. COLLBOHM

The object of this paper is to call attention to some of the principal points to be considered in the design, selection and arrangement of the various parts that go to make up a complete hydro-electric transmission property, including the more important machinery and apparatus necessary for the generation of electrical energy from water power and its control and transmission to the place where it is to be utilized. Within the limits of such a paper it will be understood that only a brief treatment of the more essential points will be attempted.

After the records of the stream flow, and the existing and possible market conditions have shown the feasibility of developing a power-transmission system, the first consideration is given to the size of the turbines and generators and their number. Convenience of operation, and also first cost of the total station equipment, tend to reduce the number of units to be installed and therefore with a given capacity of the plant would call for comparatively large sizes. On the other hand, such conditions as a number of individual transmission lines which may require independent voltage regulation; or a possible low head of the development, which would necessitate an inconveniently large number of runners on a rather long common shaft, somewhat difficult to keep in permanent perfect alignment, would call for a greater number of smaller units. The size of the turbines and generators therefore is obtained by compromising between the different opposing factors, giving each of them its proper importance.

After having decided upon the number and size of the units the frequency of the transmission system needs consideration. If the expected load is a prominent lighting load, then 60 cycles should be used, and if the energy is used to a great extent for railway purposes, then 25 cycles ought to be chosen. As a railway load offers a considerably better load factor than the lighting load, it is usually given preference, and whatever important lighting there is will be supplied over frequency changers at the point of utilization. If, however, the railway load is, or is expected to be, comparatively small as compared with the lighting and ordinary industrial power, then 60 cycles should be used and the railway supplied over motor generators instead of converters as in the former case. As regards the regulation of the transmission line, it must be admitted that it is better for the lower frequency on account of the decreased charging current and inductive voltage drop. It is hardly necessary to discuss the kind of the transmission system to be used, as because of its minimum cost for copper the three-phase system is universally employed. The voltage of the generator depends on its size and also whether step-up transformers must be used. The American Institute of Electrical Engineers recommends a generator voltage of 2200 volts, or any multiple thereof. A voltage of 2200 or 2300 is almost universally found, and even in large units of several thousand kw. In such sizes, however, the main cables, bus bars and switches become so heavy as to make it very difficult to handle them. Although a higher generator voltage is preferable, on account of smaller cables, bus bars and switches, the total cost may become greater for the higher voltage on account of the more expensive insulation required for the cables and apparatus. The determining of the generator voltage is therefore again a matter for detailed consideration. Generators supplying step-up transformers have occasionally been wound for 13,200 volts, as in the case of the McCall's Ferry Power Company's generating station, which comprises in its ultimate equipment 10 generators of 7500 k.w. each.

If the transmission distance and the energy supplied over each line is rather moderate, the step-up transformers may be dispensed with by employing a comparatively high generator voltage, thereby also saving considerably in switchboard equipment and simplifying the total layout. There have been plants in Europe in successful operation for several years with generator voltages up to 35,000 volts.

When supplying transmission lines of considerable length and high voltage due regard should be paid to the wave form of the generator e.m.f., particularly so if the system is designed to run in parallel with another plant. If the generator wave forms of the respective stations are not identical then large exchange currents may be set up in the system, thereby seriously affecting its regulation and output. The ideal wave form is, of course, the true sine curve, but the commercial machines contain more or less higher harmonies of different amplitudes. The greater their number and amplitude the higher is the charging current on the line, which under some conditions may require the total current capacity of more than one large generator to keep the voltage on the line without delivering any power at all. These higher harmonies also involve the possibility of resonance, particularly in a long transmission line, due to perhaps an arcing ground or the opening of a circuit breaker under overload in the sub-station, thereby causing abnormally high voltage. The writer knows of a 25-cycle transmission system containing the 17th harmonic of the fundamental generator wave of appreciable amplitude, which would be in perfect resonance with a line of 106 miles in length, which is not an uncommon transmission distance. This tends to show the advisability of including this point in the specifications for generators and to choose only such machines as have none or only a few higher harmonics and of small amplitude in their wave form.

Another point of importance is the interconnection of the generator windings, *i. e.*, whether they shall be star or delta connected. Usually the electro-motive force is each phase of a three-phase generator contains a third harmonic, and if the three phases are delta-connected then the third harmonics are short-circuited, and inasmuch as they have constant potential character they may give rise to large short-circuiting currents in the generator itself, particularly in machines with close regulation having a low impedance. For this reason generators should always be star-connected. The energy for the generator field excitation is generally supplied by two waterwheel-driven exciters of equal size, each of a capacity to supply the first generator installation, which is about one-half or more of the total equipment. This arrangement leaves always one exciter for reserve. As soon as the final equipment is put in another exciter must be provided, which is preferably done by installing a motor-generator set of the capacity of one of the waterwheel-driven exciters. These direct-current generators are, as a rule, flat-compounded machines, and no regulation is required with change of load except to keep the speed constant, which is automatically done by hydraulic governors. The exciter voltage is either 110 or 220 volts; even with the higher voltage the current capacity is so great that very heavy cables are required. In case of the motor-driven exciter for the McCall's Ferry Power Company's station it was necessary to provide 6,000,000 c.m. of combined copper cross-section for each pole. In case of large units it is better not to bring up the equalizer leads to the main switchboard, but to connect the machines on the floor through single-throw switches mounted either on the exciter frames or on separate pedestals nearby. The switchboard for the exciter is generally placed adjacent to the main control board for the generators and lines. In very large stations, however, as we had in the plant just mentioned, the exciter board may be entirely separate and arranged for remote electrical control from the main board, both in regard to switches as well as field rheostats.

The energy delivered by the generators, after passing through a system of oil switches and bus bars, to be discussed later, is stepped up to the transmission voltage by the main transformers. The latter are always oil-insulated for any high voltage transmission. They are preferably placed in fireproof compartments upon rails, which lead either directly or by the aid of a transfer track to a place where they can be taken by the power-house crane. Sometimes the transformers are so located that they can be handled by the crane directly. In such case provision must be made for a substantial removable covering above the transformers to avoid accidental contact of the crane chain with the conductors, which has been the cause for a shut down in some stations in the Middle West.

The transformers may be either single-phase or three-phase. The latter are cheaper in first cost, except in this country, where it appears to be due to commercial conditions and not inherent in the cost of manufacture; they occupy very much less space, and the wiring, and also the piping for oil and cooling water is much simplified. However, three-phase transformers require another three-phase unit of same size to constitute a full reserve, while in case of a single-phase transformer installation only one more single-phase unit of one-third the capacity of the three-phase unit is necessary. Very large stations with many units usually provide a full reserve in form of a complete set, including turbine, generator and transformer, completely wired up and ready for service. The usual connections of a step-up transformer is delta on the low-tension side and star on the high-tension side, with the neutral grounded. This offers the following advantages:

1. The insulators have normally to withstand only 58 per cent. of the potential between lines.

2. If a break occurs in one line conductor the service may be kept up over the other two conductors and ground, if proper provision is made therefore.

3. Destructive high-frequency surges due to an arcing ground cannot occur, since any ground on the line would develop into a short circuit and open the circuit-breaker.

The last-mentioned condition may, however, be considered a disadvantage, as it interrupts the service, although it saves the station apparatus from possible damage due to excessive potential strains.

The transformers are as a rule artificially cooled, either by forced water or oil circulation. In the first scheme water is forced through a coil placed inside the transformer tank below the oil level, supplied either from a city water main or from the exciter penstocks, or from a separate small motor-driven pump. In the oil-cooled system the oil from the transformers is withdrawn by a pump and passed through a system of cooling pipes back to the transformer. These cooling coils are generally arranged in the tailrace, and care must be taken in laying out the system that the oil in the cooling pipes has a higher pressure than the surrounding water, as otherwise water may leak through the pipe joints and mix with the oil, which would be very dangerous.

A further precaution is to provide an individual cooling system for each transformer tank in order to prevent any possible mixing of deteriorated oil from one transformer with the good oil in the others, which in the past has been one of the reasons for transformer shut-downs. It must also be remembered that the specific heat of oil is only about one-half of that of water, and the forced oil-cooling system, including pumps and piping, is therefore considerably more expensive than the system for water cooling. In order to observe the performance of the transformers they are equipped with an alcohol thermometer and an oil gage; a visual indicator must be installed to show the proper oil or water circulation. Thermoelements or other devices may be installed to read the temperature of the transformers at some remote point, perhaps at the main control board, and also to sound an alarm if the temperature rises abnormally. A signalling device for low oil level should likewise be provided.

The oil in the transformer may after some time become deteriorated, and it must, therefore, be tested periodically. The importance of this is apparent by the fact that the presence of only 0.06 of one per cent. of water decreases the dielectric strength of the oil to about one-half. The oil is tested in a spark gap with high voltage up to 50,000 volts and over, and if not found satisfactory is withdrawn for treatment and new oil pumped into the transformer. There are two methods in use for treating the oil, one by drawing heated dry air through the oil with the aid of a vacuum pump to drive out the moisture, and the other by forcing the oil through a lime filter to absorb the water. A separate sand filter is provided in each case to remove any foreign substances. The last-named method has the advantage of considerably higher speed and is applicable to continuous operation. It also simplifies the piping for oil supply. Another method has recently come into some use, and consists of blowing heated air through the transformer oil. Although this may have been satisfactory, it cannot be considered as effective as the before-mentioned two methods.

The connection between the transformers and generators is done by cables and oil switches. In larger stations these switches are built for remote control and placed away from the main control board. There are three systems in existence for operating the switches from a distant point, viz.:

1. By a small electric motor on the oil switch, closing the switch against the tension of a spring, which latter, when tripped electrically, serves to open the oil switch.

2. By a strong electromagnet performing the same functions as the motor.

3. By compressed air with electrically controlled pilot valves. This last system is only used in very large stations with heavy high-voltage oil switches requiring a great amount of power to operate. It necessitates the installation of a duplicate compressor set with main and secondary air tanks to avoid fluctuation of pressure in the long pipe lines when operating a switch. The air must be drawn through a separate tank containing moisture-absorbent chemicals in order not to reduce the insulation of the switch. The connection from the piping to the switch proper consists of a specially treated hose which, for sake of insulation, must have a

straight length of about 10 ft. and must withstand an operating pressure of between 75 and 100 lb. per sq. in. All this tends to increase the size of the power house materially. It has the other disadvantage that, on account of lack of actuating members having ground potential, a reliable indicating device showing at the switchboard the position of the oil switch cannot be installed very conveniently. Furthermore, as this type is built in single-pole units, there is less assurance that all three phases will open simultaneously.

The oil switches proper are built in two principal constructions, viz.: for breaking the arc vertically and for breaking it horizontally. The first method involving the vertical break necessitates at higher voltages very large vertical dimensions to safely interrupt the arc on the downward motion. This type of switch is therefore rather large and expensive at high voltages; it has furthermore the disadvantage of opening the contacts somewhat near the level of the oil, and any possible explosive action, particularly at overloads or short circuits, tends to throw the oil out of the switch. These disadvantages are not nearly so apparent in the other type using the horizontal break near the bottom of the tank with a sufficient head of oil above the break. As it is the natural tendency of an arc to rise vertically, it seems that the horizontal break should be much more efficient in extinguishing, or, in other words, it may be built smaller and less expensive, especially if constructed with a minimum of actuating members. The oil switches are generally equipped with protection devices to save the apparatus which they control from damage. The oil switch between the generator and the bus bar may be equipped with a reverse power overload relay, which disconnects the machine in case of an unduly high-current rush in the reversed direction, due to improper synchronizing, or short circuit in the generator itself. The transformer switch is tripped by and inverse time-limit overload relay which will disconnect the transformer instantly at heavy overload, and only after a certain time at smaller but continuous overload.

The oil switches are triple pole throughout, and care should be taken that all three contacts are opened and closed by a common operating member which prevents any contact staying closed with the others open. In case of repair on the switch, this last condition might lead to a fatal accident. Generally there are plain disconnecting knife switches provided on each side of the oil switch in order to entirely isolate it from the system in case of repairs. The arrangement of the oil switches, as well as the bus bars, which both are generally placed in fireproof brick or concrete compartments, must be such as to leave a sufficient number of passageways through the rows of switches to avoid the attendants getting trapped in case an oil switch explodes and starts the oil to burning.

The cables connecting the various apparatus and machines consist of insulated copper conductors placed in individual conduits. For alternating currents these conduits must consist of fibre, vitrified clay or any other non-magnetic and preferably non-metallic material to avoid induction. The cables may be either single conductor or triple conductor. The choice between these two depends upon the required size and is also a matter of cost. Triple-conductor cables should not be used heavier than 3 by 250,000 circular mils, as they become too difficult to handle.

The connection from the high-tension side of the transformers to the high-tension oil switches and outgoing transmission lines is invariably done by bare wiring supported upon proper high-voltage insulators. These high-tension switches are usually so large, each measuring about 12 by 8 ft. in floor space, that they determine, to a great extent, the size of the power house.

As mentioned before, the main switches are operated from the control switchboard, which is usually located in the center of the building, overlooking the machinery. Besides these small control switches which operate the main oil switches, this panelboard contains also the control switches for the hydraulic governors for synchronizing the voltmeter and synchronizing receptacles, and the measuring instruments, such as voltmeter, ammeter, wattmeter, power-factor indicator, frequency indicator and synchronism indicator, and perhaps one or more automatic voltage regulators. It may be well to mention that power-factor indicators should be provided for each generator, as it is often found that station operators neglect to adjust the field excitation properly without this instrument, thereby running the generators with different leading and lagging power factor.

In case of a station with extensive switching arrangements, the control board is built as a bench board, the vertical section containing all the instruments and the inclined section all the control switches, with their red and green indicating lamps, and receptacles. This last section is sometimes removed from the panelboard and so placed that all the instruments of the entire board may be observed from that place; this necessitates to arrange the rest of the board in a semicircle, with the bench containing the control switches in the center. It calls furthermore for instruments having flat glass covers to avoid the annoying light reflex on the curved glass covers. It is, in any case, of considerable advantage to install only instruments with flat glass covers, as they can be read very much better than the so-called horizontal edgewise instruments where the scale is arranged in a horizontal circle. All the instruments, in fact every apparatus on the control board, carry low potential only, say, 110 volts; this is accomplished by the use of the current and potential transformers, both in the low-tension and high-tension side of the station. The current transformers in the high-tension leads are usually protected by a spark gap against abnormal voltages across their terminals produced by high-frequency surges entering over the transmission line. For better protection the writer would propose, however, to install one or two small electrolytic cells across the terminals which would reduce materially the maximum voltage that can exist between the terminals. For consideration of low first cost the high-potential current transformers are sometimes omitted and series ammeters placed upon proper high-voltage insulators are provided instead. Care should then be taken that these ammeters are so arranged that they may be observed from the control board. This arrangement necessitates also the installation of high-tension series relays to trip the high-tension oil switches.

The usual danger to station apparatus comes from abnormally high potentials produced by a direct or induced lightning stroke, by an arcing ground in the system, or by opening a circuit-breaker under heavy overload. To guard against destruction from such causes, lightning arresters are installed at the power house, together with choke coils, which latter, on account of their considerable time lag under high-frequency currents, serve to hold back the surge until the arrester has come into action. The latest development in arresters is the aluminum arrester, which works on the principle of a storage battery, discharging any voltage to ground which is higher than the operating voltage by a predetermined value which depends on the total number of aluminum cells in series and which allows of a very close adjustment. The number and the arrangement of these arresters depend upon the delta or star connection of the system, and whether it operates with a grounded neutral.

The high-tension conductors, after passing through wall bushings in the power-house wall, connect directly to the transmission line. The latter consists of bare wires or stranded cables of either copper or aluminum. Copper has the advantage of greater strength and a smaller coefficient of expansion; thus a copper line may be constructed with a smaller sag in the wires, thereby economizing in the height of the towers. Its rate of depreciation is very low as compared with aluminum, because the scrap value of copper is very high. The copper cable should preferably be constructed with a hemp center instead of copper; this construction allows all the individual copper wires to be stressed alike, while if it was constructed with a copper center, this center wire would be overstressed, while the outer wires, due to their stranding, are able to give somewhat. The outer wires will be fully stressed after the center wire may have been stretched beyond its elastic limit, which then does not contribute any more its original strength, and the total strength of the cable is therefore materially reduced. This disadvantage is not inherent in a hemp-center construction. There appears to be a general tendency to stress the transmission cables unduly high in order to reduce the sag and the height of the supporting towers, thereby reducing the factor of safety to a very low figure, which may be below unity under the severest weather conditions that are likely to arise. In the writer's opinion, this tendency is entirely wrong, and is the cause for the well-known fact that the transmission line is the weakest and most unreliable part in the whole system. On account of this defect it has been proposed to install auxiliary steam plants in connection with transmission lines and keep them ready for service all the time in order to supply power at times of interruptions over the transmission line. It would seem, however, that the money for such plants, if expended for reserve purposes only, might be more profitably spent for improvements on the transmission line for the purpose of minimizing the probabilities of break-down. This may best be effected by running duplicate lines, each on a separate right-of-way, and by providing a sufficient number of guard wires of copper-clad steel above the line wires and grounded at every tower to reduce the damage from lightning.

The line wires are supported by insulators attached to poles or towers. The latest development is the suspension type insulator, comprising a series of insulator discs suspended one below the other in a vertical line with the wire attached to the lowest ones. This type has given excellent service and is particularly applicable to higher voltages, say, 40,000 volts and above. It has, however, the disadvantage of necessitating higher towers than the pin-type insulator. As mentioned before, the transmission line should be provided with ground wires above the power wires to act as lightning conductors; they will also serve to dampen out any high-frequency surge that may be set up in the system. The supporting structures for the lines are either wooden or steel poles or steel towers.

Motor Ratings

As a happy (?) example of what unregulated competition may lead to, a striking instance is to be found in the matter of the sizes and ratings of electric motors referred to by Mr. George Westinghouse in a recent address before a joint meeting of electrical and mechanical engineers at Boston. In reference to useless waste in manufacturing, he says:

"To illustrate the growth in the number of motor ratings required now as compared to the earlier days when 60 ratings sufficed, a summary is given of the motors manufactured by the company with which I am connected. These figures refer to stationary motors only in sizes up to 200 h.p. All of these motors are regularly manufactured and no special motors are included.

For direct current, 55 frames are used, giving 1600 ratings.

For alternating current, 80 frames are used, giving 1950 ratings.

Or a total of 135 frames are used, giving 3550 ratings.

Practically any one of these may be furnished in three types: (a) shaft horizontal, (b) shaft vertical, (c) with counter shaft bracket and bearings mounted on the frame. This makes a total of three times 3550, or something over 10,000 different motors available. In spite of this, there is a constant and increasing demand for special motors. In the past year approximately 10,000 estimates have been made in special motors under 200 h.p., even though the greatest effort has been made to divert all inquiries to our regular lines of motors.

Many of these special estimates were necessary because the prospective customer wanted a motor having the same characteristics as a motor offered by some other manufacturer. Our standard motor may have differed in any one of the following characteristics: (a) Horse power or speed rating; (b) Dimensions of base; (c) Over all dimensions; (d) Height from base to center of shaft; (e) Weight; (f) Method of lubrication; (g) Size of shaft; (h) Performance guarantees.

This demand for special apparatus places a heavy burden on the manufacturer. The purchaser also suffers because of increased cost and long deliveries.

Consideration of the above and a general review of the situation leads to the conclusion that the benefits that will result from standardization will more than compensate for the work and expense required in making the necessary changes.

While these particulars relate only to a part of the motors made by one large company, it must not be forgotten that there are half a hundred others manufacturing equivalent lines of motors and that each maker has his own patterns and designs, so that it is safe to say there are fifty or more thousands of needless variations in motors, which have added many millions of dollars to the investment already made in installations of electrical machinery."

A "One-Watt" Lamp

Advices from Europe report that the well-known firm of Siemens Bros. has announced that it will shortly place on the market a tungsten lamp with drawn filament whose high efficiency will be denoted by its name, "The One-Watt Lamp."

In this country it is stated that at least two concerns have, by means of patient experiment, at last contrived to produce tungsten wire that can be drawn, bent and hammered. This discovery presages a notable increase in the durability, toughness and efficiency of the tungsten lamp.

In this connection it may be explained that the greatest difficulty in making the tungsten lamps now on the market has been in getting out a strong filament. The present filaments are mostly made by mixing finely divided tungsten into a paste with a binding material. The paste is then squirted into a thread which has been heated and "sintered" until the binding material is expelled and the tungsten particles welded together. It is evident that a filament so "built up" cannot be as strong as a drawn wire, but up to this time it has been found impossible to draw tungsten wire.

The announcement that this difficulty has been overcome in several different laboratories may mean another great improvement in lighting economy, and further results will be of much significance to the vast interests involved in the production, distribution and consumption of electric light.

An English Single-Phase Electrification

By JAMES DALZIEL and JOSIAH SAYERS*

Before dealing with the results of working and of tests, it will be well to recapitulate the case set up against the single-phase motor.

It has been asserted that single-phase motors are incapable of accelerations equal to those of direct-current motors; that they require enormous flushes of current in starting; that their service capacity is not comparable with that of direct-current motors; that they necessitate more attention, require more repairs, and cost more in brush and commutator renewals; that they cannot be overloaded; that they spark inveterately at all loads; that the cost of their bearing renewals is excessive on account of their small air gaps; and that they are generally unreliable and unsuitable for traction work to such an extent as to counterbalance entirely, the advantages attainable by the use of single-phase current in the distribution and contact apparatus. It has even been asserted — presumably from a mistaken impression of the effect of the varying and, at some loads, low power factor—that a portion of the current supplied to them disappears without showing a result in actual work.

In connection with this last point, single-phase motors are frequently compared with direct-current motors on an equal voltage basis, and it has been stated that the single-phase motor, owing to its low power factor, takes on this basis more current for equal work than the direct-current motor, and must consequently heat more, be less efficient, etc.

Since from a motor built for single-phase operation a greater output can be obtained on direct current than on alternating current, it must be conceded that the alternating-current motor is inherently heavier than the direct-current. In the form in which the motors have been built hitherto for the respective currents, however, there is little or no difference in the weights per horse power, the alternating-current motors being of a lighter design. It is also true that, due to the additional iron losses resulting from the alternation of the current and flux, and also to additional copper losses, imposed by necessities of design, the single-phase motor is less efficient, as a motor pure and simple, than the direct-current motor. Comparisons on an equal voltage basis are, however, misleading, inasmuch as they give a comparison far more unfavorable to the alternating-current motor than is actually the case. Taking the same motor on alternating current and on direct current, the effect of power factor is to make the machine on equal voltage run on single phase at a lower speed than on direct current, since the effective electromotive force tending to produce rotation is less; consequently, for equal voltage, its torque and current must be greater for equal power output. The effect of power factor is clearly, therefore, a voltage and not a current one, and since the motor speed in any case is a much more practical and correct limiting factor to take than the impressed voltage, the proper course to adopt is to counteract the effect of low power factor by raising not the current and torque, but the impressed voltage, so as to bring the rotational speed to its normal figure. On this basis the single-phase motor gets fair play and shows to disadvantage only to the extent of its actual inherent additional losses.

Comparing direct-current and single-phase working of the same motor, it is true that though, for the same current, the torque on single-phase working is the same whatever the power factor may be, yet with heavy currents it is less on alternating than on direct current. This is due to the higher saturation of the field iron on the peak of the current curve reducing the effective flux to a mean which is less than what would result from a direct current equal to the root-mean-square or effective value of the alternating current. Owing to the hysteresis, there is also a slight lag of the flux behind the current, which also tends to produce a similar effect, and the effect of the commutating circulating currents on the torque is in a similar direction. This, however, obviously by no means implies that energy is being lost, as the speed clearly increases in exact proportion to the decrease of torque; while within working ranges, none of these effects materially influences the torque output of the motor so as to reduce its accelerating or other working possibilities. Granting the efficacy of forced draught, they, together with the lamination and the necessarily less saturation of the field iron, supply the only reasons for the alternating-current motor being heavier than the direct-current type.

The switching of an equal proportion of full voltage, therefore, on to similar direct-current and single-phase motors, results, in the case of the latter, in the passage of a less current. The voltage, however, only requires to be raised sufficiently for the largest permissible current to be passed through the motor, and as this current is sufficiently great to compare in its production of torque quite favorably with the currents permissibly passed through direct-current machines in similar circumstances, there is no disadvantage in this feature of the single-phase motor. The reverse is, in fact, the case, since the rise in the power factor as the current falls off increases the effective electromotive force tending to produce rotation, and so maintains the current and torque at a higher level during the acceleration on each notch. Or, put in another way, the point at which it is permissible to switch over to the next control notch is reached earlier as a result of the more sustained acceleration in the single-phase case, resulting in higher average torque and higher overall acceleration for equal maximum torque.

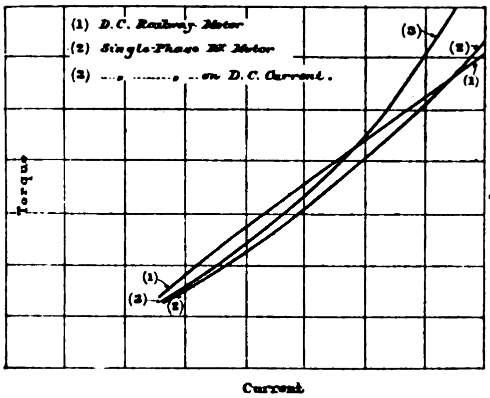


Fig. 19.—COMPARATIVE CHARACTERISTICS OF ALTERNATING SINGLE-PHASE AND DIRECT-CURRENT MOTOR.

In Fig. 19 are shown approximate current torque curves for single-phase and direct-current motors of about the same size. Curve (3) shows the increased torque of the alternating-current motor when operating on direct current, while curves (1) and (2) show that the torque of the single-phase motor rises more steeply as the current increases than in the direct-current case. This latter fact, while easing the working conditions of the motor, is on the whole a disadvantage, as it results in a greater speed decrease for a given torque increase when required, e. g., on an incline. The effect of power factor is also in the same direction, but both can be compensated for by the provision of extra high voltage tappings on the transformer, which will allow of the necessary torque increase without excessive speed reduction. In this way the necessary effect is obtained by better

*Institute Civil Engineers.

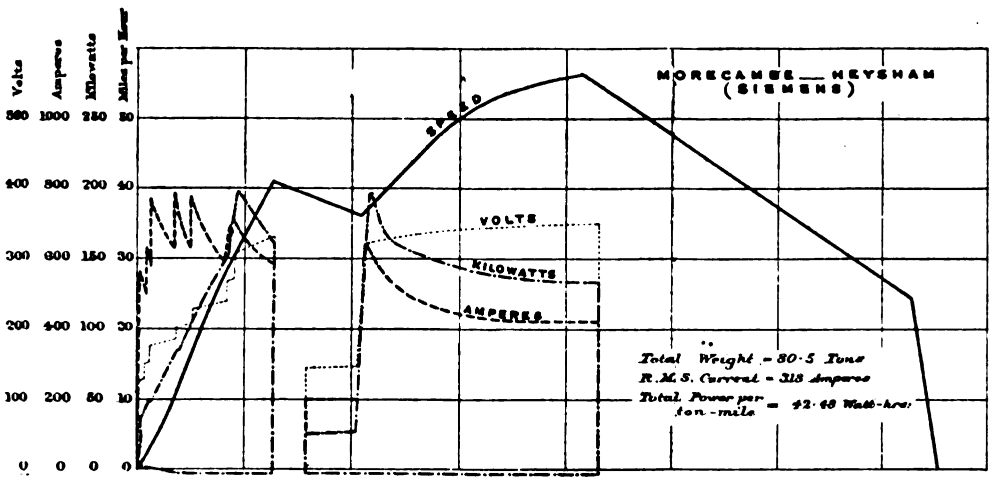


Fig. 20

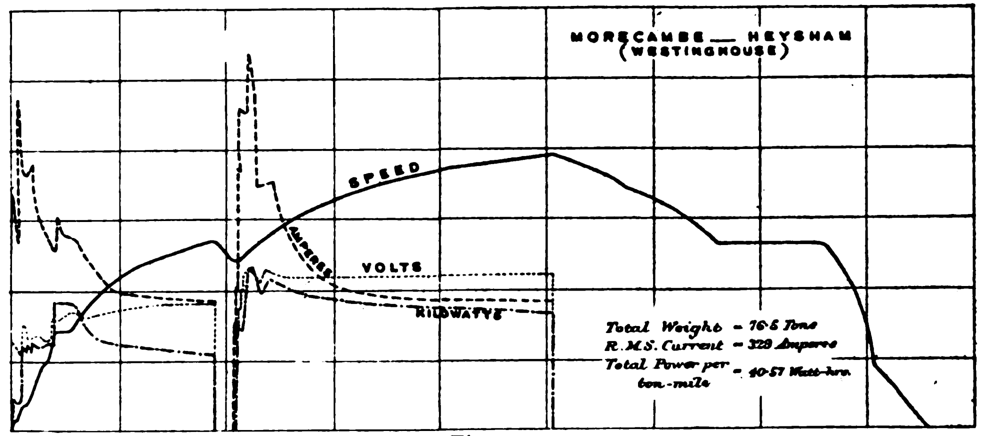


Fig. 21

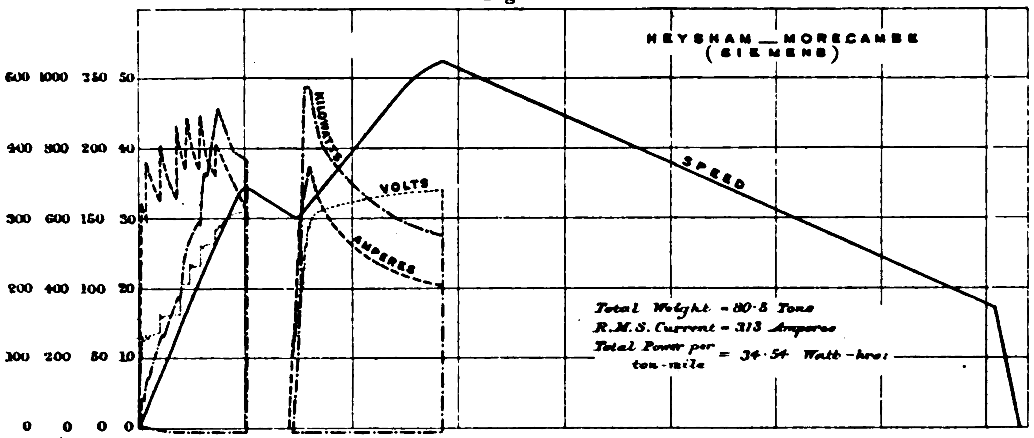


Fig. 22

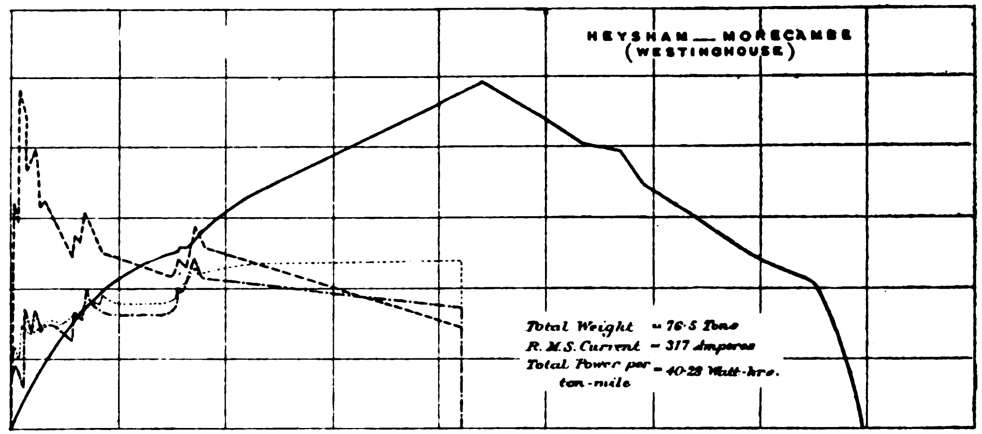


Fig. 23

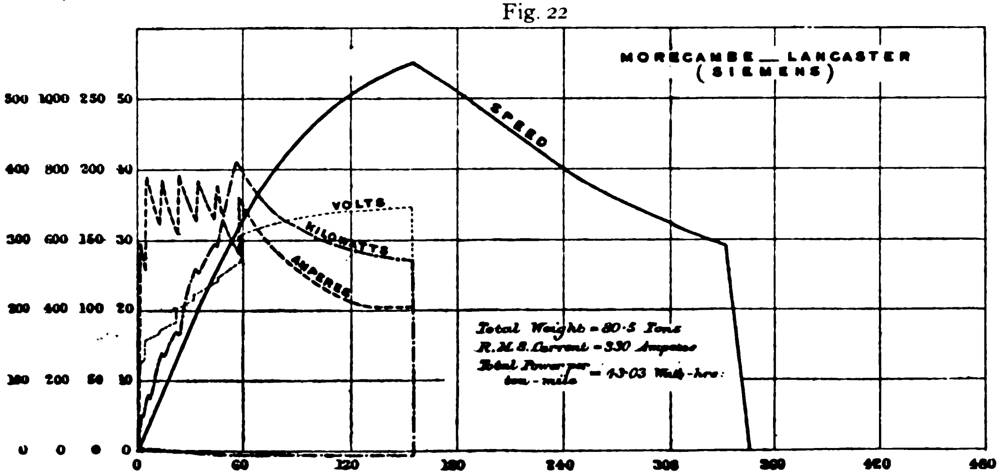


Fig. 24.—TIME IN SECONDS.

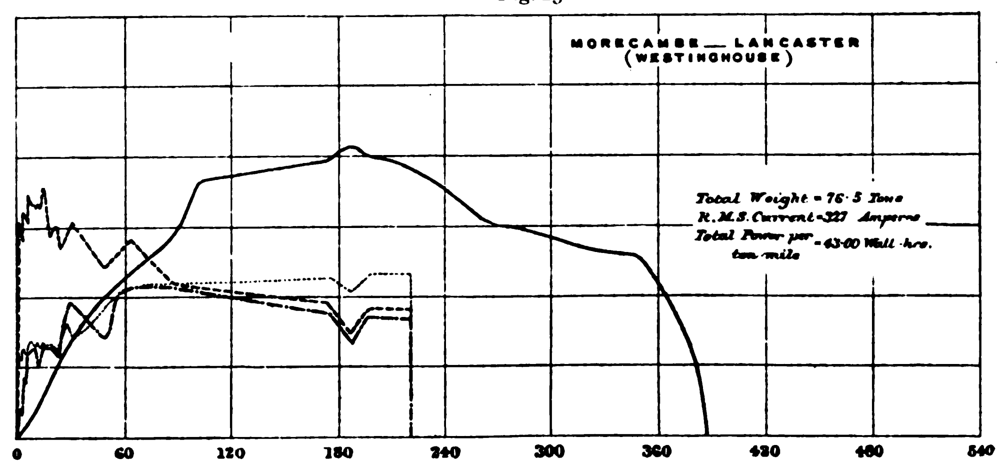


Fig. 25.—TIME IN SECONDS.

Figs. 20-25.—TRIAL RUNS WITH THREE-CAR TRAINS.

specific utilization of the material of the motor at a time when the conditions of loading permit of it, and without the torque per ampere being decreased so that there is no extra heating or losses such as take place when, in direct-current motors, the fields are shunted for similar purposes.

There is then no difficulty in getting the necessary power for acceleration into single-phase equipments, nor in obtaining from them the necessary tractive effort that should result. The contentions of the authors as to the capabilities of these equipments are borne out by the following tests, and it is noteworthy that, for the foregoing reasons, their results are uniformly better than any so far published as obtained with direct current under similar conditions.

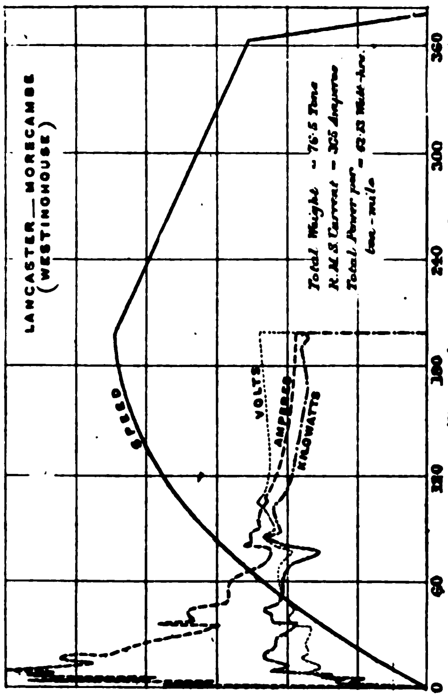


Fig. 27

ACTUAL RUNNING TESTS

These tests and curves illustrating the results are shown below. The tests deal first of all with the results obtained during the actual contact runs and during runs made with trains typical of ordinary daily traffic up to a total train weight of 190 tons.

The curves in Figs. 20–30 give the results obtained in the course of the trial runs. It will be noted that the energy-consumption comes out uniformly at a low figure.

In Figs. 31 to 36 are shown the results obtained with special test-trains made up to represent trains suitable for high-speed frequent-stop services, the second figure in each pair giving the theoretical improved result with the higher gearing. Though these tests have no actual parallel in the working of the actual traffic of the line, all the results shown are those of tests repeated many times over; in no case were the equipments worked beyond what they could actually be relied upon to do under continuous-service conditions, nor, though the test conditions were more exacting than would be the case in working these high-speed frequent-stop services, since the gear ratios were not the most suitable for such service, did the motors or any part of the equipment at any time show sign of distress.

Though the accelerations in actual traffic are much lower than those obtained under the test conditions it must be remembered that the normal electric train is much heavier than the test-trains.

As regards the remaining tests of which particulars are given, two specific services, typical of the traffic conditions wherein it has been alleged that single-phase apparatus must, owing to its inferior accelerating proper-

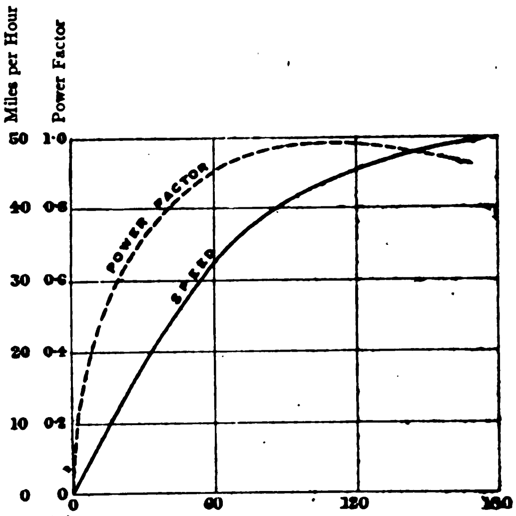


Fig. 30.—GUARANTEE RUNS—3-CAR TRAIN.

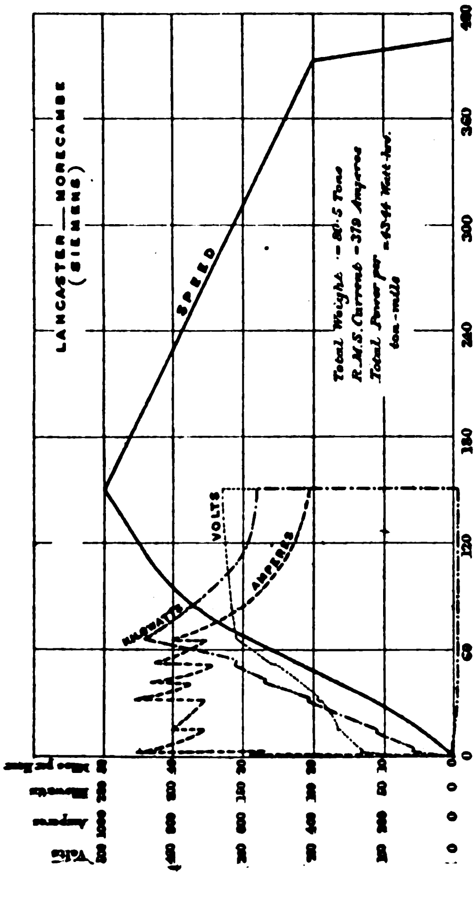


Fig. 26

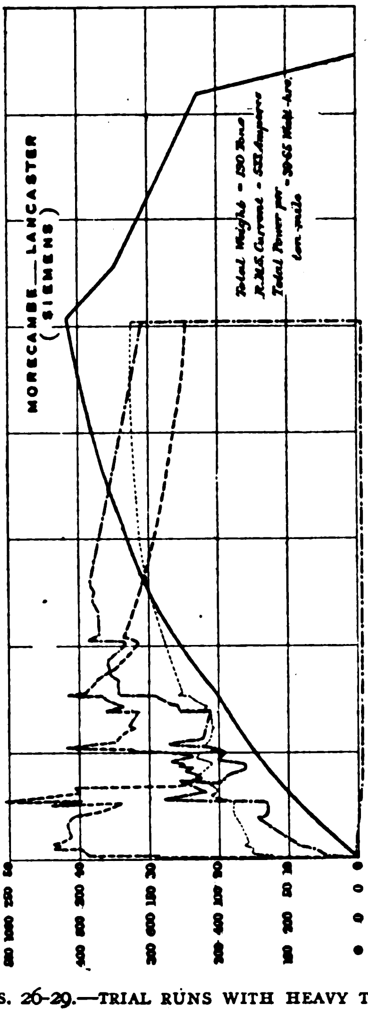


Fig. 28

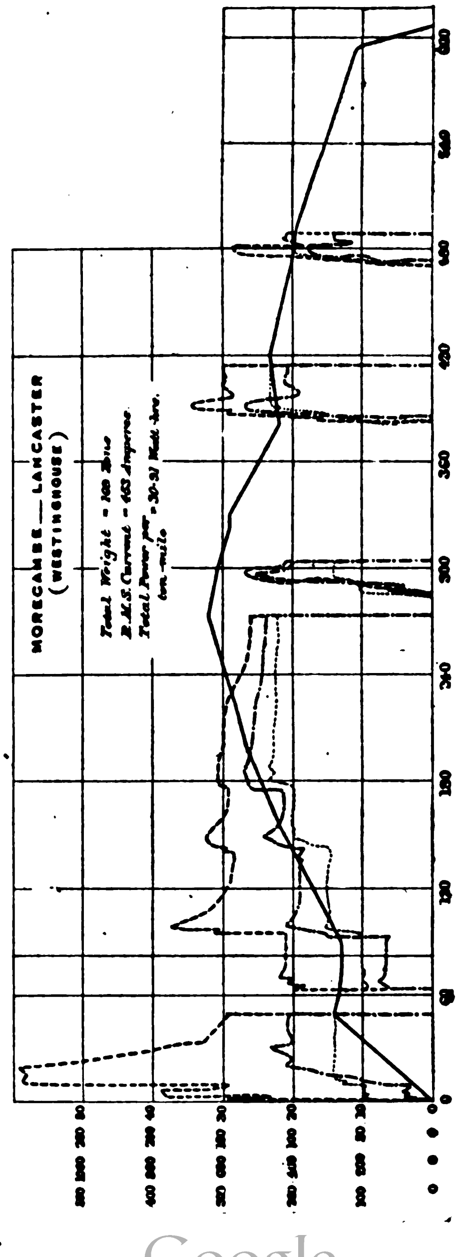


Fig. 29

Figs. 26-29.—TRIAL RUNS WITH HEAVY TRAINS.

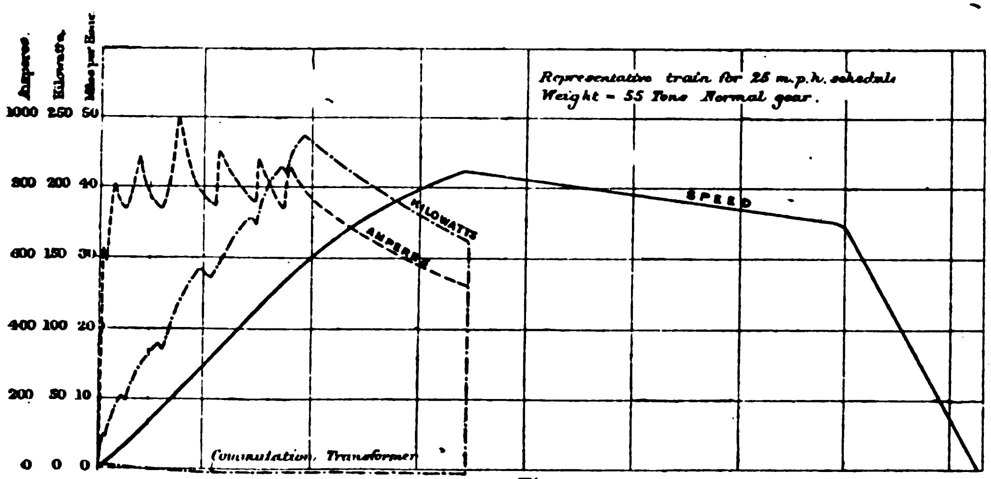


Fig. 31

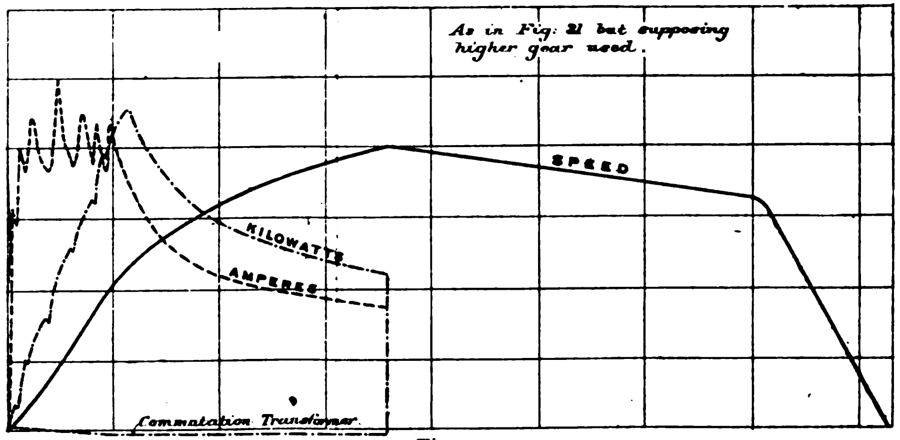


Fig. 32

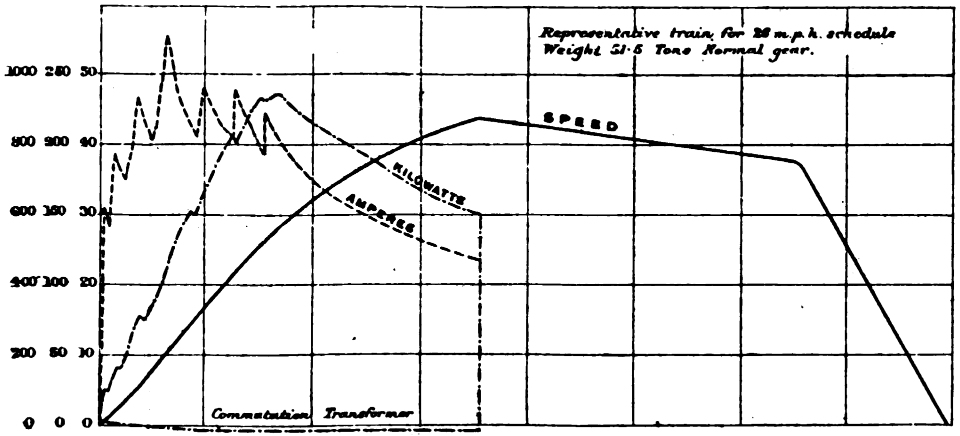


Fig. 33

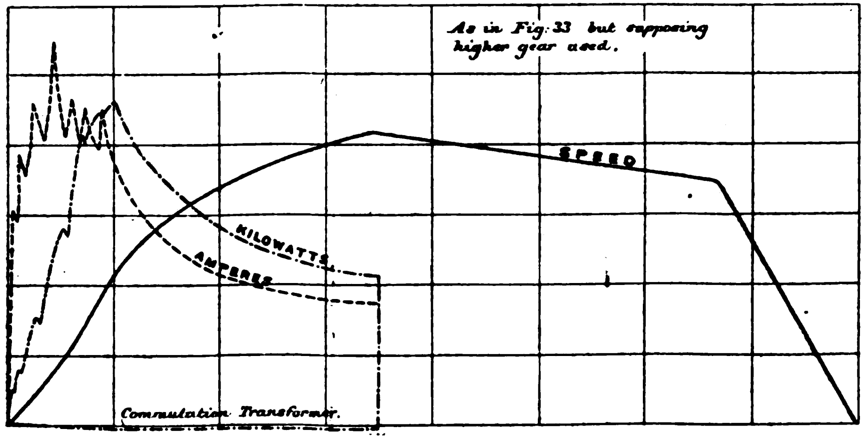


Fig. 34

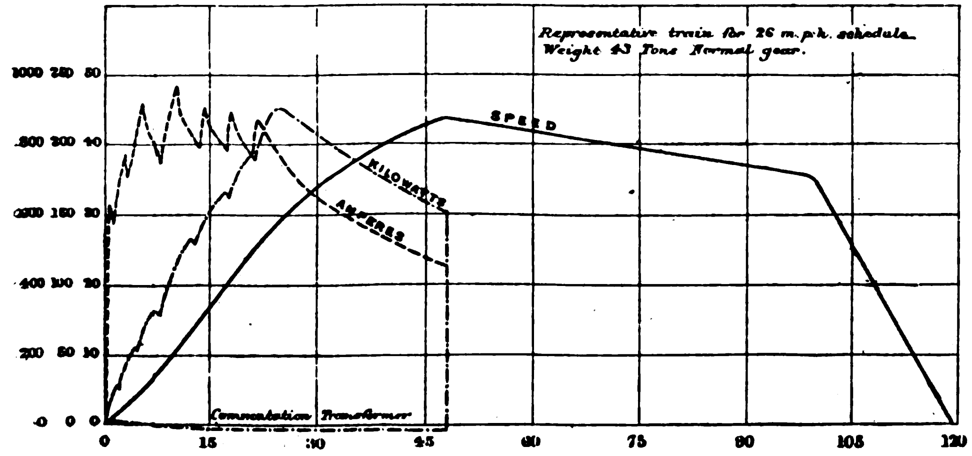


Fig. 35 TIME IN SECONDS.

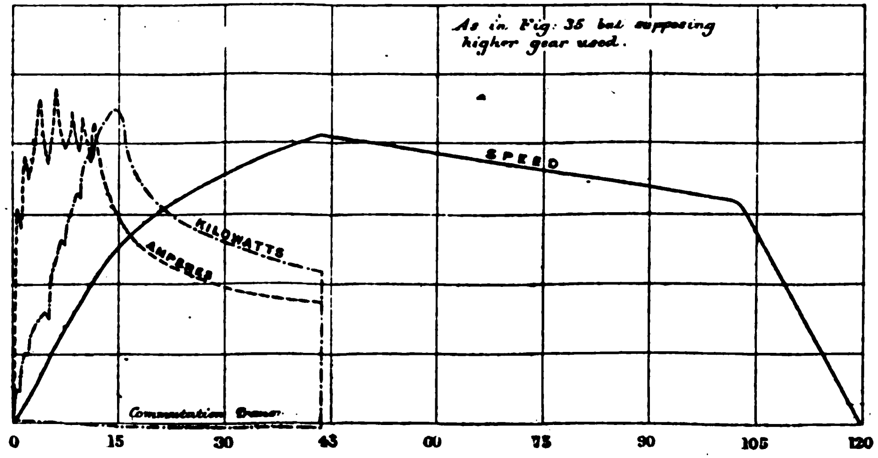


Fig. 36 TIME IN SECONDS.

Figs. 31-36.—EXPERIMENTAL RUNS—HEAVY SERVICE CONDITIONS—(SIEMENS CARS).

ties, show to great disadvantage, are: first, the working of a train seating 300 passengers on a 25 miles per hr. inclusive schedule, with a 20-sec. stop per mile—such a train as might work between Leeds and Bradford, for example—and secondly, the working of a train seating 180 passengers on a 26 miles per hr. schedule with a 20-sec. stop per mile—a train suitable for a constant flow urban traffic. These are exacting services demanding high accelerating properties on the part of the electrical equipments, whatever type be used, and for this reason and because it happens that not only could the Heysham stock be very well adapted for them, but that apparently so also could existing direct-current stock, so that direct-current figures should be easily obtainable to put against the single-phase figures quoted, the authors have selected them as typical services on which to base tests.

Neither the amount of stock nor the capacity of the power station at the author's disposal is sufficient for the making up of these typical trains in full, nor, as has been pointed out, are the equipments and stock quite suitable or so light as they would be when revised. The trailer cars in particular are shorter than would be selected for such services. Further, the gear ratios, which of course have been chosen so as to be suitable for the long runs of the ordinary service, are not the most suitable for these frequent-stop runs.

It will be seen from the speed-time curves of the actual runs that the accelerating possibilities of the motors are, in these runs, by no means fully utilized; in fact, the motors never attain nearly their highest permissible rotational speed, and most of their work is done on the lower notches, thus necessarily increasing the current and the energy consumption. Plotted against the curves of actual tests, therefore, there is in each case a curve showing a theoretical curve on the basis of the use of more suitable gear ratios.

Taking the first train, by adopting 60-ft. trailer coaches and 250-h.p. motors of a type already built, a four-coach single-phase train could be made up seating 320 passengers on a weight, without passengers, of 123 tons and 1000 h.p., against a direct-current weight on the same coaches of 114 tons. Taking the existing stock as it stands, however, three Siemens motor cars and two trailers would give a seating capacity of 324, and on the revised weights the train without and with passengers respectively would weigh 144 tons and 164 tons, on a total of 1260 h.p., *i. e.*, 8.8 h.p. per ton of train without, and 7.7 h.p. with, passengers. The direct-current train on the same coaches would weigh 134 tons, so that the single-phase weight is at most in this case 7½ per cent. greater than the direct-current train of similar capacity and capabilities.

The train for the test corresponding with this train was made up of a single car and an additional vehicle weighing, with load, a total of about 55 tons on 420 h.p., making a similar power of about 7.65 h.p. per ton of train.

TABLE I—DATA OF SPECIAL TEST TRAIN RUNS.

The principle of these tests is illustrated in the following set of calculations:—

(1) *Train for 25 miles per hour. Inclusive Schedule with one 20-seconds stop per mile.*

	Tons.	Passengers.
3 motor-cars (Heysham Siemens cars as they would be repeated)	108	216
2 trailer cars (Heysham Siemens cars as they would be repeated)	36	108
	144	320
Weight of passengers	20	
Total	164	

Total horsepower	1,260.0
Horsepower per ton of train with passengers	7.7
Horsepower per ton of train without passengers	8.8

Test Train.—Fig. 31. 55 tons, 43½-inch wheels. Gear ratio 88/30 for free-running speed of 55–60 miles per hour.

R.M.S. current = 438 amperes = 9.5 per cent. over motor capacity.

Watt-hours per ton mile (L.T.)	82.5
Main transformer C^2R (1⅓ per cent. of 82.5)	1.1
Main transformer, Iron, 3.65 Kilowatts for 124 seconds	2.3
Auxiliary transformer, 0.4 kilowatt for 124 seconds	0.25
Vacuum pump, 3.75 kilowatts for 62 seconds	1.18
Vacuum pump, 1.13 kilowatts for 62 seconds	0.35
Blower, 1.5 kilowatts for 124 seconds	0.94
Control, 0.375 kilowatt for 52 seconds	0.1
Total (H. T.)	88.72

Sustained acceleration	25 miles per hours in 25 seconds.
Maximum acceleration	1.1 mile per hour per second.

In the same train with 16 per cent. higher gearing, and using the characteristic obtained in the foregoing figure, the following results will be obtained (see Fig. 32):

Wheels 40 inches. Gear ratio 3.7 to 1.

R.M.S. current = 346 amperes = 11.0 per cent. under motor capacity.

Watt-hours per ton-mile (H.T.)	78.05 total.
Sustained acceleration	19 miles per hour in 14 seconds.
Maximum acceleration	1.55 mile per hour per second.

Results of a further test taken with the motor car alone, on this timing basis also, but loaded to 43 tons, *i. e.*, nearly 10 h.p. per ton of train, are also shown. The results obtained prove this exacting service to be well within the timing capacity of the motors, while, even with the existing gear and with only 10 h.p. per ton of train, it is almost within their service capacity, while with a suitable gear ratio it is within their capacity even with the lower horse power.

TABLE II—DATA OF SPECIAL TEST TRAIN RUNS.

(2) *Train for 26 miles per hour. Inclusive Schedule with one 20-seconds stop per mile.*

	Tons.	Passengers.
2 motors (Heysham Siemens cars as they would be repeated)	72	146
1 trailer-car	18	54
	90	108
Weight of 198 passengers	12.5	
Total	102.5	

Total horsepower	840
Horsepower per ton of train with passengers	8.2
Horsepower per ton of train without passengers	9.33

Test Train.—Fig 33. 51.5 tons. HP. = 420. HP. per ton = 8.15. Wheels 43½ inches. Gear ratio 88/30 for free-running speed of 55–60 miles per hour.

R.M.S. current = 445 = 11.0 per cent. over motor capacity.

Watt-hours per ton-mile (H.T.)	99.30
Sustained acceleration	25 miles per hour in 22 seconds.
Maximum acceleration	1.3 mile per hour per second.

With a higher gearing as before the result shown in Fig. 34, and indicated as follows, would be obtained:

Wheels 40 inches and gear ratio 3.7 to 1.

R.M.S. current = 360 = 10.0 per cent. under motor capacity.

Watt-hours per ton-mile (H.T.)	83.83
Sustained acceleration	19 miles per hour in 13 seconds.
Maximum acceleration	1.8 mile per hour per second.

With regard to the 26 miles per hr. schedule, in a communication to a technical journal 12 h.p. per ton of train without passengers, making 10.5 h.p. with passengers, was suggested for this train as the equipment capacity, and for direct-current working a total of 1000 h.p., and a three-car train weight, without passengers, of 84 tons. The single-phase train was estimated to weigh 150 tons and to require a total of 1800 h.p. This train could, however, be composed of two motor cars and one trailer of the stock herein described, giving a seating capacity of 200 passengers. On this basis it would weigh 82.5 tons with 800 h.p., or 86.5 tons with 1000 h.p. direct current, and with 840-h.p. single-phase current 99 tons with the stock as now existing, or, under the revised weights, 90 tons. This last is equal to a total weight, with passengers, of 103 tons, and 9.3 h.p. per ton of train without, and 8.15 h.p. with, 200 passengers.

With 1000 h.p. in four single-phase motors the weight of this train would be about 97 tons, or, built for 180 seats, with 45-ft. coaches, about 92 tons.

As before, new curves with a more

suitable gear ratio are plotted against those obtained. The results shown are of a test with a two-vehicle train of 420 h.p. and weighing 51.5 tons.

The results show that on the present gear ratio the service is within the timing capacity of the single-phase motors, but puts on them a demand exceeding their continuous service capacity. With a suitable gear ratio, however, not only is the service within their capabilities, both as regards timing and service capacity, but the watt-hour consumption is such as to compare favorably with that obtained with direct-current equipments — a result which is no doubt largely due to the elimination of rheostatic losses.

looked that these tests have, as stated, been in several cases made with less motor horse power per ton than has been installed for direct-current working, and with a higher installed horse power still better results would be shown, though, of course, against increased equipment weights.

The tests have all been carried out on a forced-draught service-capacity basis, but forced draught on the Heysham stock has necessitated no appreciable complication by its installation.

It should also be mentioned that no trouble was given by any portion of the equipments during any of the tests, there being no commutation difficulties

TABLE III—DATA OF SPECIAL TEST TRAIN RUNS.

(3) *Train for same Schedule as last but lighter.*

Test Train.—Fig. 35. 43 tons. 26 miles per hour schedule. Wheels 43½ inches. Gear ratio 88/30 for free-running speed of 55–60 miles per hour.

R.M.S. current = 414 = 3.5 per cent. over motor capacity.	
Watt-hours per ton-mile (H.T.)	100.76
Sustained acceleration	25 miles per hour in 21 seconds.
Maximum acceleration	1.4 mile per hour per second.

The same train with higher gearing would give the following result as indicated in Fig. 36.

Wheels 40 inches and gear-ratio 3.7 to 1.	
R. M. S. current = 318 = 20.5 per cent. under motor capacity.	
Watt-hours per ton-mile (H.T.)	81.23
Sustained acceleration	19 miles per hour in 10.5 seconds.
Maximum acceleration	2 miles per hour per second.

Very considerable reductions in consumption would be obtained with longer trains. Mr. Aspinall's experiments would indicate these as about 40 per cent. 25 per cent. and 27 per cent. respectively.

Energy consumptions of only 88.7, 99.3 and 100.76 watt-hr. per ton-mile were obtained, as against figures with direct-current equipments which would be in the region of 110 watt-hr.

The accelerations obtained were as follows: Sustained accelerations giving 25 miles per hr. in 25, 22 and 21 sec., or 1.0, 1.14 and 1.19 mile per hr. in a second were given by the 7.7, the 8.15 and the 10 h.p per ton trains respectively, which would with better gear ratios be improved to 19 miles per hr. in 14, 13 and 10.5 sec., or 1.36, 1.46 and 1.81 mile per hr. in a second. The maximum attained accelerations were 1.1, 1.3 and 1.4 mile per hr. in a second, improvable to 1.55, 1.8 and 2.0.

The new gear ratios taken are for the highest gear ratio and smallest wheel available, namely, 3.7 to 1, and a 40-in. wheel.

The results of these tests clearly establish: (1) the watt-hour economy of single-phase equipments in high-schedule speed service, a result quite contrary to frequently expressed opinions based apparently on inadequate data; (2) that the accelerating possibilities of single-phase motors are in no way less than those of direct-current motors; (3) that single-phase trains in high-schedule speed service need not be seriously heavier than direct-current trains; and, therefore, that (4) single-phase working is perfectly applicable to and suitable for such services. Nor must it be over-

whatever; in fact, there has never been a case of flashing over on the commutators of any of these motors, and the equipments could be worked continuously on such services without trouble of any kind. The fact should also be noted that the tests have been made with very short trains. Very considerably better results would be shown with longer trains of similar horse power per ton.

Besides the curves and particulars of the tests to which reference has been made, some figures of working costs and also of transmission efficiency have been determined as follows:

TABLE IV—WORKING COSTS.

Working Costs.—The total electric traffic mileage for the year ending June 30, 1909, was 85,662 miles.

Running costs are as follows:—	
Drivers' Wages	1.12*d*. per train-mile
Drivers' Wages during the three summer months	0.96*d*. " "
Stores, repairs, cleaning and similar shed charges	1.54*d*. " "

Drivers' wages in the slack months per train-mile are enhanced by the low daily mileage run.

TABLE V—IMPEDANCE OF CIRCUIT.

Impedance of Overhead Line and Rail.—Tests gave the following results at 25 cycles:—

Impedance of Overhead Line and Rail.—Tests gave the following results at 25 cycles:—

Impedance of one trolley-wire and catenary	0.5 volt drop per ampere per mile.
Impedance of one rail (bonded)	0.37 " " " " " "

The current-consumption totals 3.6 units per train-mile on the alternating-current switchboard, debiting the whole of the current-consumption to traffic-mileage only, and making no allowance for leakage-current, for shunting-mileage, or light or inspection-current consumption. The coal consumption is about 20½ pounds per train-mile against the 34½ pounds per train-mile used by steam-locomotives, and 27 pounds by steam motor-coach trains working the same service, but were the alternating current generated directly the coal-consumption would be only 14 pounds per train-mile. Shunting-mileage amounts to about 5 per cent. on the total mileage, there being a good deal of shunting of vans, etc., also some goods-traffic shunting at Morecambe and Heysham. At Morecambe, where the platforms and sidings are very long, there is a considerable amount of running round in making up trains, etc., while at Lancaster, where there is no direct cross-over, there is nearly one-half mile of running for crossing over.

The average weight of train excluding passengers is about 65 tons; thus the gear watt-hours per ton-mile work out at 55.

Ths transmiseion efficiency is difficult to ascertain but appears to be about 97 per cent., bus-bars to bow.

The leakage from the overhead line amounts to 0.5 to 1 kilowatt in dry weather; this rises in wet weather to as much as 20 kilowatts for a short time after switching on, while leaks of about 10 kilowatts lasting ½ to 1 hour have been recorded. The average leakage appears to be about 1.5 to 2 kilowatts or 0.092 unit per hour per mile of single track. This leakage, which in a future case will probably be reduced, on the small mileage appreciably affects the consumption as measured at the switchboard, representing 0.13 unit per train-mile.

Thus the consumption at the car-collectors, eliminatingo hmic losses and leakage in the line and adding the shunting-mileage, amounts to 3.2 units per train-mile, or 50 watt-hours per ton-mile.

The tests mentioned above have been made with a recording instrument of a novel type. It was designed to obtain readings which could be referred with certainty to each other as simultaneously obtained. There were difficulties in adapting ordinary recording instruments to the conditions. It was finally resolved to fit mirrors on the needles of ordinary instruments, the mirrors reflecting the vertical image of a straight filament glow-lamp on to a narrow horizontal slot, beneath which travels a sheet of sensitized photographic paper. The instrument pointers move horizontally, reflecting the image of the glow-lamp filament similarly. The records of the readings of four instruments are thus obtained, namely, voltmeter, ammeter, wattmeter, and a voltage speed indicator.

On the paper are also recorded, by pencil, readings of wheel revolutions alternatively by one and 20 revolutions, and also constantly by five revolutions, and the paper is also marked by a clock contact at 2-sec. intervals. These curves require replotting, as the scales are unfortunately not uniform, but accurate results are obtained, and all the figures given herein are based on readings obtained from this instrument, except that an integrating watt-meter is used in conjunction with it, this wattmeter reading thehigh-tension watts when the recording instrument is reading th elow-tension figures, and vice versa. The two sets of readings checked out very closely.

The paper is driven by a small motor actuated by a secondary battery. It was originally a synchronous motor driven from the alternating supply, but this method had to be discontinued owing to the inconvenience caused by the stoppage of the motor if the bow ceased to make contact on the wire for any short interval.

MAINTENANCE.

The following data relates to the performance of the electrical equipments in service, the amount of maintenance required and the wear, etc., on wearing parts, the occurrence of breakdowns and their causes, the steps taken to avoid their repetition:

Commutators, Main Motors.—Two Siemens commutators have been turned up owing to damage from motor failure. Ordinary wear in the Siemens motors has amounted to only 0.02 inch radial, and on the Westinghouse motors to 0.03 inch radial. Both types of commutator only require cleaning occasionally.

Wheel-Tires.—These will be conveniently turned up once a year previous to the commencement of the summer working after running about 30,000 miles. Apparently they could continue in service for about a further 15,000 miles.

Attention Required.—The repair- and cleaning-costs per mile tend to be somewhat raised in comparison with more heavily worked electric lines by the small number of cars, the low mileage, and the fact of there being no shed facilities. It is, of course, impossible to have less than one man on the work; and a portion of the drivers' time during the slack winter months is occupied in doing small repairs, cleaning tc.

ALTERATIONS AND ADDITIONS TO CAR EQUIPMENTS

Siemens Equipments

Bows. It was found that, when the bows were exactly balanced by the wind vanes, the leading bow which pointed into the wire tended, when the car was running fast, to thrust the wire upwards and strike the pull-offs. The leverages were altered so that the wind-vane overbalanced the bow to a slight extent, and consequently the leading bow tended to come down slightly, while the trailing bow was kept in better contact with the wire.

Ball-bearings were fitted to the main shaft in order to make the bow follow up the wire better. The range of pressure was by this means reduced to 9 pounds upwards and 11 pounds downwards.

Main High-tension Cable through the Car.—The lead-covered rubber cable originally in use has been replaced by the arrangement described on page 23. The several breakdowns of the high-tension cable, though possibly attributable to surges caused by the switching on and off of the main transformer, certainly appear to indicate the use of cable as untrustworthy and requiring somewhat elaborate precautions in installation to obviate ozone effects and dangers of breakdown from even slight crushing of insulation, while cable does not lend itself to any rapid or temporary repairs. Bare wire on insulators is not only less liable to breakdown but lends itself to quick replacement, and with the arrangement now used the only portion of the wiring embodying cable can, by stocking a complete spare tube for passing down through the coach, be replaced in one-half hour. This would be particularly suitable for future cars in which there would be no auxiliary transformer, so that the high-tension wiring under the coach would be a minimum, particularly in any case where the main circuit-breaker was on the low-tension side, when the main high-tension cable would come straight down to the main transformer.

Switching of Main Transformer.—The breakdown of the insulation between the windings of the main transformer, and to some extent also the failure of the high-tension cable appeared to indicate that some surge effect was being caused by the frequent switching on and off of the main transformer, particularly in view of the immunity from such breakdown of the Westinghouse car which did not embody this arrangement. The Siemens cars were therefore altered to leave the main transformer excited continuously during running.

Overload Cut-out.—This was originally of the hot-wire type but it was found to be unsuitable, particularly owing to the long time it took to reset itself. It is now replaced by a magnet-operated type adjustable by means of a tension-spring, an arrangement which appears to be quite suitable.

Driving Motors.—The original lubricating arrangement consisted of a pump driven by the motor-pinion and raising oil into supply-tanks, from which it siphoned through pipes to the bearings. This circulating system was not satisfactory. The pump was removed and the siphons enlarged. All oil-taps were also removed. This is still not altogether satisfactory, and pad lubrication is being fitted as in the Westinghouse car.

The main cables to the motors terminated originally in large cone-shaped plugs having three contacts each, which were held in a socket by means of a screw and crosshead. These were found to heat through the contact being unsatisfactory and were removed entirely, the motors being now coupled to the terminal boxes on the car-frame by flexible leads fixed to the motor.

Brush Gear.—The connections between the brush-holders now consist of bent copper rod instead of the solid cast rings originally in use. This arrangement has fewer small parts, is lighter, more accessible and easier to dismantle, and gives more room round the commutator and more clearance from the motor-frame.

Ventilation.—The guide-vanes inside the Siemens motor-cases have been removed, and the air is simply blown in and allowed to find its own distribution. It is found that the ventilation is thereby much improved, the guide-vanes thus proving to be one of those refinements more serviceable on paper than on the motor.

Jumpers and Control Plugs.—The material of which these were made was found to be too soft, and trouble was experienced through the jumpers not making proper contact in their sockets. Contacts of harder material have been fitted, making the jumpers quite satisfactory.

Westinghouse Motors and Equipment.

No alterations, except that to the high-tension cable through the car, have been necessary.

RECORD OF BREAKDOWNS AND FAILURES

The following notes refer to the breakdowns and car-failures tabulated on page 100.

The mileage lost during the 15 months period to September 30th, through electrical defects of any kind whatever due to power-house, line or cars, amounted to 212 miles, and the cars have made 99.63 per cent. of the total mileage they were called upon to do. The results, as a whole, the Authors consider to be very satisfactory, considering that these were not only the first electric cars belonging to the Midland Company, but were the first cars of a system of electric working new to this country, as well as being among the first put in work by the respective contractors.

Cars and Motors.—There have also been a few minor stoppages and defects due to bad jumper contacts and loose connections in the control wiring, and one case of the motor suspension-spring breaking. The majority of the breakdowns of Siemens motors have been due to lack of sufficient surface insulation between the stator and windings. The armature defects have, as stated, been due to the commutator, there being a gap between the quill and the clamping ring, up which carbon dust worked to the inside of the segments. Some metal (borings) was also found inside the commutator and may have been a contributory cause.

On January 19, 1909, one of the Westinghouse armatures went to "earth," the fault having the appearance of being caused by some foreign material having got in between the windings and the supporting end drum, and having been driven in with sufficient force to break through the insulating material on the end drum. As this insulation consisted of thick micanite the conclusion that mechanical damage initiated the breakdown seems unavoidable. The binder at the end concerned was burst, and this may either have caused the damage or may merely have resulted from it.

The motor took current on several trips after the development of the failure, and the car took a train of 165 tons on one motor.

The cars normally in service from July 1st onwards were two, leaving one car spare. All three cars, however, are required and are used in service simultaneously during Bank Holiday periods and for some hours of the busier days of July and August. From April 13 till July 1, 1908, only one car was in service except during Easter and Whitsuntide, during the latter of which periods there was running to Lancaster. During the months from January 1st till Easter there is no spare motor-coach, as the carriages are then taken in turn into the carriage shops for the annual inspection and repairs.

Power-Station.—The power-station breakdowns and alterations are included in the above, where they caused delay, but this was never of long duration, as each of the alternators is sufficient for the whole service.

Three electrical breakdowns of the alternators have taken place. The first, which occurred on May 14, 1908, resulted in earthing and locally burning out part of the stator end winding. This was found to be due to mechanical damage of the insulation, breakage of some of the clamping fingers on the stator core end plate allowing the tooth disks to vibrate and chafe it. These fingers were constructed of malleable iron riveted to the last plate of the stator core, and while this construction appears to have been good enough for a large number of machines working under comparatively steady loads, it turned out to be insufficient for machines operating on such a very "peaky" load as obtained at Heysham. New clamping fingers of a much heavier and different type were fitted. These were fixed in the following manner: The clamping ring bolts were eased back equally all round, and the fingers, after being wedged into position, were drilled and fastened to the clamping ring with radial set screws, after which the whole was drawn up tight with he clamping bolts so as to insure an absolutely tight fit. The direct-current armatures of these machines have now been fitted with similar fingers, as they showed signs of failing in the same way as the stators.

The second breakdown occurred on August 12, 1908, and was brought about by insufficient clearance between the end guard and the stator end winding. Flashing over took place and two windings were broken down. More clearance was secured by packing out the guards with washers. No further similar trouble has been experienced.

The third breakdown (June 26, 1909), occurred during a violent storm with lightning. The stator-

TABLE VI—MAINTENANCE OF EQUIPMENTS. LIFE OF WEARING PARTS.

The following particulars cover a period of 15 months, from July 1, 1908, to September 30, 1909, during which the service was in full operation.

Name of Part	Number in Use per Car	Total Renewals during Period	Total Mileage run	Average Mileage between Renewals per Set	Best Mileage between Renewals per Set	Remarks
Siemens Equipments.						
		Two cars	Two cars Miles	Miles	Miles	
Bow collector wearing strips (aluminum)....	2	14	71,459	10,200	11,000	Experiments with materials of varying hardness were made during this period, otherwise the mileage would have been higher.
Main motor brushes............	64	179	71,459	25,000	..	Over 100 of these brushes were renewed, due to breakage brought about by unsuitable attachment of shunts. Since fitting new brush-gear without shunts, in June, 1909, no breakages have occurred. Allowing for wear of the broken brushes the average life comes out at 47,000 miles. Since fitting brushes without shunts one set has run 6,400 miles and the wear has been only 1/16 inch, which gives a life of 100,000 miles.
Main motor-bearings (armature).	..	..	..	..	..	The lubrication of these bearings has not so far been satisfactory, and several renewals have been made owing to hot bearings. Of the others one set of bearings on car 2,237 ran 10,000 miles before renewal was necessary.
Contactor contacts	56	5	71,459	..	..	
Westinghouse Equipment						
	One car	One car	One car			
Bow collector wearing strips (galvanized iron)..........	1	6	39,066	6,511	9,417	The low average life is due to three of the strips being very soft. Those now in use are harder.
Main motor-brushes............	48	195	39,066	9,020	..	A large number of these were broken at first, due to brush-pressure being too great and brushes being of poor quality. Allowing for wear of the broken brushes the average life comes out at about 20,000 miles.
Main motor-bearing (armature)	..	..	..	..	..	One set of bearings ran 19,000 miles before renewal was necessary.
Contactor contacts	16	4	39,066			

winding was broken down in two places, due apparently to the lightning striking back, as the arrester had not acted.

The following minor troubles have been experienced in connection with the running of these machines. The wooden armature wedges gave trouble by becoming slack after the machines had been running a short time. This was considered to be due to displacement caused by the warming of the coils; new wedges hollowed out to allow for this were fitted, and these have remained quite tight.

As indicated in the record of breakdowns, the ball-bearings have heated on several occasions, due apparently to the conduction of heat from the machines along the shaft, causing expansion and jamming of the bearings. The balls had very little clearance in the races. This trouble was overcome by increasing the clearance in the ball-race so as to be suitable for the conditions of working of the machines, the increased clearance having no detrimental effect on the running of the bearings.

Bows.—Four cases of the bows coming off the wire have occurred, all during preliminary trial runs while the line was in course of erection.

(1) *February* 2, 1908.—Bow came off wiring at center of span during trial run. Speed 62 miles per hour. Bow in highest position, contact wire out at farthest point, line curved.

In this case the overhead wire dropped on to the car where it was "earthed" by the netting quietly and completely. Investigation showed that the stagger, which was then 4 feet, should be reduced to 3 feet, and pull-offs fixed at all poles.

(2) *February* 13, 1908.—This was due to a steam-engine pulling the car for maintenance purposes going on to the wrong road. The bow thereby left the wiring, sprang up between the two roads, and fouled the adjacent road. The wiring was damaged but no other harm was done.

This case incidently proved the strength of the fittings, etc., as, although the steel and copper cables and fittings were cut across by the car, nothing broke.

(3) *February* 22, 1908.—At the cross-over at Torrisholme No. 2, during trials in a very heavy wet gale. Bow came off the wire at the cross-over roads through which the car was passing. No damage was done in this case, but alterations in the design of the links between the different contact-wires were carried out.

(4) *March* 22, 1908.—Gantry No. 129, near Middleton Road Station, down road. Heavy gale blowing broadside on the wiring. Bows left the wire at extreme side position, at a point where, unfortunately no pull-off had been fixed. These were in course of erection but had not been put up at this place.

The car was coming out of the curve into the straight and therefore would have a maximum amount of roll.

Insulators.—In all the cases of insulator failure the insulator was punctured through from the ring to the bolt, and it occurred after a period of low temperature followed by wet.

They all occurred on the section of line which had been longest erected, and other circumstances have clearly proved that the failures were due to the cement fastening the cap to the main insulator, which had in all cases disappeared to a considerable extent from weathering.

The authors find from the makers that this cement consists of litharge and glycerine, and for various reasons it is unfortunate that it was used for such a purpose.

TABLE VII—RECORD OF BREAKDOWNS.

Failure Occurred in	No. of Failures	Cause	Secondary Result	Train Delay	Mileage Lost	Remarks
Failure Occurred in	No. of Failures	Cause	Secondary Result	Train Delay	Mileage Lost	Remarks
				Minutes		
High-tension cable on cars.........	5	Four cases (Siemens) due to sharp bends. One (Westinghouse) due to moisture penetrating taping...............	In one case adjacent low-tension cables were burnt.......	64	5	
Main transformers (Siemens)......	2	One case of short between high- and low-tension windings. One case due to transformer being only partly filled with oil.............	Motor field "earthed"	..	..	There was no delay, as in one case the car was standing at the platform and in the other was running light.
Driving - motors, electrical faults.	7	Four cases (Siemens) due to lack of surface insulation on stator causing short circuit. Two cases (Siemens) recently due to faulty commutator construction allowing carbon dust to work inside and causing short circuit. One case (Westinghouse) earthed armature.....	....	41	..	In most cases the cars were able to come in on one motor.
Driving - motors, hot bearings, (Siemens)......	3	Two cases were due to breakage of oil-pipe to bearing..............	In one case the armature came down on the poles and damage resulted to it, and stator before stoppage...	58	108	The large figure for mileage lost is due to the spare car having been at Derby for annual overhaul. There have been other hot-bearing cases (Siemens), but none causing delay.
Contactors.......	2	One coil "earthed" (Westinghouse) and one broken interlock (Siemens)............	Auxiliary high-tension fuse blown...	27	5	Delay occurred in obtaining new fuse.
Car-arrester (Westinghouse..	1	Faulty insulator........	High-tension terminal "earthed"....	92	10	Car had to be brought in by steam-locomotive.
Bows and gear (Siemens)......	2	Hand-pump leaky....... Stretching screw broke..	Driver unable to raise bows............. Bow-gear earthed to roof...............	64	10	
Overhead line....	12	Nearly all due to bad cement in insulators. One broken pull - off rod. Two line switches failed...............	Line earthed.......	192	182	One of the line switch failures was due to surface leakage over the insulators which remained undamaged.
Power-station....	8	Three failures of alternator stator - windings. Two hot bearings. One repairs to machinery. One station - arrester damaged. One frozen water-pipe...........	Service interrupted and in one case suspended for some time.......	31	73	In most cases the second alternator was available and only a short delay occurred in changing over.
Mismanagement..	9	Leaving in switches. Late start at station. One case of running off the road, etc..............	....	95	13	
			Total...........	664	406	

Percentage of mileage lost = 0.37 per cent.

SUMMARY OF CAR FAILURES.

	Number of Failures	Train Delays	Lost Mileage	Remarks
		Minutes	Miles	
Siemens cars..................	18	220	123	
Westinghouse car.............	3	114	15	92 minutes' delay caused by one failure, when lightning arrester broke and went to earth.
Total................	21	334	138	

While it will be observed that the usual breakdowns inherent to a new installation have taken place, in neither type of equipment have these been excessive for the first 12 months of working. In only two cases, namely, the transformer failures, has the fundamentally single - phase apparatus been involved. The motor failures on the Siemens cars have resulted from causes rather of construction than of design or type, and a large proportion of the failures on these cars have resulted more from troubles of bearing lubrication following the failure of the rather elaborate original method than from electrical causes. It is fair to state that technically the Siemens equipments are of a very high order of merit, and the minor defects that have shown themselves on these equipments of new designs are being rapidly eliminated. Their higher power is the reason why most of the tests shown have been made with them.

The record of the Westinghouse equipment may be left to speak for itself in respect to the eminently practical nature of its design and construction, and to the results that are to be expected from single-phase apparatus of tried and standardized design.

None of the particular points of weakness attributed to single-phase apparatus has shown itself; commutation is as good as with direct current, and the life of commutators and brushes is better. Apparently such sparking as takes place is less destructive than with direct current, possibly on account of the current alternation, and there is no flashing over. Similarly the wear of the contactor sparking tips is very small. Neither type of control gear has given any trouble whatever.

Experience with the contact wire is equally satisfactory. After being erected for nearly two years, and being in actual use for fully 18 months, tests with a micrometer show not the slightest signs of wear, and the collection of current is sparkless.

In conclusion, the authors wish to acknowledge their indebtedness to Messrs. Deeley and Worthington, without whose kind assistance this paper could not have been written; and they also desire to thank the members of their respective staffs who assisted them in making the tests and in preparing the information given, namely, Messrs. Holt, Harradine, Spendlove and Aldred, as regards the overhead equipment, and Messrs. Conradi, Brooks, Hornbuckle and Porter, as regards the rolling stock and power station. Thanks are also due to Mr. R. W. Yardley, District Locomotive Superintendent, who has charge of the working of the electric trains.

Cylinder Oil Consumption of Steam and Gas Engines

In a paper presented at a recent meeting of the Pfalz-Saarbrück local section of the Society of German Engineers, and published in a recent issue of *Zeitschrift des Vereines deutscher Ingenieure,* Herr L. Weiss gave an extended account of an investigation on this subject, made by him during the years 1903-1908. Some brief particulars of the engines tested and the main conclusions of the author are given herewith.

At the beginning of the investigation, the oil consumption was found to be inordinately high. By means of a premium system, however, the author succeeded in interesting the attendants to such an extent that in the last year the consumption was reduced 50 per cent.

As a result of his observations, the author concludes that:

1. The cylinder-oil consumption of a compound steam engine is a function of the diameter of the high-pressure cylinder and the number of revolutions per minute. It is not necessary to provide any additional amount of oil for lubricating the low-pressure cylinder. A single-cylinder engine requires the same amount of oil as a compound engine having a high-pressure cylinder of equal diameter.

2. The hourly cylinder-oil consumption of a compound engine with a high-pressure cylinder 1 meter in diameter and running at 100 rev. per min is 0.2 kg. = 0.441 lb. = 0.455 pint, taking specific gravity of oil = 0.93. (For any diameter *D,* in inches, and rev. per min. *N,* cylinder-oil consumption per hour in pints = 0.0001155 *DN.*) For triple-expansion engines the diameter used in calculating should be equal to one-half the sum of the high-pressure and intermediate cylinder diameters.

3. A cheaper oil can be used for piston rod lubrication. With a piston speed of 1 meter per sec., and where the sum of the internal diameters of all the piston-rod glands equals 1 meter, the hourly consumption of oil is 0.054 kg. = 0.119 lb. = 0.1228 pint. (For any piston speed, *S,* in feet per second, and sum of internal gland diameters, *d,* in inches, oil consumption per hour = 0.00095*Sd.*) This also holds good for gas and oil engines with internally cooled piston rods, and for blowing engines.

4. The consumption of cylinder oil in 4-cycle gas engines is about 50 per cent. higher than in steam engines of the same dimensions and speeds. The author has observed but two engines of this type, however. A two-stage intercooled air compressor for supplying air at 85 lb. pressure was found to require only half the oil needed for a steam engine of the same dimensions and speed.

A contribution on this subject, by J. H. Spoor, appeared in *Power* January 4, 1910, in which, as an illustrative example, he calculates by means of diagrams the 10-hr. oil consumption of a compound engine having 26-in. and 42-in. cylinders and a stroke of 40 ins. This he finds to be 4.9 pints (2.5 pints for the h.-p. cyl., 2.4 for the l.-p. cyl.).

Assuming the piston speed of this engine to be 600 ft. per min., the rev. per min. = 600 ÷ (2 × 40 ÷ 12) = 90.

According to Herr Weiss, however, the oil consumption per hour would be 0.0001155 × 26 × 90 = 0.27 pint, and for 20 hr. 2.7 pints for both cylinders.

In the issue of the same journal, dated February 15, there appeared a table giving the cylinder-oil consumptions of 81 engines of various sizes and types. These ranged from 5.94 pints to 0.089 pint per million square feet of surface lubricated. The average, however, of the 81 values was 0.97 pint, and this was not materially changed by omitting the abnormally high and low values.

Taking the data in the example given above, square feet per minute = (26 × 3 1/7 ÷ 12) × 600 = 4086; do, per hour = 245,160, which, at 0.97 pint per million square feet = 0.238 pint. Weiss's formula, as before stated, gives 0.27 pint.

Engine No. 7 in this table worked under practically the same conditions as those tested by Weiss, namely, a steam pressure of 146 lb. and superheat of 100 degrees fahr.; cylinders were 20 in. and 36 in., speed 100 rev. per min. Its hourly consumption was 0.255 pint. By Weiss's formula, the consumption works out as 20 × 100 × 0.0001155 = 0.231 pint.

It would seem, therefore, that the simple expression of Herr Weiss affords a means of determining the amount of oil that should suffice with ordinary diligence on the part of the engine attendants; and the many low values in the *Power* table that bring down the average to 0.97 pint, show that, under exceptional conditions and with close attention, the consumption thus calculated for steam engines can be measurably reduced. Reports from other sources indicate that this is being done in many cases.

CYLINDER-OIL CONSUMPTION IN STEAM ENGINES FOR EACH 100 R.P.M. (WEISS).

Cylinder diam. ins.	10	12	14	16	18	20	22	24	30	36	42
Oil per hour, pints	.116	.139	.162	.185	.208	.231	.254	.277	.347	.416	.485

DATA ON COMPOUND ENGINES TESTED.

Drive.	Cylinder Diams., ins. h.-p.	l.-p.	Stroke. ins.	Revs. per min.	HP.	Valves h.-p.	l.-p.
A. C. Generator	22.8	36.2	35.4	107	350–800	poppet	Corliss
Rolling Mill	19.7	31.5	39.4	100	75–800	piston	slide
D. C. Dynamo	9.8	15.	19.7	117	50–100	"	"
A. C. Generator	12.6	19.7	18.5	107	60–150	"	"

Steam pressure for all engines, 142.2 lbs. per sq. in., gage; superheat at admission to h.-p. cylinder, 120° to 190° F.

Distant Control Switchgear

STEPHEN Q. HAYES

PART II—Continued.

In all high-tension circuits it is customary to install knife-type disconnecting switches for isolating oil circuit-breakers, feeders, etc., or for making various connections that do not have to be opened under load.

In American practice the knife switches for 3300 volts or less are usually mounted directly on a base of soapstone, marble or similar material, while for higher voltages insulators of various kinds are used to support the switch jars. Up to 33,000 volts these disconnecting switches are made either front connection or rear connection or both, while for higher voltages they are almost invariably made front connection only.

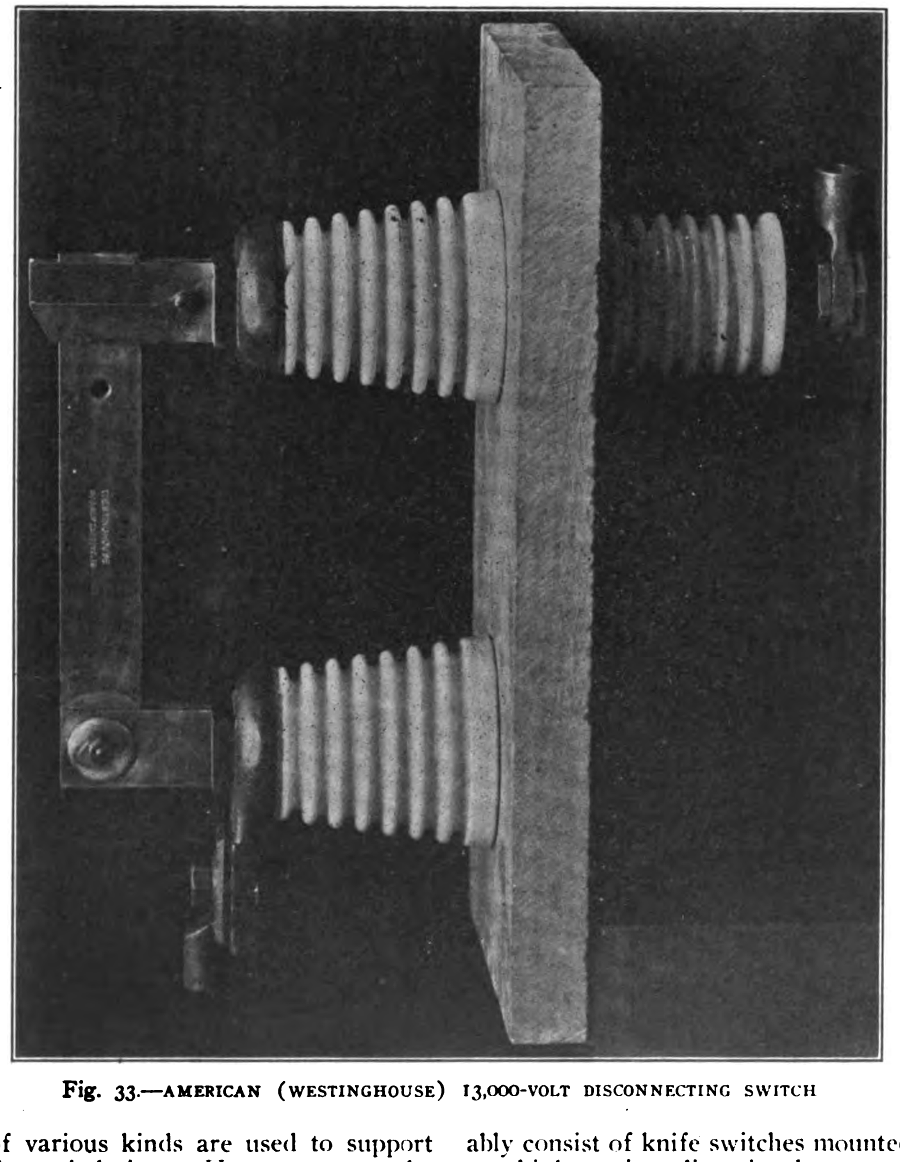


Fig. 33.—AMERICAN (WESTINGHOUSE) 13,000-VOLT DISCONNECTING SWITCH

Fig. 33 shows a 600-ampere 13,000-volt disconnecting switch built by the Westinghouse E. & M. Co. As may be noted, the switch jaws are part of the metal caps that are cemented to corrugated pillar-type porcelain insulators mounted on a soapstone base, the break jaw is rear connection and the hinge jaw front connection. The switch is operated by means of a wooden rod with a hoop on one end.

In all high-tension circuits for voltages above 33,000 the Westinghouse disconnecting switches almost invariably consist of knife switches mounted on high-tension line insulators, as shown in Fig. 34, which illustrates a 60,000-volt disconnecting switch intended for indoor service. As may be noted, a projecting arm is provided so that the station attendant can operate them by means of a direct pull from below when the switch is mounted horizontally with the blade above. A similar switch has been designed with the projecting arm shifted 90 degrees for vertical mounting. For outdoor service or where the switches are to be located in inaccessible places they can sometimes be arranged for operation by means of compressed air or a solenoid or motor-driven mechanism.

Fig. 35 shows a series of disconnecting switches built by the General Electric Co. for voltages from 22,000-110,000. These are mounted on corrugated pillar-type insulators that are given a dry test of three times normal voltage. On the larger sizes a truss blade is furnished to secure rigid construction, and safety catches are supplied to prevent the switches jarring open. The caps holding the jaw blades are clamped to a wall or other flat structure after they are removed from the wooden templates on which they are shipped. On the 110,000-volt switch the center line of the blade is 36¼ in. from the base and the jaws are 44 1/16 in. on centers.

Fig. 36 shows one of the disconnecting switches supplied by the Alioth Company for the 50,000-volt circuits of the Brusio transmission. The switch jaws are attached to a corrugated porcelain that is mounted on a metal pin attached to a flat iron base. This method of construction is typical of European practice for single-pole knife-type disconnecting switches.

All of the previously described disconnecting switches are intended to be operated individually by means of a long wooden pole.

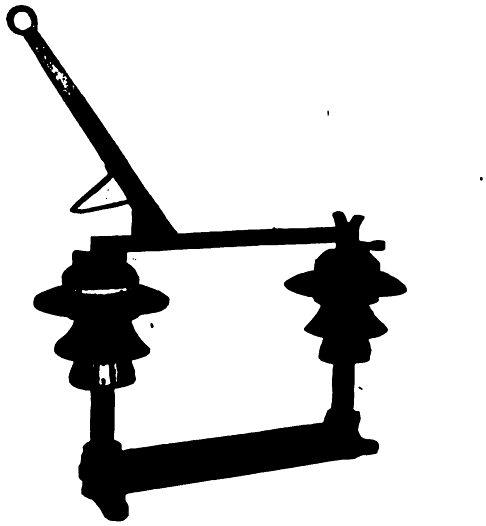


Fig. 34.—AMERICAN (WESTINGHOUSE) 66,000-VOLT DISCONNECTING SWITCH

In a large number of European plants the disconnecting switches are used in groups, as two-pole, three-pole or four-pole switches, and are mechanically operated from a distance by means of a shaft or similar device. Fig. 37 shows a three-pole double-throw, 13,500-volt disconnecting switch supplied by the Oerlikon Co. to the Compagnie Vaudoise. These switches are occasionally made for three or more throws and almost invariably interlocked mechanically with the main breaker in such a manner that the disconnecting switch cannot be manipulated unless the main breaker is open. The excellent mechanical and electrical design of this switch is evident from the illustration.

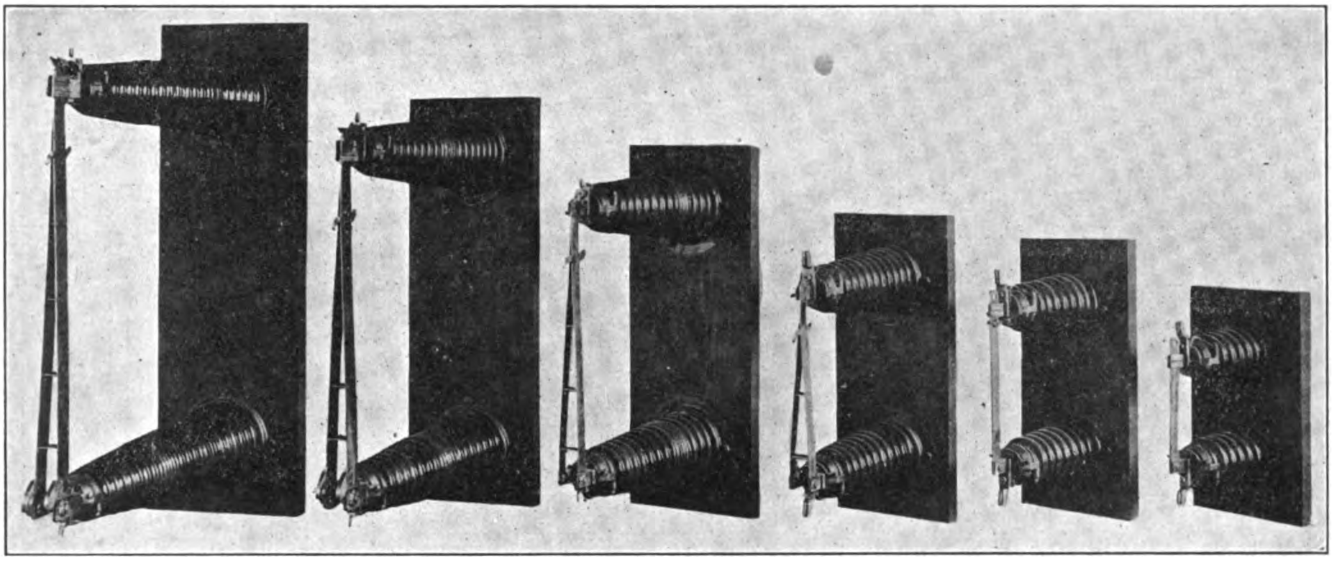


Fig. 35.—AMERICAN (G. E.) DISCONNECTING SWITCHES, 22,000 TO 110,000 VOLTS

In the Fontana station of the Milan Edison Company the 3200-volt ring bus bars are located in concrete compartments, one above the other, and are sectionalized by means of brush contact switches that are mounted on, but insulated from, a steel shaft. All of the three switches are operated together from the floor by a mechanism that first turns them from a position at right angles to the plane of the busses to a position in the same plane parallel to the bus, and then lifts the brush contacts until they press against the stationary contacts of the bus bars.

At the Novara Station of the Societa Lombarda in northern Italy, the 50,000-volt bus bars are placed one above the other with concrete barriers between. Sectionalizing switches made by Magrini, similar in general design to Fig. 36, are mounted on porcelains about 8 in. high, 6 in. diameter on the bus, and the three switches of one bus are connected through paraffined wooden rods about 24 in. long to crank arms mounted on a vertical shaft that passes down in front of the bus structure. This vertical shaft was provided with a porcelain insulator to form an insulated coupling, and a hand wheel on the floor above was used to operate the switches. Similar disconnecting switches in groups of three are mounted on the walls above the oil-breakers to isolate them from the bus.

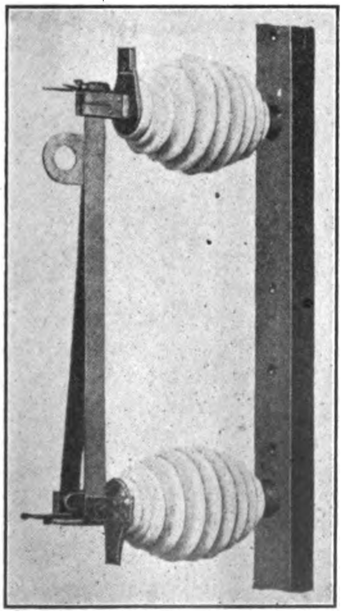


Fig. 36.—EUROPEAN (ALIOTH) 50,000-VOLT CONNECTING SWITCH

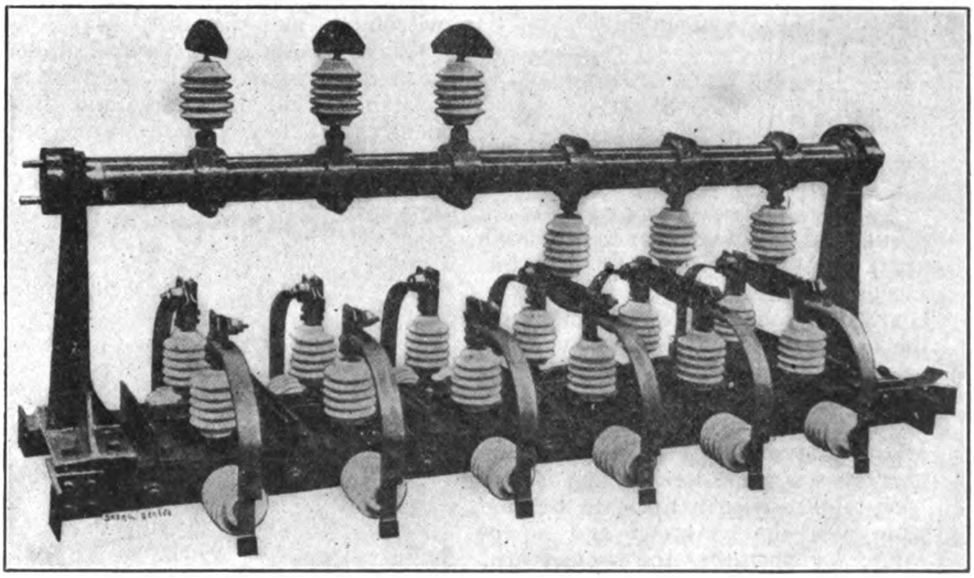


Fig. 37.—EUROPEAN (OERLIKON) 13,500-VOLT DISCONNECTING SWITCH

SECTION K.—PNEUMATICALLY OPERATED DISCONNECTING SWITCHES

The 110,000-volt, single-pole, single-throw disconnecting switches supplied by the General Electric Company to the Great Western Power Company are similar in general design to those shown in Fig. 35, except that they are provided with an air cylinder for pneumatic operation.

SECTION L.—ELECTRICALLY OPERATING DISCONNECTING SWITCHES

It is possible in some cases to use a solenoid or motor mechanism to operate disconnecting switches, but such a scheme is seldom used.

SECTIONS M AND O.—MANUALLY OPERATED FIELD SWITCHES AND RHEOSTATS

Owing to the heat developed in the resistance of field rheostats and the space required for its mounting, rheostat resistances were among the first portions of the switchgear to be placed apart from the board. At first the face plates were left on the switchboard and connections made between the face plate and resistance by wires or cables, usually bunched together in one or more bundles and treated as a large multiple conductor cable. With a large rheostat the cost of these connections was considerable, and it was soon found advisable to locate the face plate near the resistance and to arrange for operating the contact arm of the face plate from a distance, either by means of an extended shaft, rope or chain drive, spur or bevel gearing, or combinations of these methods.

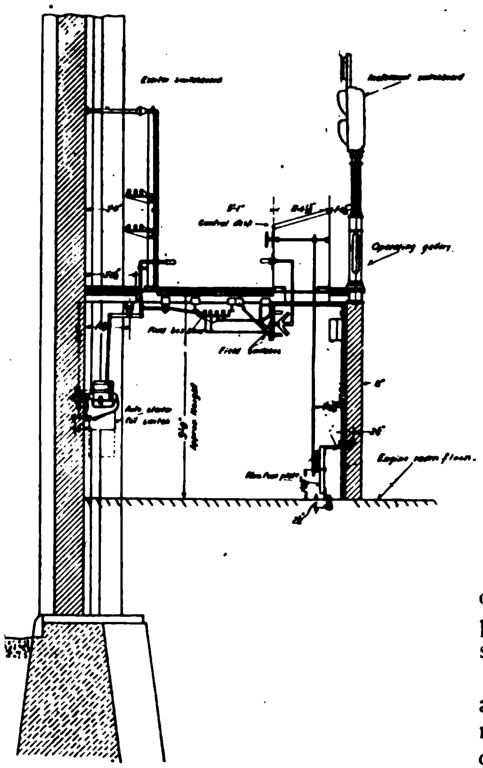


Fig. 38.—AMERICAN (WESTINGHOUSE) ARRANGEMENT OF RHEOSTAT CONTROL

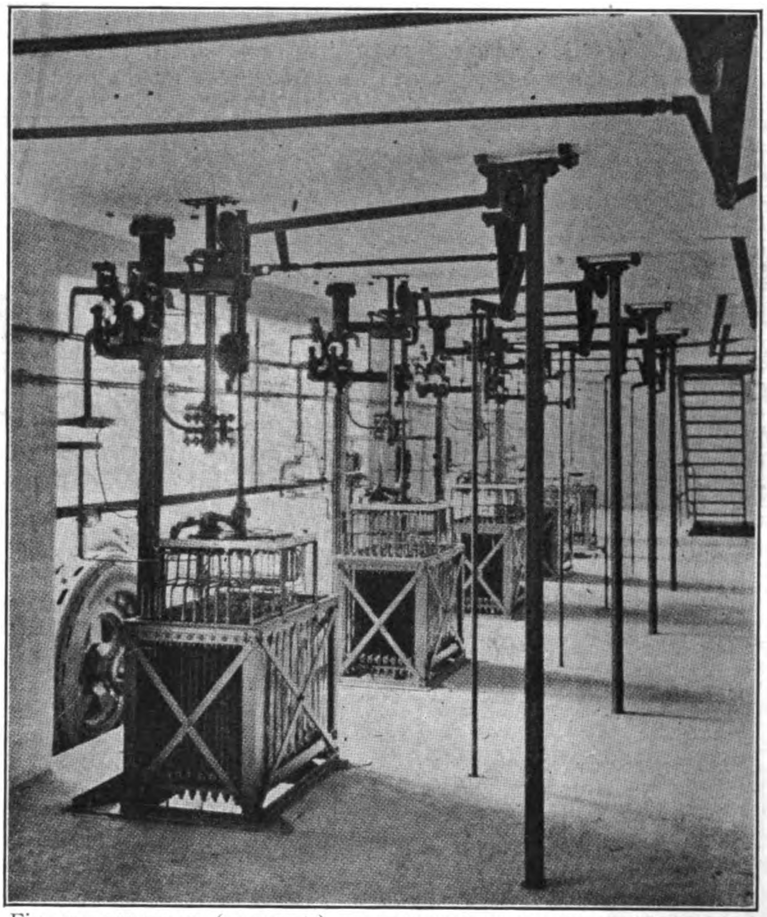


Fig. 39.—EUROPEAN (OERLIKON) ARRANGEMENT OF RHEOSTAT CONTROL

Even with panel switchboards, where all of the apparatus is placed directly on the panels, it has become common American practice to mount the rheostat apart from the switchboard wherever the resistance is too large to place directly on the back of the face plates, and standard methods of mounting have been developed for practically all relative locations of switchboard and rheostats.

Where pedestals or control desks are used, it is practically essential to make the field rheostats, and frequently the field switches, distant control. Fig. 38 shows the arrangement adopted by the Westinghouse Company for the Brunots Island plant of the Pittsburg Railways Company for the exciter switchboard and the field switches and field rheostats of the alternating-current generators. As may be noted, the excited board stands close to the station wall on the same

Fig. 40.—AMERICAN (WESTINGHOUSE) MOTOR-OPERATED FIELD-RHEOSTATS

gallery as the control desk. On the desk are placed the handles for the double-throw field switches and the hand wheels for the rheostats, the rheostats being located under the gallery.

Fig. 39 shows the field control equipment supplied by the Oerlikon Company for the Obermatt generating station of the Engelberg Luceren plant in Switzerland. The apparatus shown in this view is located on a mezzanine gallery and is worked by means of levers and hand wheels located at the control pedestals on the operating gallery above. The field rheostat face plate is mounted above and supported by the grid resistance, and the contact arm is attached to a vertical shaft worked by a hand wheel. The field switch may be seen a short distance above the face plate, and is also operated by a vertical shaft and hand wheel, and connects to the field bus bars of bare copper strap that runs along the front of the gallery supported on porcelain insulators. The bell crank mechanism controls the generator oil circuit-breaker on the floor below the mezzanine gallery, while the bevel gear mechanism operates a three-pole, double-throw disconnecting switch of the type shown in Fig. 37, for connecting the generator either to the lighting bus or the power bus. All of this apparatus is interlocked to prevent the operator from working the field switch or the disconnecting switch unless the oil-breaker is open.

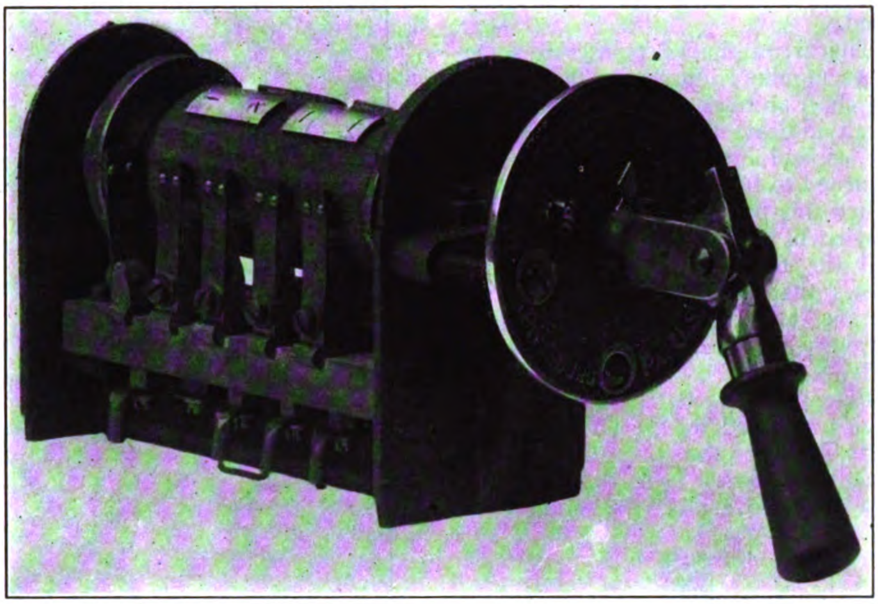


Fig. 42.—AMERICAN (WESTINGHOUSE) CONTROL DRAIN SWITCH FOR OIL CIRCUIT-BREAKER

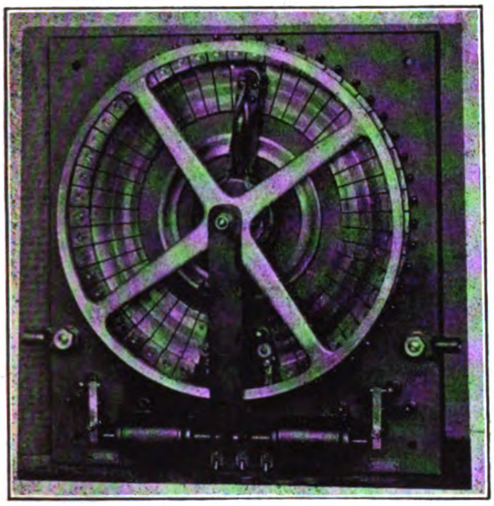


Fig. 41.—AMERICAN (G. E.) 200-AMPERE, 46-DIVISION RATCHET FIELD-SWITCH

SECTIONS N AND P.—ELECTRICALLY OPERATED FIELD SWITCHES AND RHEOSTATS

Where the distance from the switchboard to the field switches and field rheostats is great, it frequently becomes advisable to operate these devices electrically. These are frequently combined to form a switchboard like that shown in Fig. 40, which was supplied by the Westinghouse E. & M. Co. to control the field circuits of six 5000-kva. generators and the field and armature circuits of three 200 kw., 250-volt exciters in the plant of the Rio Janeiro T. L. & P. Co. Each exciter is provided with two 800-ampere, 3-pole, solenoid-operated carbon-breakers for connecting to either or both of two sets of direct-current bus bars, one of which is used for light and power service, and the other for excitation. The generator panels are provided with 2-pole, solenoid-operated field switches and motor-operated field rheostats.

The two-pole solenoid operated field switch is provided with auxiliary contacts for cutting in a discharge resistance just before opening the field circuit. No signal switch is ordinarily provided with such a field switch as the field ammeter will show whether the switch is open or closed.

The motor-operated field rheostat face-plate used in this plant is provided with a clutch, so that in case of trouble to the motor the face-plate may be operated by hand after disengaging the clutch. With this face-plate a signal switch is provided to actuate a lamp on the switchboard when the arm is bridging two contacts. This face-plate is also provided with a limit switch that opens up the motor circuit when the arm has reached the limit of its travel in either direction, and the connections are so made that while the motor can no longer be operated in one direction it can be run in the opposite direction.

Where the capacity of the rheostat face-plate does not exceed 200 amperes it is often feasible to install a solenoid-operated rheostat similar to that shown on Fig. 41 in place of the motor-operated rheostats shown in Fig. 40. This device built by the General Electric Co. shown in Fig. 41 consists of a double solenoid and plunger actuating a knurled-rim wheel by means of a simple lever and pawl mechanism. The knurled wheel carries the switch arm which cuts in and out the resistance in the usual way. One solenoid operates to cut in resistance by a continuous step-by-step rotation of the switch arm while the solenoid is energized. The other solenoid cuts out the resistance in the same manner.

SECTION Q.—CONTROL SWITCHES AND INDICATORS

For the operation of the various breakers, field switches and similar devices the Westinghouse E. & M. Co. is accustomed to supply a controlling switch similar to Fig. 42. The operating handle and direction dial are mounted on the front of the switchboard, while the contacts are back of the board and are made part of a drum-type controller. This construction removes even the direct-current operating voltage from the front of the board and readily adapts itself for use on 550-volt control circuits. This particular control switch is intended for use with oil circuit-breakers, and the handle is so designed that after turning to the trip position it can be lifted to stand at right angles to the plane of the dial-plate when a circuit is to be put out of service for any length of time. In this position all the indicating lamps are disconnected. For use with this controller an electro mechanical indicator or lamp indicators with colored prisms are supplied.

The arrow-shaped pointer is sometimes mounted loosely on the operating shaft and has sufficient lost motion as to indicate the last movement of the control handle even after it has returned to the central or off position. When this pointer shows that the last movement was to close the breaker and the tell-tale or indicating lamp shows that the breaker is open, the station attendant knows that the breaker has been tripped automatically.

Fig. 43 shows the twin pull-button device supplied by the General Electric Co. for the operation of oil circuit-breakers. Like the controller described above, all of the contacts and

Fig. 43.—AMERICAN (G. E.) CONTROL PULL-SWITCH

wiring are on the back of the panel so that the operator cannot touch a live circuit. By using pull-buttons in place of push-buttons, there is little likelihood of the attendant operating the device unintentionally when cleaning or working about the switchboard. Red and green indicating lamps with prismatic lenses are used for signals and a little target colored red and green and located between the buttons shows the last movement that has been made, so that if the target shows one color and another color indicating lamp is lit it is known that the breaker has been tripped automatically.

SECTION R.—AUXILIARY APPARATUS

In order to furnish automatic protection to various circuits, relays of different knids are provided to perform various functions and to be instantaneous or with time-limit adjustable or inverse, and to take care of conditions of overload, underload,

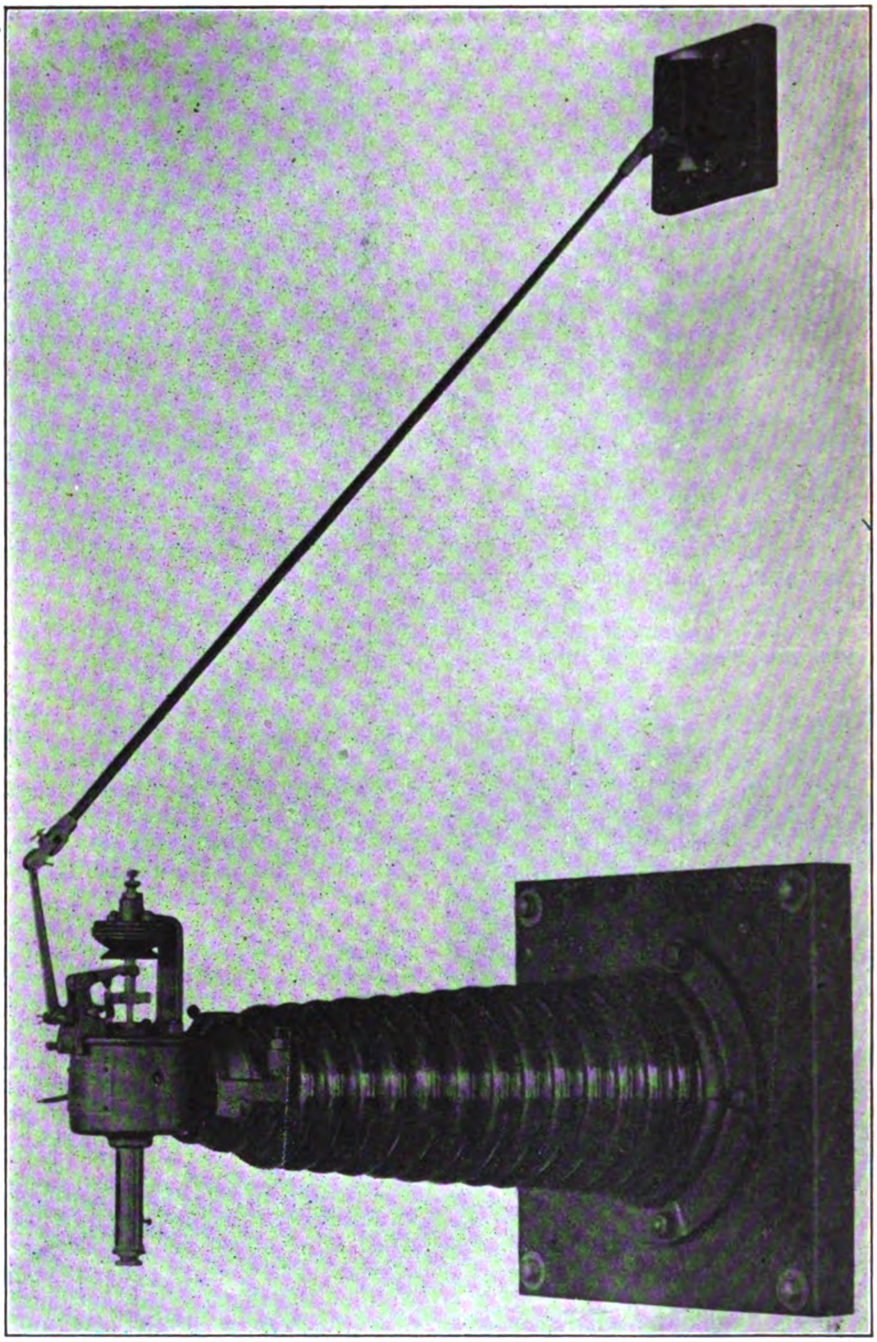


Fig. 44.—AMERICAN (G. E.) SERIES RELAY

reverse power or no voltage. As a rule, these relays are operated from series transformers, but occasionally they are mounted directly in the circuit, mounted on high-tension insulators like Fig. 44, which is a relay built by the General Electric Co. for 66,000-volt service. The relay is provided with a bellows attachment to give an inverse time element feature, and when the current through the coil exceeds that for which the relay is set the plunger is lifted and mechanically actuates the little relay switch that closes the tripping circuit of the breaker.

In type of series relay used by the Westinghouse Electric & Mfg. Co. for the relays are 100,000-volt service above the oil-breaker. They are hung from suspension insulators and mechanically operate the tripping device of the breaker.

The other types of relays are so numerous that not even passing mention can be made of them here, and it will also be necessary to pass over the series and shunt transformers and similar apparatus.

For making the connections from the controllers to the breakers, field switches, field rheostats, etc., and from the instruments and relays to the series and shunt transformers multiple cable is used, and this is ordinarily provided with different colored braids for the different cables, and the assembled cables given a lead or fireproof covering. Such cables are usually installed in iron conduits, having a nominal diameter of about 1¼ in.

With the evolution of apparatus for the control of power to its present degree of complexity, the refinement in auxilaries has become such that, in a modern plant of good design, the work and responsibility of switchboard attendance has been reduced to a minimum. The number of intricate functions that are thus performed automatically, either directly or by relays, includes almost every conceivable variation of time and energy variations and their combinations. It is a question whether in some instances the reliance on such devices has not been pushed too far. In the most recent examples of good practice, a tendency toward simplification is noticeable. But in any event, great credit must be given to the ingenuity that has conceived and worked out the numerous types of auxiliary devices to their present perfection.

(To be continued.)

Test of a 15,000-KW. Steam Engine Turbine Unit*

By H. G. STOTT and R. J. S. PIGOTT

During the year 1908 it became apparent that owing to the cost of increasing traffic in the New York subway, it would be necessary to have additional power available for the winter of 1909-1910.

The power plant of the Interborough Rapid Transit Company, which supplies the subway, is located on the block bounded by Fifty-eighth and Fifty-ninth Streets, and by Eleventh and Twelfth Avenues, adjacent to the North River; it contains nine 7500-kw. (maximum rating) engine units, besides three 1250-kw., 60-cycle turbine units, which are used exclusively for lighting and signal purposes.

The 7500-kw. units consist of Manhattan-type compound Corliss engines, having two 42-in. horizontal high-pressure cylinders and two 86-in. vertical low-pressure cylinders. Each horizontal high-pressure cylinder and vertical low-pressure cylinder has its connecting rod attached to the same crank, so that the unit becomes a four-cylinder 60-in. stroke compound engine with an overhanging crank on each side of a 7500-kw., maximum rating, 11,000-volt, three-phase, 25-cycle generator. The generator revolving field is built up of riveted steel plates of sufficient weight to act as a flywheel for the two engines connected to it. This arrangement gives a very compact two-bearing unit. The valve gear on the high-pressure cylinders is of the poppet type, and on the low-pressure of the Corliss double-ported type. The condensing apparatus consists of barometric condensers, arranged so as to be directly attached to the low-pressure exhaust nozzles, with the usual compound displacement circulating pump and simple dry-vacuum pump.

These engine and generator units are in general probably the most satisfactory large units ever built, as five years' experience with them has proved; their normal economic rating

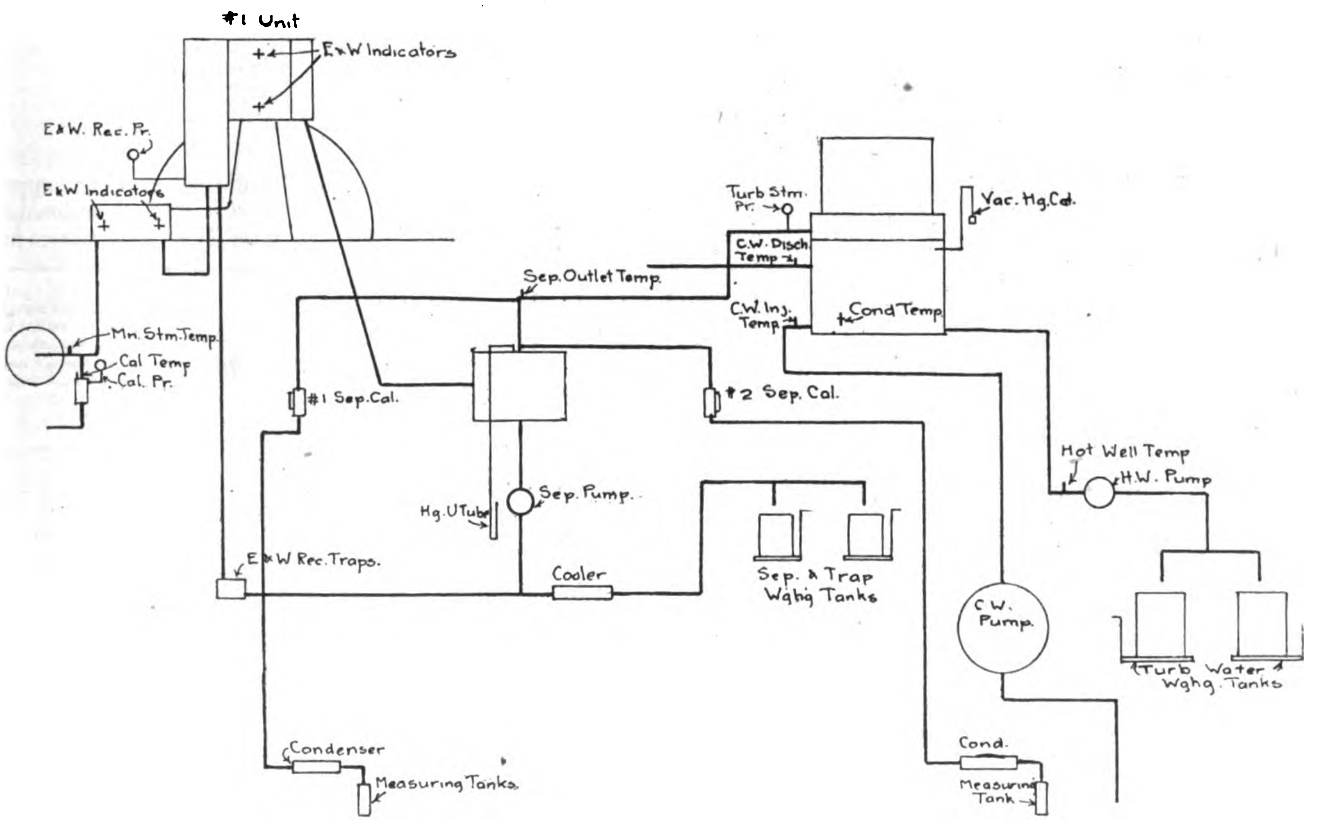


Fig. 1—DIAGRAM OF TEST LAY-OUT FOR UNIT NO. 1.

*Abstract of paper presented at joint meeting of American society of Mechanical Engineers and American Institute of Electrical Engineers, New York, March 8, 1910.

is 5000 kw., but they operate equally well (water rate excepted) on 8000 kw. continuously.

In considering the problem of how to get an additional supply of power, every available source was considered, but by a process of elimination only two distinct plans were left in the field. The electric transmission of power from a hydraulic plant was first considered, but owing to the high cost of a double transmission line from the nearest available water-power, and the impossibility of getting reliable service (that is, service having a maximum total interruption of not more than 10 min. per annum) from such a line, further consideration of this plan was abandoned. The gas engine, while offering the highest thermo-dynamic efficiency, at the same time required an investment of at least 35 per cent. more than an ordinary steam-turbine plant with a probable maintenance and operation account of from 4 to 10 times that of the steam turbine. The reciprocating engine unit, of the same type as those already installed, was rejected in spite of its most satisfactory performance on account of the high first cost and small range of economical operation. Careful tests have shown that the economic limits of operation are between 3300 kw. and 6300 kw.; beyond these limits the water rate rises so rapidly as to make operation undesirable under this condition, except for a short period during peak loads.

The choice was thus narrowed down to either the high-pressure steam turbine or the low-pressure steam turbine. There was sufficient space in the present building to accommodate three 7500-kw. units of the high-pressure type, or a low-pressure unit of the same size on each of the nine engines, so that the questions of real estate and building were eliminated from the problem.

The first cost of a low-pressure turbine unit is slightly lower than that of a high-pressure unit, due to the omission of the high-pressure stages and the hydraulic governing apparatus, but the cost of the condensing apparatus would be the same in both cases. The foundations and the steam piping in both cases would not differ greatly. The economic results, so far as the first cost is concerned,

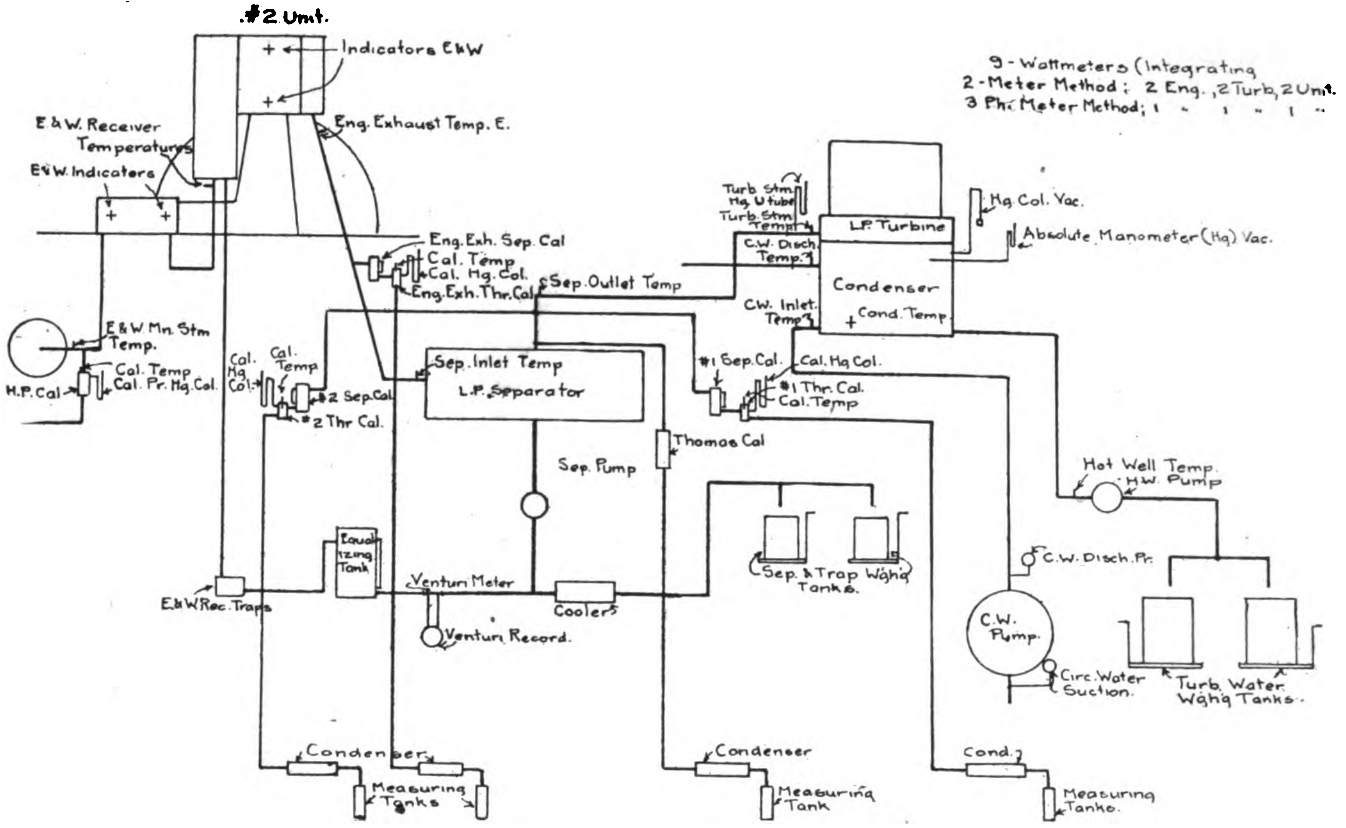


Fig. 2—DIAGRAM OF TEST LAY-OUT FOR UNIT NO. 2.

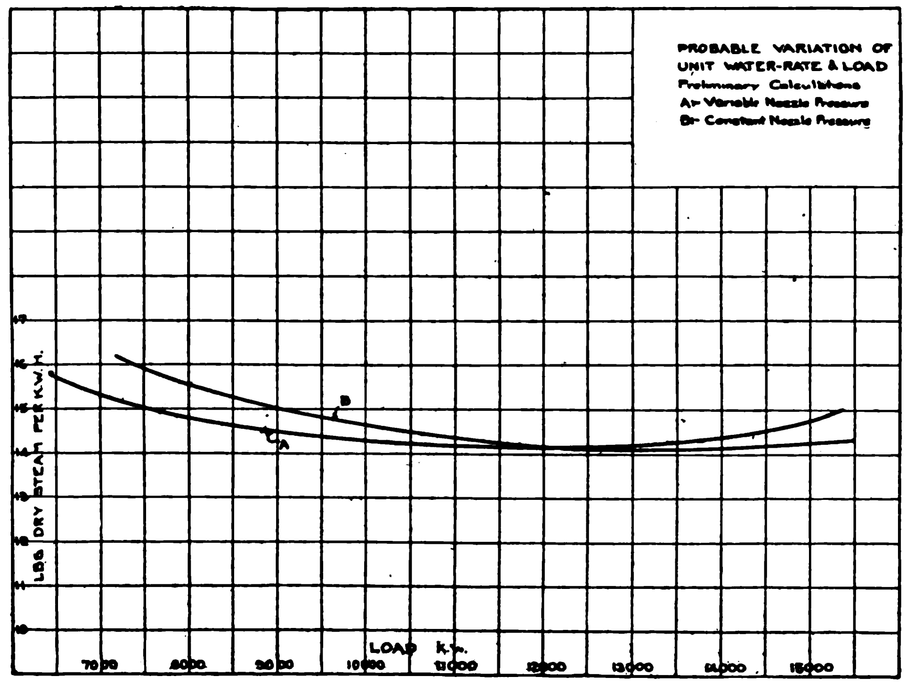


Fig. 3—WATER-RATE CURVES FROM PRELIMINARY ENGINE TESTS AND MANUFACTURER'S DATA.

would then be approximately the same, if we consider the general case only; but in this particular instance the installation of high-pressure turbines would have meant a much greater investment for foundations, flooring, switchboard apparatus, steam piping and water tunnels, amounting to an addition of not less than 25 per cent. to the first cost.

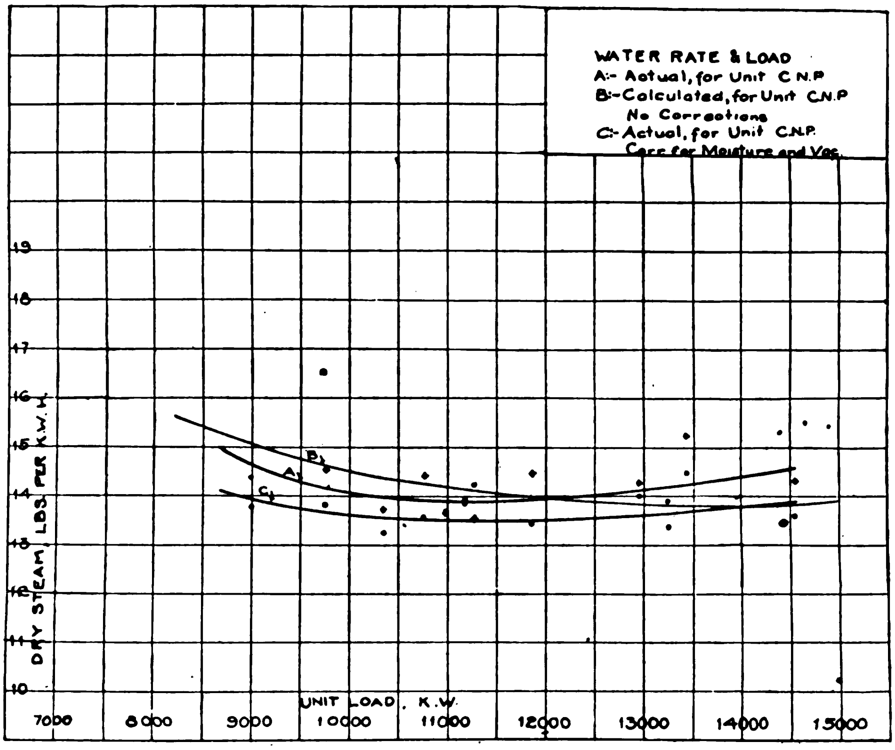


Fig. 4—ACTUAL AND CALCULATED WATER-RATE CURVES.

The general case of displacing reciprocating engines and installing steam-turbine units in their place was also considered. The best type of high-pressure turbine plant has a thermal efficiency approximately 10 per cent. better than the best reciprocating-engine plant, but the items of labor for operation and for maintenance, together with the saving of about 85 per cent. of the water for boiler-feed purposes and the 10 per cent. of coal, reduce the relative operating and maintenance charges for the steam-turbine plant to 80 per cent., as compared to 100 per cent. for the reciprocating-engine plant.

Assuming that the reciprocating-engine plant is a first-class one and has been well maintained, about 20 per cent. of its original cost (for engines, generators and condensers) may be realized on the old plant and so credited to the cost of the high-pressure turbine plant. But, on the other hand, if the high-pressure turbine installation is to receive credit for the second-hand value of the engines, it must also have a debit charge for 100 per cent. of the original reciprocating-engine plant which it displaced. The relative investments, therefore, upon this basis would be approximately equal for the high-pressure or the low-pressure turbine; but 80 per cent. of the cost of the original engine plant would have to be charged against the high-pressure turbine plant, as against an actual increase in value (to the owner) of the engine by reason of its improved thermal efficiency, due to the addition of the low-pressure turbine.

The preliminary calculations, based upon the manufacturers' guarantees for the low-pressure and high-pressure turbines, showed that the combined engine-turbine unit would give at least 8 per cent. better efficiency than the high-pressure turbine unit, so that it was finally decided to place an order for one 7500-kw. (maximum rating) unit, as by this means we would not only get an increase of 100 per cent. in capacity, but at the same time give the engines a new lease of life by bringing them up to a thermal efficiency higher than that attained by any other type of steam plant.

The turbine installed is of the vertical three-stage impulse type, having six fixed nozzles and six which can be operated by hand, so as to control the back pressure on the engine, or the division of load between engine and turbine. An emergency overspeed governor, which trips a 40-in. butterfly valve on the steam pipe connecting the separator and the turbine and at the same time the 8-in. vacuum breaker on the condenser, is the only form of governor used. The footstep bearing, carrying the weight of the turbine and generator rotors, is of the usual design supplied with oil under a pressure of 600 lb. per sq. in., with the usual double system of supply and accumulator to regulate the pressure and speed of the oil pumps.

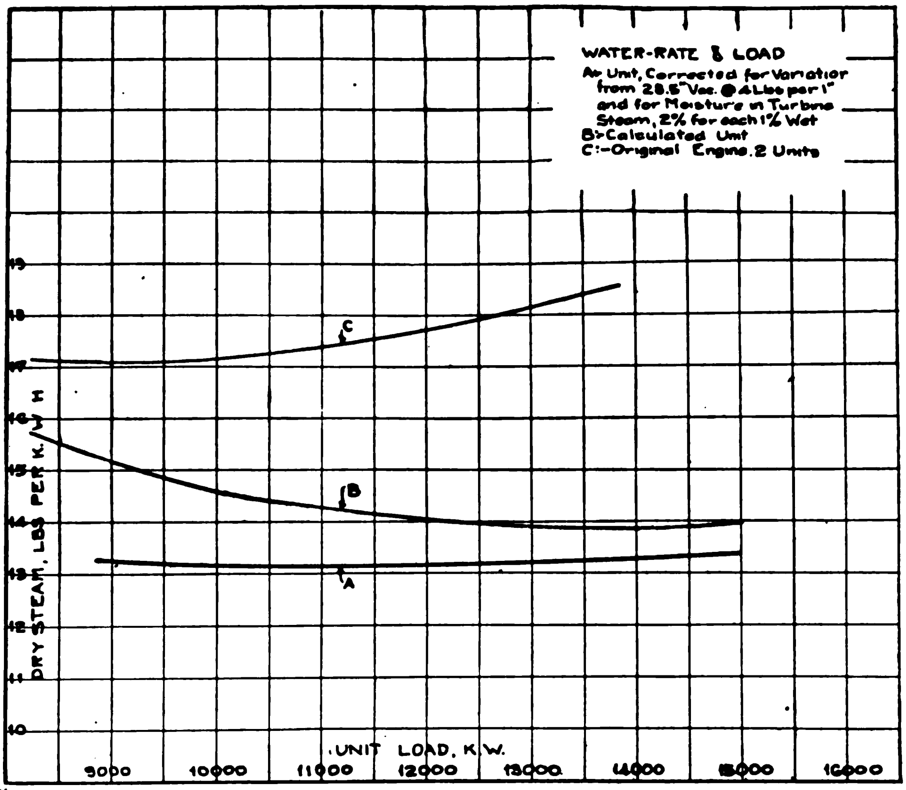


Fig. 5—WATER-RATE CURVES FOR EQUIVALENT ORIGINAL ENGINE CAPACITY AND FOR COMPLETE UNIT.

The condenser contains approximately 25,000 sq. ft. of cooling surface arranged in the double two-pass system of water circulation with a 30-in. centrifugal circulating pump, having a maximum capacity of 30,000 gal. per hr. The dry vacuum pump is of the single-stage type, 12 in. and 29 in. by 24 in., fitted with Corliss valves on the air cylinder. The whole condensing plant is capable of maintaining a vacuum within 1.1 in. of the barometer when condensing 150,000 lb. of steam per hour when supplied with circulating water at 70 degrees fahr.

The electric generator is of the three-phase induction type, star-wound for 11,000 volts, 25 cycles and a speed of 750 rev. per min. The rotor is of the squirrel-cage type with bar winding connecting into common bus-bar straps at each end. This type of generator was chosen as being specially suited to the conditions obtaining in the plant.

With nine units operating in multiple, each one capable of giving out 15,000 kw. for a short time, operating in multiple with another plant of the same size, it is evident that it is quite possible to concentrate 270,000 kw. on a short-circuit. If we proceed to add to this synchronous turbine units of 7500-kw. capacity, which, owing to their inherently better regulation and enormous stored energy, are capable of giving out at least six times their maximum rated capacity, the situation might soon become dangerous to operate, as it would be impossible to design switching apparatus which could successfully handle this amount of energy. The induction generator, on the other hand, is entirely dependent upon the synchronous apparatus for its excitation, and in case of a short-circuit on the bus bars would automatically lose its excitation by the fall in potential on the synchronous apparatus.

The absence of fields, leads to the simplest possible switching apparatus, as the induction generator leads are tied in solidly through knife switches, which are never opened, to the main generator leads. The switchboard operator has no control whatever over the induction generator, and only knows it is present by the increased output on the engine-generator instruments.

The method of starting is simplicity itself—the exciting current is put on the engine generator *before* starting the engine, and then the engine is started, brought up to speed and synchronized in exactly the same way as before. While starting in this way, the induction generator acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronism, when it immediately becomes a generator and picks up the load. Three of these 7500-kw. low-pressure turbine units have been installed and tests run on Nos. 1 and 2. No. 3, having been just started, has not yet been tested.

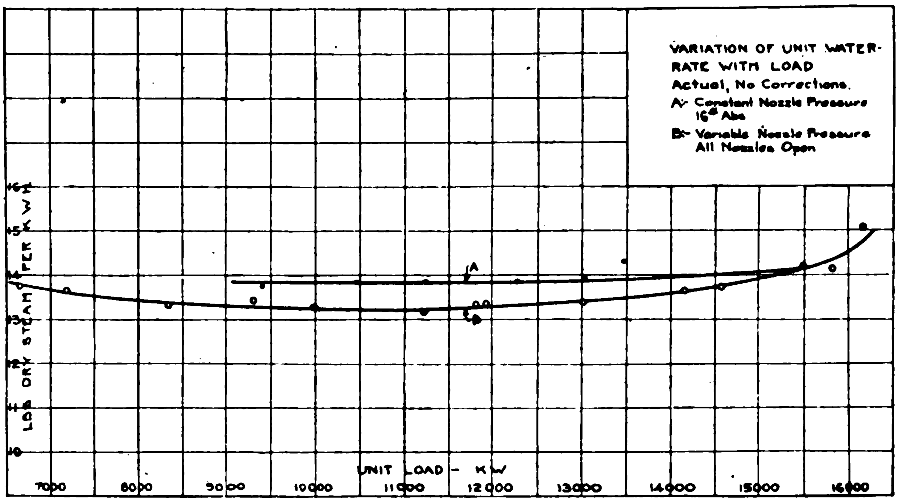


Fig. 6—ACTUAL UNCORRECTED WATER-RATE CURVES.

Diagrams of the layout of the apparatus for tests of units Nos. 1 and 2 are shown in the first two figures. The various water rates, calculated and original as well as actual and corrected, for conditions of both constant and variable nozzle pressure, are shown in Figs. 3 to 7. To all results, except where specially noted, the moisture corrections are simple corrections, *i. e.,* for each per cent. of moisture 1 per cent. of correction has been made. The vacuum corrections for the complete unit are 1 lb. per each inch variation from 28.5 in. referred to 29.92 in. barometer.

The net results obtained by the installation of low-pressure turbine units may be summarized as follows:

a. An increase of 100 per cent. in maximum capacity of plant.

b. An increase of 146 per cent. in economic capacity of plant.

c. A saving of approximately 85 per cent. of the condensed steam for return to the boilers.

d. An average improvement in economy of 13 per cent. over the best high-pressure turbine results.

e. An average improvement in economy of 25 per cent. (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.

f. An average unit thermal efficiency between the limits of 6500 kw. and 15,500 kw. of 20.6 per cent.

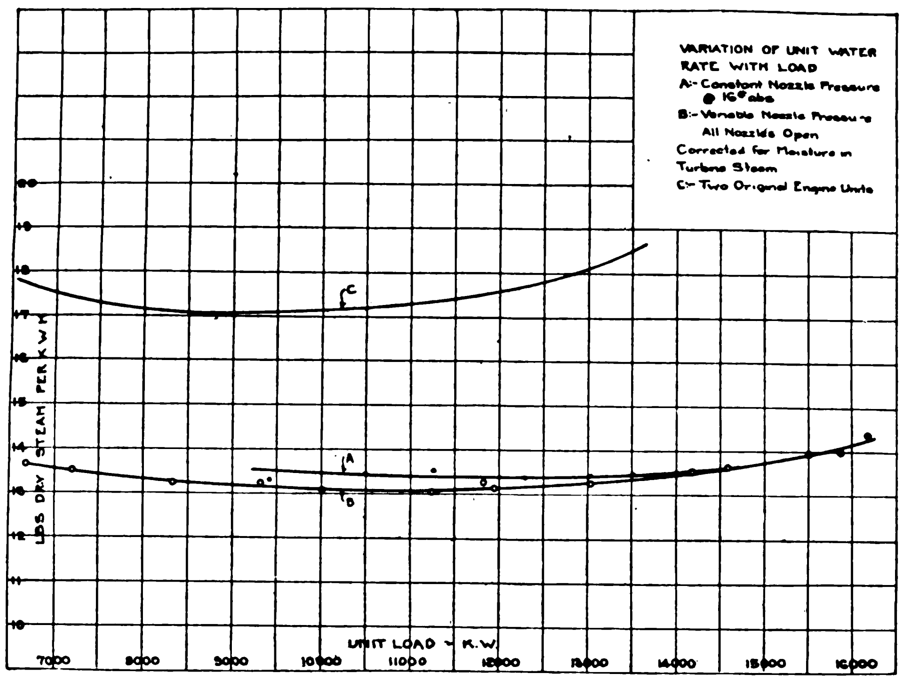


Fig. 7—ACTUAL CORRECTED WATER-RATE CURVES.

The Evolution of a Great Industry

The annual report of the President of the American Telephone & Telegraph Company for 1909 furnishes a very interesting picture of the growth and development of the world's greatest public utility concern. The "Bell system" in the United States, according to these official figures, is one of the largest combinations of money and brains that has been evolved by the great changes of the past 25 years. Although already capitalized at $300,000,000, the report, which is a very full document, covering about 40 pages, recommends that the capital be increased to $500,000,000.

In view of the showing made, this recommendation does not look unreasonable. Last year the companies, which now have over 5,000,000 subscriber stations and 10,000,000 miles of wire, made somewhat over 20,000,000 connections per day on an average. For this service they received from the public the modest sum of $150,000,000. Of this, $50,000,000 was used for operating expenses, $7,000,000 for taxes and $45,000,000 were charged off for repairs, maintenance and depreciation, out of which nearly $29,000,000 went into plant additions.

The ownership of this gigantic property is divided among some 35,000 shareholders, an increase of nearly 10,000 over the number of owners one year ago. The shares are mostly held in small lots, the average number per holder being about 50. They received $22,000,000 in dividends and their surplus fund is now over $8,000,000.

About half of the report is devoted to a concise history of the companies from their beginning in 1879, with 8500 shares at $100 par value, and to a discussion of competition in the telephone business and its effect, a study of rate changes and some general consideration, which are treated with a broad conception of the companies' relations with and duties to the public.

Electrification of Steam Railroads

The distinguished committee that was appointed some time since by the New York Railroad Club to study the electrification of steam railroads, has presented its report to the club at the March meeting. The committee is composed of the following well-known engineers and railroad men: W. J. Harahan, Assistant to the President Erie Railroad, Chairman; L. C. Fritch, Consulting Engineer Illinois Central Railroad; H. M. Warren, Electrical Engineer Delaware, Lackawanna & Western Railroad; H. H. Vaugn, Assistant to the Vice-President Canadian Pacific Railroad; J. H. Davis, Electrical Engineer Baltimore & Ohio Railroad; G. W. Wildin, Mechanical Superintendent New York, New Haven & Hartford; Wm. McClellan, Consulting Engineer, and E. B. Katte, Chief Engineer of Electric Traction New York Central & Hudson River Railroad.

The report opened with a recital of the more important work already done in the line of substituting electrical for steam traction on railroads. It then considered the principal features of electric traction. It referred to flexibility of motive power with and without multiple unit operation. It found that electric locomotives and motors were less affected by cold weather than steam locomotives. Also that the electric locomotive would have much less idle time under the same operating conditions than its steam-driven competitor, and could be designed for practically continuous service over any length of run; and that it has a larger power capacity and is much more cleanly.

The principal reasons for electrification, according to the report, are an increase in station and track capacity and facilities, an increase in gross earnings, due to a better and more attractive service, and legislative enactment. Referring to the possible increase in gross earnings, the report very pertinently remarks that the mere substitution of electricity for steam will not necessarily produce any very great increase in gross earnings, but the service must be improved by changes in schedules and stop. Inattention to this feature is preventing some of the roads now electrified from reaping the fullest possible returns on their electrification investment.

Referring to legislative action in requiring the substitution of steam for electric traction under certain conditions, the committee says: "The operation of a steam railroad in the heart of a large city is, of necessity, attended by features not always ideal. On account of the cost of land and other conditions, the amount of space for roadway is likely to be cramped and closely pressed by city and private property. The emission of smoke and gases from the locomotives, especially if a subway or tunnel is involved, often leads the community to demand that the railroad abolish the objectionable features. This demand, in its essentials, may be reasonable enough, and if by calm and considerate discussion it can be shown that conditions are unnecessarily bad, the public has a right to expect the railroads to provide a reasonable remedy. Unfortunately, however, the discussion is sometimes fanned into a condition where hostility and acrimony become the chief features. As a consequence, the public may make demands, the difficulty, expense and result of which it has no conception, and the railroad is compelled to refuse anything like the full extent of the demands because it knows it cannot afford to do otherwise.

In this connection, the following are a few broad considerations which common sense and equity present:

1. A railroad has a charter franchise or special privilege from the commonwealth, and, therefore, belongs to a class of activities which must especially consider the interest of the public.

2. A railroad is also a business venture organized to make money, and those responsible to the stockholders must conduct its affairs so as to serve their best ultimate interest.

3. A nuisance, for example, smoke, incident to the operation of a property, whether factory, railroad, store, or what not, may be deplored, but all sources of such nuisances must be treated alike, and it should also be determined how far a removal of the nuisance might endanger the industry itself and cause its failure.

4. It is only fair to assume that men who have worked in the public eye, at any particular business, for a number of years, are men of integrity and well informed as to their business. Action should be taken, therefore, by the community only when advised by well-informed persons, and after comprehensive consideration.

5. There are not two sides to this problem. The interests of the railroads and those of the public are one.

The committee made an effort to secure operating data for publication for the existing electrified steam railroads, but this attempt met with little favorable response, because, almost without exception, the men who are responsible for the operation of these properties did not think the conditions were sufficiently settled to permit them to publish data that would be just to either steam or electric operation.

The report concludes as follows:

To sum up, the following may be stated as the advantages and disadvantages of electrification:

ADVANTAGES.

1. Increasing the capacity of a given terminal by the elimination of switching movements, where multiple units are used, and increasing the schedule speed of trains without increasing maximum speed by the higher acceleration possible with electric power; also increasing the capacity of the line and permitting shorter block signal spacing.

2. Avoidance of smoke and steam nuisance, making unobjectionable tunnels, subways and underground stations, and reclaiming the aerial space above track for offices, stores, warehouses, hotels, or other buildings; also a saving in deterioration of metallic structures because of the corrosive products of combustion in steam locomotives.

3. Uniform power over grades and greater tractive power of electric locomotives of equal weight with steam locomotives, including tender, making heavier trains possible over mountain divisions. Locomotives may be used in multiple without increasing the cost for enginemen.

4. Economy of operation under conditions favorable to electric traction, such as frequent multiple-unit train service or cheap electric power, as compared with the higher cost of locomotive coal.

5. Electrical operation has proved itself reliable.

6. Electric power is not a source of danger to the traveling or general public.

DISADVANTAGES.

1. A large investment for re-equipping the railroads with the new power which can only be justified by definite financial or economic results.

2. Increased danger to employees of the railroad due to the presence of the third rail or the overhead conductor, especially in yards or terminals.

FEATURES TO BE CONSIDERED FOR FUTURE ELECTRIFICATION.

The following features with reference to present conditions should be considered, having in view future electrification:

1. The signal systems should be designed with a view of meeting the restrictions involved in electrification work.

2. Bridges, yards and terminal platforms should be designed to conform to the clearances necessary for the installation of working conductors.

3. Locomotives and cars should be designed to conform to electrification clearances.

4. The lighting system of cars should be designed for economical use on electrified roads. This applies also to the heating systems.

5. Steam, water, air and gas-pipes, in yards and at stations, should be laid out to avoid current collectors on future electric equipment and working conductors, also bonded to avoid electrolysis.

CONCLUSIONS.

1. No general information is available on the basis of which steam railroads, as a whole, would be justified in electrifying terminals or main lines, solely on the grounds of economy.

2. Careful investigation is necessary to decide if electrification of terminals and suburban districts would be warranted in order to increase earnings.

3. More attention should be given to the possibilities of electrification in connection with heavy grades, and at other places where an increase in facilities is needed.

4. It is not likely that conclusive data on the economy of electrification will be available until electrification is extended over a complete steam locomotive stage.

5. The electrification for passenger terminal and suburban service is now more or less settled as to method, but for freight and general trunk-line service it is in the experimental stage.

a. The types of locomotives for various service have not been determined, though progress is being made.

b. The method of secondary distribution (working conductors) needs much development. The third rail is thoroughly reliable and efficient, but unsuitable for complicated switchwork. In its present form it has only been used for voltage up to 1200.

c. The overhead system for high voltage working conductors also needs much development. Few, if any, are satisfied with present designs, and many changes are proposed.

6. The steam railroad men and electrical engineers should work together in as close harmony as is possible, so as to produce results that will be as free from mistakes and experiments as is possible in any developing art.

Each problem must be studied on its merits and a decision can only be made after careful study of the conditions pertaining to each situation.

8. The electrification of large freight terminals has not as yet been attempted, nor satisfactorily worked out, therefore it is necessary to proceed with caution in this matter and the problem must be exhaustively studied and new developments made before it would be justifiable to make such an installation. The electrification of any large freight terminal would involve a number of roads, and cannot be undertaken independently, without the co-operation of all the railroads affected, on account of the relations existing among the various roads in the interchange of freight traffic.

The report was discussed at considerable length by Messrs. George Gibbs, Chief Engineer of Electric Traction Pennsylvania Railroad; L. B. Stillwell, Consulting Engineer; W. S. Murray, Electrical Engineer New York, New Haven & Hartford Railroad; G. M. Basford, Assistant to President American Locomotive Company; C. O. Mailloux and Wm. McClellan, Consulting Engineers.

An Unknown Scientist

The question as to who really are the discoverers of those great secrets of nature whose uncovering has worked the changes in human life and thought that are just beginning to impress the fullness of their effect on the world, is always more or less uncertain. For example, here come the Pennsylvania Germans with a fair claim for a certain Dr. David Alter, of Armstrong County, Pa., who was born in 1807 and died in 1881.

Among the inventions claimed for him are: the electric telegraph in 1837; an electric motor in the same year; the spectrum analysis in 1854, six years before Kirchoff's announcement; a "simple" telephone, and an electric locomotive, working drawings for which were almost complete at the time of his death.

It would be interesting to know how much of all this is true, and how many of these remarkable statements can be really verified. This would be a labor of love for someone with time and ability to devote to the task.

Some Far-Fetched Deductions

A curious study, entitled "Electrotechnics in the Bible," is contributed by E. Stadelmann, an electric engineer of Munich, to the *Electrotechnische Anzeiger*. The writer asserts that the ancient Jews had some knowledge of electricity, and he tries to prove this by an ingenious analysis of scriptural narrative. "The first place," says Stadelmann, "Moses evidently understood the uses of the lightning conductor." To quote:

"Did he not make a brazen serpent to defend his people against the fiery serpents (lightnings) sent upon them by the Almighty, so that the fiery serpents were seized by the brazen one? The temple at Jerusalem was protected against lightning by interconnected metal points communicating with the ground through reservoirs of water."

Still more curious is the explanation given by Mr. Stadelmann of the construction of the Ark of the Covenant and of the terrible punishments visited upon the unfortunates who dared to approach too near it:

"If we study the details of its construction, we find that it was composed of an insulating receptacle (of acacia wood) and of two metallic coatings (gilding), one exterior, one interior; it therefore formed a Leyden jar of great dimensions. This condenser, charged with atmospheric electricity by the metal conductors of the temple roof, had, as may be calculated from its dimensions, a capacity amply sufficient to produce a fatal discharge. Only the initiate could touch it, and this immunity enjoyed by the officiating priest is explained by the nature of his costume, which was in part of gold tissue, thus protecting him from electric discharges."

Mr. Stadelmann cites in support of his hypothesis many scriptural texts, on the construction of the ark, on the nature of the priest's costume and on the punishment dealt out to profane persons. Moreover:

"The altar, also, must have been a powerful Leyden jar, although information regarding its installation is not available; but the passages in the Mosaic books forbidding approach to it on penalty of death to persons not wearing the prescribed costume, authorize us to consider it such.

"It would perhaps appear improbable that such powerful effects could be obtained with metallic rods on elevated points, but we must bear in mind the atmospheric peculiarities of Palestine; and even the experiments made in Europe on the collection of electricity by means of kites have shown that huge sparks 9 or 10 ft. long may thus be obtained.

"Moses probably got his notions of electricity from the Egyptians, and perhaps," Mr. Stadelmann concludes, "Egyptologists may discover facts indicative of the state of electrical knowledge in the Pharaonic times."

General News

A recent report from Germany, via an English source, states that Herr R. Gaus has discovered that wire insulated with a coating, a certain kind of enamel, is practically insensitive to a magnetic field, and that a research is being made with a view to discovering the kind of enamel that will give the best insulation from magnetic lines of force. Hitherto there has been no substance known that will at the same time serve as an insulator both to electric current and to a magnetic field, and it is stated that if the new double insulation proves a success under exhaustive and practical tests, it will cause almost a revolution in the design of many kinds of electrical apparatus, especially measuring instruments of precision.

The Montreal Elevated and Underground Railway Company, for which a charter has been asked, will have a capitalization of $20,000,000. It will absorb the Montreal Street Railway, Montreal Light, Heat and Power Company and the Shawinigan Light and Power Company, all of which are operating in Montreal.

The official figures of the General Electric Company for the year which ended Jan. 31, 1910, has not yet been made public, but it is understood that the gross business was approximately $60,000,000. This is an increase of nearly 35 per cent., or $15,500,000, as compared with the preceding year. The fiscal year of the company, which heretofore ended Jan. 31st, has been changed to end Dec. 31st, so that the next official report will only embrace 11 months. The company says that it now has on hand all the business in turbine engines that it can handle during 1910, and has some special orders which will not be delivered until 1911.

At the annual banquet of the Long Beach, Cal., Chamber of Commerce, the Southern California Edison Company, of Los Angeles, announced that a steam-driven electric plant, whose ultimate capacity would be 100,000 h.p., would be erected on a plot of land near the entrance of Long Beach Harbor. The initial installation will be about 30,000 h.p., which it is hoped to have in operation in a year.

Plans reported from Canada indicate that there is likely to be built a dam across the St. Lawrence at the head of the Long Sault Rapids which is to be 4500 ft. long and 45 ft. high, and will render possible the development of 600,000 h.p. The requirements of navigation are to be met by constructing a lock and channel, and the cost of the whole development scheme is estimated at $20,000.

Reports from Northern Mexico state that American capital has been interested to construct a power plant on the Pilon River, near Montemorelos, which will have an initial capacity of 15,000 h.p. and an ultimate capacity of 100,000 h.p. Power is to be disposed of in Monterey, distant 48 miles, as well as in Saltillo, Linares, Victoria and other places.

New York City's passenger traffic continues to increase at an enormous rate. From a recent report of the Public Service Commission, the subway figures for the last four months of 1909 are as follows:

September	20,796,207
October	23,489,467
November	23,193,014
December	25,401,182

For all the lines the total number of passengers carried in December was 128,881,160, as against 118,789,113 in December, 1908, an increase of nearly 9 per cent. The total revenues of the various companies for the month was $6,667,947.29, of which transportation revenue was $6,481,463.92.

Exposition Postponed

The German-American Exposition that was scheduled to be held at Berlin in June has been indefinitely postponed. Unexpected opposition, due to the jealousy of German manufacturers and landholders, has led to this result.

Curtis Turbine Used As Regulator

An interesting example of the effectiveness of a Curtis steam turbine when used as a regulator on a large power system is found in the new Oakland power-house of the Pacific Gas & Electric Company of San Francisco.

The installation consists of a 9000-kw. vertical type Curtis turbo-generator manufactured by the General Electric Company, eight 750-h.p. McNaull water-tube boilers and a Worthington condenser outfit, cooling surface, 20,000 sq. ft.

The 60,000-volt transmission system of the Pacific Gas & Electric Company entering Oakland is delivering more than 100,000 kw. during maximum demand. Of this amount, 20,000 kw. maximum are supplied to Oakland and immediate vicinity, the load factor being about 60 per cent.

While the new plant is of great value in carrying the local peak load during hours of maximum demand, it is almost continuously kept connected to the transmission system on account of the steadying effect on the voltage and consequent improvement in the lighting service. When acting as a regulator, the duty is especially severe, the turbine taking sudden momentary swings in load from 500 to 9000 kw. In a word, the action of this turbine on an alternating-current system is equivalent to that of a large storage battery on a direct-current system.

The ability of the Curtis turbine to successfully take these sudden fluctuations in load is due to the large flywheel effect (about ten times that of a reciprocating engine of equal capacity) close speed regulation, large radial clearances between moving and stationary steam-using elements, and sturdy mechanical construction.

This use of a Curtis team turbine is particularly interesting on account of the high economy obtained under varying load. Even when the turbine is operating as a regulator the overall economy of the plant is exceptionally good.

German Electrical Works Seeks To Emigrate

The Bergmann Electrical Works, of Berlin, Germany, said to be one of the largest concerns in the electrical business in that country, is coming over to Canada and is looking for a site in Ottawa. The company manufactures, among other things, the tungsten electric lamp. It is the intention of the German company to erect, as a beginning, a tungsten lamp factory for Canada in this city. The company desires in Ottawa a plant of 40,000 sq. ft., having its own water power of about 500 h.p., and a gas supply of 10,000 cu. ft. per day. The Bergmann concern has a capitalization of $8,000,000, and employs 6,000 workmen. It is the company's intention not only to erect electrical works in Canada, but also to extend its business operations in this country for the purpose of importing its different electrical goods and mechanical apparatus, which can now be done at a very low rate, owing to the abolition of the German surtax by the Dominion government. The company is said to have a very high financial standing both in the United States and in Europe.

A Mammoth Station For Chicago

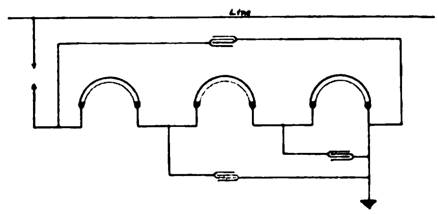
The Chicago Edison Company, in its Fisk Street and Quarry Street plants, already has a generating capacity of 120,000 kw. and 84,000 kw. respectively, to which must be added some 36,000 kw. in miscellaneous plant, giving it a total capacity of 240,000 kw. In spite of this, the company's load, which has doubled every three years for 12 years past, is such as to force a provision for more plant.

The management, therefore, has just purchased 109 acres on the north branch of the Chicago River, on part of which it intends to erect a pair of new turbine-driven plants having an ultimate capacity of 120,000 kw. each, which is to be provided by means of six turbo-alternators in each station of a continuous capacity of 10,000 kw. each. These turbo-alternators will be the largest machines yet attempted anywhere, but it would appear that they will be much needed, for it is estimated that the present annual output of the company is running between 500 and 600 millions of kilowatt-hours, and that it has every prospect of reaching a billion before the new plants will be ready for service.

A New Lightning Arrester

The mercury-vapor tube, already well known as a lamp and rectifying device, is also suitable for lightning protection, according to the claims of a patent recently issued to Mr. P. H. Thomas, in which an arrangement of tubes shown in the diagram is the principal feature.

The arrester group is connected to the line through an adjustable spark-gap, and the mercury-vapor tubes are shunted with condensers. Although the mercury-vapor tube does not admit of being set so that the discharge due to a rise in voltage shall be accurately predetermined, the device has certain special properties which are of importance in suppressing a flow of line current to the ground. This last is the function of the shunted tubes in this arrester.



MERCURY-VAPOR LIGHTNING ARRESTER

The operation of the arrester is as follows: After the breakdown of the spark-gap at high voltage, an abnormal charge is impressed between the terminal of the condenser connected across the line and upon the adjacent vapor tube. The condenser circuit can absorb only a limited portion of this quantity, so that if the discharge is sufficient in amount the adjacent vapor tube is broken down and conditions similar to the above are impressed on the next discharge circuits. Thus, in succession, all of the vapor devices will be discharged, thereby providing a direct path to ground. After the abnormal flow has ceased, the vapor tubes will reestablish their characteristic high resistance, thereby suppressing any tendency for a flow of the line current to ground.

A Novel Use For Electro-Magnets

By means of a large electromagnet built by the Cutler-Hammer Company, steel cargoes are being rescued from the bed of the Mississippi River for the first time.

The present experiment is being made near New Orleans, where a barge load of kegged nails is being raised. A load of cotton ties, sunk near Natchez, will be next taken up, while a load of woven wire, sunk near Pittsburg, will be the third task. All are property of the United States Steel Company.

The magnet used in the work is 3½ ft. in diameter, and weighs 3000 lb. It is dropped into the stream, the current turned on, and five or six kegs of nails raised to the lift. A derrick is employed for the purpose. The nails weigh 200 lb. to the keg, so the magnet lifts from 1000 to 1200 lb. each trial.

A great saving is being realized by the use of the magnet, which could not be otherwise effected. Were a dredge used, kegs would be broken open and much valuable material lost. In this way the kegs are raised intact, and the nails are uninjured, except for slight rust. Between 85 and 95 per cent. of the cargo can be raised. It is valued at $45 the ton.

The kegs are raised from a depth of 70 ft. The cotton ties are strips of steel, used in fastening cotton bales. They will be raised next.

The Bituminous Gas Producer

Among the electrical plants that are being driven by Westinghouse bituminous coal gas producers is that of the Amarillo Water, Light & Power Company, Amarillo, Tex., which has installed a Westinghouse bituminous gas-producer plant for supplying its 300-h.p. gas-engine-driven alternator set. This new bituminous type "T" producer is charged with coal costing from $3.50 to $4.75 per ton, and delivers fuel gas having a calorific value of 110 effective B.t.u. per cu. ft. The gas engine is of the single-crank horizontal type, with cylinder 18 by 26 in., and delivers 300 b.h.p. Three-phase, 60-cycle current, generated at 2300 volts, is used for local lighting and power in Amarillo. The tests in the experimental plant at East Pittsburg and in the installations now in service have proved the practical utility and economy of this bituminous producer for converting into gas the fuel properties of even such widely diverse materials as the leanest Texas lignite or the best Pennsylvania bituminous coal.

Other plants so equipped are those of the Southern Cotton Oil Company, at Montgomery, Ala., where there are two type T-50 producers supplying gas for engines totaling over 900 h.p.; at Bennettsville, Ga., which consists of a type T-35 producer and a 16 by 18 in. three-cylinder gas engine; and the new plant at Greenwood, S. C., where a 15 by 14 in. three-cylinder engine is being served by a producer.

In a paper recently presented before the Electrical Engineering Society of Columbia University, it was said that the 8000 passenger elevators in the Borough of Manhattan carry approximately 6,500,000 persons a day. According to the Public Service Commission, the number of passengers carried daily by the surface, elevated and subway cars in the entire city of New York is 3,500,000.

News Notes

The avalanche which crushed the two trains of the Great Northern Railroad at Wellington, Wash., near the west portal of the Cascade tunnel, on March 1st, carried with it three steam locomotives and four electric locomotives, the passenger station and the water tank. The service will be conducted temporarily with steam.

The Interborough Rapid Transit Company contracted last week with the Westinghouse Electric & Manufacturing Comany for four 3000-kw. rotary converters and twelve 1100-kva. air-blast transformers. These machines are duplicates of sets purchased last June. They are to be used to replace 1500-kw. converters, which will be installed in other substations.

The test of the new electric freight locomotive of the New York, New Haven & Hartford Railroad Company showed a speed of 50 miles per hr. between New York and Stamford. The trailing load consisted of a heavy freight engine and caboose and 30 loaded freight cars. Track conditions were far from good owing to a pouring rain rendering the rails very slippery.

It is stated that as soon as the necessary permission is obtained through the Quebec Legislature, the Montreal Street Railway Company will begin the construction of a subway under St. James Street. The subway will extend from the Champ de Mars to Victoria Square, in the heart of the city, and is intended to relieve the congestion from the present surface system. This section will cost $1,500,000, and will take a year to construct.

The Pennsylvania Railroad, anticipating an increase in the terminal congestion in Pittsburg, is seriously considering the question of electrifying the sections embraced between Pitcairn and Sewickly, about 28 miles in a direct line and an approximately equivalent mileage in branch lines.

The example of the Washington, Baltimore & Annapolis Electric Railway Company in changing over from single-phase operation to 1200 volts direct current has been followed by the Milwaukee Electric Railway and Light Company on its line from Milwaukee to Watertown.

With the change over from 25 cycles to 60 cycles of the United Railways of San Francisco, which was involved in the arrangement to use power from the plants on the Stanislaus River, there is released for the second-hand market one of the largest lots of electrical machinery ever thrown out at one time. In all there is about 25,000 kw., in detail as follows: One 1500-kw. Westinghouse rotary, one 1650-kw. Westinghouse air-blast transformer, five 1000-kw. General Electric rotaries, five 1100-kw. General Electric air-blast transformers, one 750-kw. Westinghouse rotary, one 825-kw. Westinghouse air-blast transformer, six 750-kw. General Electric rotaries, five 500-kw. General Electric rotaries, nine 185-kw. General Electric air-blast transformers and three 275-kw. General Electric air-blast transformers. A large portion of this apparatus is said to be entirely new, and some of it had never been installed. The original cost of the entire lot was in the neighborhood of $300,000.

Mica Duty Lowered

As the result of an objection made as to the tariff assessment made on a consignment of mica by the collector of customs at Plattsburg, N. Y., the duty on rough trimmed mica has been considerably lowered. The original tariff assessed against this mica was 10 cents per pound and 20 per cent. ad valorem.

The objection, which was sustained by the Board of United States General Appraisers, was made on the ground that the sheets were in no manner trimmed for use, but only with a view of eliminating the worthless parts.

New York Edison's Load

According to its recent report, the New York Edison Company had, on Jan. 1, 1910, a connected load as follows:

Incandescent lamps	3,590,887
Arc lamps	38,232
Heating appliances	1,218 kw.
Storage batteries	5,435 kw.
Motors	219,832 hp.
16-cp. equivalents	7,108,367

Following is the service supplied for city lighting: 5871 arcs, 450-watt, alternating-current series and multiple low-tension, direct-current, enclosed, $100 per lamp per year with sliding scale to minimum of $80 per lamp per year for a total of more than 15,000 lamps; 176 pairs of 450-watt arcs, $164.25 per pair yearly; 675 alternating-current series 60 c-p. tungsten lamps, company's equipment, $30 per year; 1996 multiple 60 c-p. tungsten lamps, city's equipment, $28 per year. Incandescent, arc and power service for public buildings is supplied at special city lighting meter rates of 7½ cents per kw-hr. for lighting and 6 cents per kw-hr. for power.

In the Borough of the Bronx the following service for street lighting is supplied: 1499 arcs, 2000 c-p., $100 per year, with sliding scale to minimum of $80 per lamp per year for a total of more than 15,000 lamps; 612 incandescents, 25 c-p., at $25 per year.

To supply this the company had power producing capacity as follows:

Boilers	109,620 hp.
Reciprocating engines	76,150 hp.
Steam turbine	121,000 kw.
Engine-driven alternators	38,500 kw.
Low-tension direct-current dynamos	10,200 kw.
Storage batteries	11,625 kw.

The total figures are considerably less than those for the Chicago Edison Company, given elsewhere in this issue.

The "Witham" Portable Testing Batteries

A neat form of portable storage battery for testing purposes is being manufactured by E. Marcuson, 136 Liberty Street, New York City.

Batteries of any voltage can be furnished, but at present three standard sizes are carried, viz.: 100 volt, 168 volt and 256 volt batteries, which weigh 16½, 27 and 40 lb., respectively. An idea of their compactness will be gained from the illustration, which shows a man carrying a 100-volt and

a 500-volt battery. A special commutating switch permits of charging from 110-volt direct-current mains.

These batteries are used principally for potentiometer work, calibration of instruments, insulation tests, etc., but they are also of great service to wiring contractors for testing the continuity of the various circuits and fittings before the main current is available, for, since the internal resistance of the batteries is low, comparatively high rates of discharge are possible, and an 8 c-p. or a 16 c-p. lamp can be fully incandesced for a considerable time.

Questions and Answers

Question.—*How can I determine the size of a tin-foil and paraffine-paper condenser to be of one-microfarad capacity?*

Answer.—Assume a convenient size for your sheets, as, for instance, 1 sq. ft., then the thickness of the dielectric in inches may be determined from the formula for such a condenser, which is

$$A = \frac{15458 \times M \times t}{K}$$

where A is the area in square feet, M the capacity in microfarods, t the thickness of the dielectric in inches and K the specific inductive capacity, which for paraffine paper may be taken as about 2. If the thickness of a sheet of paper is 1/100 of an in., we have for total area

$$A = \frac{15458 \times 1}{200 \times 1} = 77 \text{ sq. ft.},$$

which, if the sheets are 1 ft. sq., would require 77 sheets. Assuming that the foil was one-half the thickness of the paper or 200 sheets to the inch, the total thickness of the condenser would be 77/100 of an inch plus 77/200 or 231/200 in. The outside dimensions of the condenser would be 12 × 12 × 1.15 in.

Question.—*Why do the eddy current losses in a dynamo vary as the square of the speed?*

Answer.—The reason is that the eddy currents vary directly as the electromotive forces to which they are due, and these are directly proportional to the speed of the machine. The eddy current losses are c^2 r losses where c is the value of the eddy current and r the resistance of the eddy current circuits. The losses, therefore, are as the square of the speed.

Question.—*What is the best way to determine the candle power of a searchlight?*

Answer. The usual way is to measure it with a photometer at a safe distance from the reflector, taking it half-way between the center and circumference. The diameter of the beam at the same point should also be measured. Having measured the average candle-power at that distance, the total may be determined by multiplying the average by the square of the diameter of the beam and dividing by the square of the diameter of a circle having the same area as that of the effective crater.

For example, suppose a beam 12 in. in diameter coming from a 0.5-in. effective crater shows an average candle-power of 2000, then the total candle-power is

$$\frac{2000 \times 144}{0.25} = 1,152,000 \text{ c-p.}$$

This method of determining the power of the beam is rather empirical, and other and more refined and accurate methods have been devised, but are too complicated to give here.

Question.—*Please state exactly what is meant by the term "megohms per mile," as applied to the insulator resistance of covered conductors?*

Answer.—It means just what the term indicates, that the resistance of the insulation of the conductor is so many megohms or millions of ohms for each mile of its length. In other words, if the cable was immersed in a liquid conductor like mercury, for example, for a mile of its length and an electromotive force was applied to the metal cable and to the liquid conductor surrounding it, the resistance to the passage of any current, which is that of the amount of insulation submerged, would be found to be so many millions of ohms, or whatever the case may be. It can be easily measured with a voltmeter and known resistance, or a voltmeter and milliammeter, if the values of the resistance are not too great for the instruments.

Question.—*What limits the length and diameter of the core of an induction coil?*

Answer.—The length of the core is fixed by the lengths of the coil that is to be wound about it. Its diameter or area by the number of lines of magnetic force it is to carry. Beyond fulfilling these requirements, any greater dimensions are simply useless or wasteful.

Question.—*Is it best to insulate the frames of high-voltage alternating-current generators from the ground, or not?*

Answer.—It is mostly a matter of preference. We think it best not to so insulate the frame in most cases. In large direct-coupled machines it is expensive and difficult to insulate frames and keep them well insulated.

Question.—*Will a magnet act at all in a perfect vacuum? If so, will it pull as much as in ordinary air?*

Answer. Why not? As there is no air to resist the movement of the armature it might even be said to be able, theoretically, to pull a little more.

Question.—*Why does the voltage from an ordinary alternator go down after it has carried its full load for a while?*

Answer.—The only reason that it might do that is because of the heating of the armature and field coils reduces somewhat the exciting and armature current.

Question.—*Is a water rheostat the most convenient means of handling the current of a good-sized generator in running a test?*

Answer.—Not in our experience. We have found the best device for this purpose to consist of a water-cooled rheostat, which was far more compact, handy and constant in its resistance than any water rheostat. Figure out your necessary resistance and get iron wire and coil up enough to give you the required amount, remembering to make an allowance for the increase in the resistance when hot. Place your coil in a barrel and run cold water through a pipe in at the bottom of the barrel, and let the hot water flow off at the top. The wire will then carry satisfactorily and steadily currents of an intensity that would melt it in a few seconds in the open air. If it is desired not to ground the circuit under test, a few simple insulating precautions are necessary in connection with the mounting of the rheostat and its water supply. A simple calculation based on the fact that a kilowatt-hour equals 3412 British thermal units, or equals 22.8 lb. of water raised from 62 to 212 degrees fahr. will enable you to determine how much water you will need to dissipate a given kilowattage.

Question.—*Would connecting up the fields of a 1000-volt alternator in such a way as to double the current in them make it generate 2000 volts?*

Answer.—No. The voltage generated with the intensified field would depend on many other conditions, such as the degree of saturation of the field iron, the armature reaction, etc.

Question.—*How much of a drop in voltage will it take to make a synchronous motor pull "out of step"?*

Answer.—The amount of under-voltage that a synchronous motor can stand without quitting its business depends on the design of the motor. Also on the load it is carrying. If the make of the motor is known, the manufacturer will supply the information. Speaking generally, motors with a small air gap and low saturation will stand greater voltage drops without falling out of synchronism than ones with opposite characteristics. Some may endure a drop of 25 per cent., or even more.

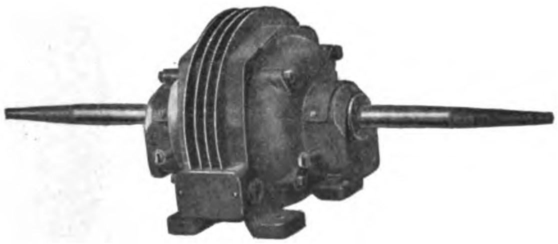
General Electric Alternating-Current Grinding and Buffing Equipments

In the present age of mammoth manufacturing establishments, "intensified" production, and high-paid skilled workmen, it becomes imperative that facilities be provided for utilizing both the tools and the employees' time most efficiently, in order to secure with a given equipment the maximum output, accompanied by the highest possible grade of workmanship. Electrically operated devices, which at once expedite the work and improve the quality of the product, are meeting with a wide application, due to the many advantages of electric control and operation.

The General Electric Company's new and improved types of alternating-current buffing and grinding equipments are designed for use in woodworking, machine and repair shops, foundries, large manufacturing establishments, etc., where alternating current is available.

GENERAL ELECTRIC GRINDING EQUIPMENTS

The General Electric grinding equipment consists of an alternating-current motor with substantial supports fitted with tool rest and water attachment; these latter accessories being rigidly clamped to the bearing brackets in such manner as to permit ready removal when desired.



GENERAL ELECTRIC BUFFING EQUIPMENTS

These self-contained, compact and rugged buffing equipments provide a very effective polishing device, the each end being tapered and threaded use of which invariably results in a great saving of time and labor. These devices are similar in construction to the grinding outfits, with the exception that tool and water attachments are omitted. The shaft is also longer, for receiving the buffs. The bearing brackets are circular and so designed that they may be turned through 90 deg. to admit of side-wall installation, thus allowing relocation of the device at will.

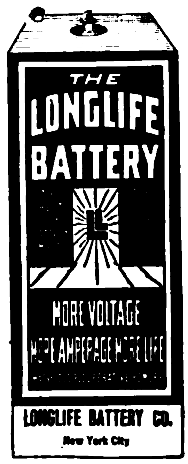
These devices find a ready application for dressing small castings, accomplishing the work much more quickly and giving a finer finish than can be obtained with machine tool, chipping hammer, chisel, etc.

Sale of Storage Battery Patents

It is announced that the patents and rights of the Westinghouse Storage Battery Company have been sold to the Electric Storage Battery Company of Philadelphia. The Westinghouse Storage Battery Company owned all the rights of the General Storage Battery Company and all the storage battery rights and interests of the Westinghouse Machine Company. Henceforth the sole rights to make these batteries will belong to the Electric Storage Battery Company.

An Improved Dry Battery

The "Longlife" Ignition Battery is the latest type of portable dry battery. It registers from 30 to 35 amperes, and has an electromotive force over 2 volts. To put at rest any objections raised against the life of such a high amperage battery, it is guaranteed without qualification that it will last for a period of ninety days on the shelf.



Another feature of the battery is the fact that it is wrapped in a square carton; this prevents rolling when the connections are made, insuring perfect contact unless voluntarily disconnected at the wish of the operator. All batteries are uniform throughout, are strongly built and do not rattle. This battery is made by The "Longlife" Battery Company, 808 East Fifth Street, New York.

Growth of The Steam Turbine Business

A recent sales report of the Steam and Electrical Department of the Allis-Chalmers Company shows how favorably the steam turbine has been received as a prime mover by users of power. A little over four years ago the company obtained the right to manufacture in this country the latest improved type of Parsons machine. The end of the first year saw only one unit in operation; but, since then, there has been a steady and rapid growth in sales, which has reached a total capacity of over 300,000 h.p. Of this aggregate 48.2 per cent. were sold during 1909 and 20.6 per cent. have been placed on orders since January 1, 1910. A large proportion of the units have been for use by power, lighting and railway companies, and approximately 40 per cent. of the total sales were for this purpose, textile manufacturers being next with 14 per cent. of the machines. Practically every type of industrial enterprise is represented in the buyers of these turbines, including gas plants, cement mills, mines, lumber mills, flour mills, paper factories, tanneries, celluloid works, etc. In geographical distribution the machines are to be found in nearly every State in the Union and also in Canada

The Public Service Commission has filed an order on the Coney Island & Brooklyn Railroad directing it by October 15 to equip all closed passenger cars with wheel guards, and by July 1 to equip all open passenger cars with wheel guards or platform trip fenders to be approved by the commission. Commissioner Maltbie said that the matter of fenders and wheel guards is one of the most important considered by the commission and that at the time the commission took office, companies operating surface cars in New York City were incuring expenditures for injuries, damages and legal expenses amounting to $3,500,000 a year.

A New Invention

A new development in the care of metal work is the invention of an article known as "Electroline," which, in addition to possessing exceptional cleaning properties for nickel and silver, actually replates worn parts with pure silver. Possibly the most remarkable feature of the product is the fact that it contains no mercury or acids and is absolutely non-injurious

The March Technical Press

Leading Articles of General Technical Interest

Commercial

"Commercial Motor Service Rates and Their Effect on Station Economy," A. E. Walden. A discussion, reinforced with curves and tables, of best methods of building up central station power business. The writer concludes that in cases where the load is well diversified and proper conditions imposed on motor installations, the power load may be carried on the same circuit as lighting load. This is the usual practice.—*Elec. Wld.*

"Development of the New Metropolitan Street Railway." An instructive study of the work of reorganizing and reconstructing the Metropolitan Street Railway of New York which went into the hands of receivers in 1907. The story of this undertaking is of especial interest as being an instance of the reversal of the schemes of combination that have built up the traction industry in this country to its present proportions. The causes that led to the break-down of the New York consolidations are too well known to need repetition. In the two years of receivership management the condition of the segregated property has been greatly improved in every respect. This has been made possible largely by ruthless defaulting on the notes and rentals with which the company was loaded up, thus relieving the property of fixed charges amounting to over $8,000,000 a year.—*Elec. Ry. Jour.*

Detail Apparatus

"Application of Oscillograph to Study of Operation of Mercury Rectifiers," Y. Saki. Gives the methods of investigating the performance of the rectifier with many curves, as obtained by the instrument, showing the effects of different circuit conditions.—*Elec. Jour.*

"Large Artificially Cooled Transformers," E. R. Pearson. A brief description of some of the recent developments in the design and construction of large capacity transformers and of the steps leading up to them. According to the writer, the highest voltage transformers in commercial use are the six single-phase 3750-kw. units of the Stanislaus Power Company, in California, which are designed to work at 138,500 volts, star connected, and were tested for 280,000 volts.—*Elec. Wld.*

"Impregnation of Coils with Solid Compounds," J. R. Sanborn. A study of the improved processes of coil insulation, with a description of the methods of applying them and of testing their properties, such as melting point, fluidity hardness, penetrative power, etc.—*Elec. Jour.*

"Tubular Electric Condensers," A. D. Budd. A description of a new line of condensers recently produced in Germany which is made of specially prepared paper wound up with strips of foil. The result is a condenser somewhat resembling a mailing tube and apparently of great capacity and durability.—*Elec. Wld.*

Electric Railways

"The Development and Design of the Electric Locomotive," T. Rich. A very complete and copiously illustrated historical account of the evolution of the electric locomotive for railways. The article is particularly rich in outline illustrations and general data of the many types used abroad, as well as those in this country. From a table, which is probably complete for the principal commercial locomotives built between 1895 and 1910, it is shown that no less than 23 different types have been produced, of which the general data, as abstracted, shows the following:

TABLE OF ELECTRIC LOCOMOTIVE DATA.

Date	Manufacturer	Railway	Type of Current	Voltage	Motors and Rating	Weight in Tons	HP Per Ton
		GEARLESS					
1890	Mather & Platt	City & South London	Direct	500	2 100	13	7.7
1895	General Electric Co	Baltimore Tunnel	Direct	600	4 1440	96	15.5
1901	Ganz & Co.	Valtellina, Italy	Three-phase	3000	4 900	46	19
1905	Westinghouse Co.	New York, New Haven & Hartford	Single-phase	*11000	4 1000	77	13.1
1905	General Electric Co	New York Central	Direct	600	4 2200	95	23.2
		GEARED					
1905	British Westinghouse Co.	London Metropolitan	Direct	600	4 1000	50	20
1907	British Thomson-Houston Co	London Metropolitan	Direct	600	4 960	47	20.2
1905	British Thomson-Houston Co	London Metropolitan District	Direct	600	4 800	38	21
1909	Dick, Kerr & Co	British Columbia Electric	Direct	600	4 640	50	12.8
1906	Siemens-Schuckert Co.	Mazieres Minerals	Direct	2000	4 640	55	11.6
1908	General Electric Co	Great Northern Tunnels	Three-phase	6000	4 1600	102	15.6
1908	Algemeine Co.	Prussian State	Single-phase	6000	3 1050	59	17.8
1907	Siemens-Schuckert Co.	Seebach-Wettingen	Single-phase	15000	6 1350	79	17.1
1909	Westinghouse Co.	New York, New Haven & Hartford	Single-phase	11000	4 1400	116*	12
		CRANK AND GEAR					
1899	Brown, Boveri & Co.	Bergdorf Thun	Three-phase	750	2 300	29	10.3
1901	Oerlikon Co.	Seebach-Wettingen	Single-phase	15000	2 400	42	9.5
1910	Siemens-Schuckert Co.	St. Polten-Mariazell	Single-phase	6600	2 500	48	10.[illegible]
		CRANK AND GEARLESS					
1904	Ganz & Co.	Valtellina, Italy	Three-phase	3000	2 1200	62	19.4
1907	Brown, Boveri & Co.	Simplon Tunnel	Three-phase	3000	2 1100	62	17.7
1909	Brown, Boveri & Co.	Simplon Tunnel	Three-phase	3000	2 1700	68	25
1910	Italian Westinghouse Co.	Italian State	Three-phase	3000	2 2000	60	33.3
1909	General Electric Co	Experimental	Single-phase	*6600	2 1600	..	..
1910	Siemens-Schuckert Co.	Baden State	Single-phase	10000	2 1000	62	16.1
1909	Westinghouse Co.	Pennsylvania Tunnels	Direct	600	2 4000	149	26.8

*Also capable of operation on 600 volt direct current.

This data furnishes a fair illustration of the advance of electric locomotive design in 20 years.—*Cass. Mag.*

"Multiple Unit Trains on the New Haven Road." A short illustrated description of the first multiple unit trains to be operated by the New York, New Haven & Hartford Railroad Company. The motor cars weigh somewhat over 85 tons and are designed to haul two 50-ton trailers. The equipment consists of four 160-h.p. single-phase geared motors, with Westinghouse multiple-unit control designed to operate on the company's 11,000-volt overhead circuit or 600-volt third rail. The accelerations reached with a three-car train averaged 0.5 miles per hr. per sec. up to 25 miles an hour. The trains are in operation between New York and Port Chester.—*Elec. Ry. Jour.*

Measurements and Tests

"Commercial Electrical Testing," E. F. Collins. A continuance of the series on this subject. Very complete data, including curves, diagrams and tables, on the tests of railway motors is the feature of this instalment.—*Gen. Elec. Rev.*

"The Magnetic and Electric Properties of Iron-Silicon Alloys," C. F. Burgess and J. Aston. A series of measurements and tests of the magnetic and electrical properties of various iron-silicon alloys made in the engineering laboratories of the University of Wisconsin under a grant from the Carnegie Institute. This is a companion test to the investigation of similar properties for the alloys of iron and nickel noticed in a previous issue. Full curves and tables are given. It is shown that, with bars of commercial steel free from silicon and bars of the same steel alloyed with a little less than 5 per cent. of silicon, the magnetic properties of the latter were considerably better while the electrical resistance was nearly five times as great. Thus in the two prime requisites for transformer steel, viz.: high magnetic conductivity and high electrical resistance, these silicon alloys are especially suitable.—*Metal and Chem. Eng.*

Power Plants

"Electrical Plant of Hudson and Manhattan Railroad Company," H. Hazleton. A brief illustrated description of the power plant of the company operating the subway and tubes uniting New York with New Jersey. This plant consists of four medium-sized 11,000-volt turbo-alternators, and is now operating about 140 cars, as well as the lighting and ventilating equipment.—*St. Ry. Jour.*

"Power Plant of Merchants' Heat and Light Company." An account of a recently completed power plant at Indianapolis which is a good example of up-to-date plant construction for a special case where the furnishing of heat forms an important part of the plant's output.—*Elec. Rev.*

"The Johnsonville Hydro-electric Development of the Schenectady Power Company," J. Liston. A description of the water-power plant of this company. It is interesting as a fine example of up-to-date practice in plants of a medium size (3600 kw.) and operating under a medium head (35 ft.).—*Gen. Elec. Rev.*

Prime Movers

"Elementary Theory of the Steam Turbine," W. E. Snow. The explanation of the principles on which the design of the various types of turbines is based is the subject of this instalment of the serial.—*Power.*

"Development of the Hydraulic Turbine in America," H. B. Taylor. An interesting illustrated account of the way in which the American turbine builders have brought their output up to its present stage of perfection. The coming of the high-head turbine and the influence of design on durability, particularly with respect to erosion, are given special attention. Recently the turbine has been put to work under head of more than 600 ft., and the efficiency has been brought up to over 90 per cent.—*Eng. Mag.*

"Most Powerful Turbines Ever Built," H. B. Taylor. An illustrated description of the huge water turbines built for the Feather River plant of the Great Western Power Company at Oroville, Cal. These machines, of which four of 18,000 h.p. each have recently been installed and tested, have several features of special interest. They are by far the largest in point of power developed in a single runner or any other way. They are also among the most efficient, as the tests given below will indicate. They operate under a 525-ft. head, and are designed in such a way as to practically eliminate erosion or pitting of the vane surfaces. The machines are of the vertical shaft, single-runner, inward-flow Francis type, operating at a speed of 400 rev. per min. The weight of the revolving parts of turbines and generator, amounting to about 145,000 lb., is borne on an oil-filled thrust bearing.

Efficiency tests of four units under a head of 4200 ft., or 0.8 of that for which they are designed, showed the following:

Unit No.	1	2	3	4
Per cent. load	87	90	93	91.5
Maximum efficiency	87	87	88.2	89

These load percentages are based on 14,000 h.p., which would be full load for the present head. Upon completion of the dam, the ultimate head of 525 ft. will be attained. With this head at a full gate it is calculated that each turbine can deliver 20,000 h.p. to the generator which it drives.—*Power.*

"The Gas Turbine," A. W. H. Griepe. An illustrated description of several types of gas turbines recently proposed here and abroad, including one devised by the writer.—*Power.*

Theory

"Commutation," F. W. Carter. Another contribution to the somewhat voluminous series of mathematical treatment of commutation phenomena. This discussion treats specially of the contact resistances and their part in the process. Good results are claimed to have been produced in some cases by filing the toe of the bench in such a way as to serrate it, thus altering the local current density.—*Elec. Wld.*

"Static Strains in High-Tension Circuits," P. H. Thomas. This is a revision of the well-known paper delivered before the American Institute of Electrical Engineers in 1902.—*Elec. Jour.*

"Transmission Line Calculation," M. W. Franklin. Continues the presentation of the calculation of the characteristics of transmission lines. This chapter deals with the finding of a section of maximum economy for lines on the basis of annual interest equal to annular loss. The method used is developed at length by another writer in a recent issue of the ELECTRICAL AGE.—*Gen. Elec. Rev.*

"Voltage Regulation of Stationary Transformers," E. H. Acton. A presentation of the phenomena of voltage regulation in transformers by means of the usual vector diagrams. The discussion is intended to derive formulas for calculating regulation and to show that in good commercial designs the regulation is practically independent of the exciting current.—*Elec. Wld.*

Utilization

"Electricity in a Modern Restaurant," T. I. Jones. Tells of the many useful and decorative uses to which electricity is put in one of New York's high-class restaurants.—*Elec. Wld.*

"Electricity in Puget Sound Dredging," A. E. Ranson. An illustrated description of the electrically operated suction dredges used in the Puget Sound country, with some figures regarding their performance.—*Elec. Jour.*

"Ice Making and Steam Heating by Small Central Stations." A study of the effort of a small (290 kw.) central station in the Middle West to build up auxiliary business and keep up the load factor on its plant. Well worked out, with full figures on investment and returns.—*Elec. Wld.*

"The Heroult Electric Refining Furnace," J. B. C. Kershaw. A brief description of the results of the first few months' operation of the steel refining furnace of the United States Steel Corporation at South Chicago. The plant is employed in turning ordinary Bessemer steel into high-grade steel for rails, car wheels and axles. The present capacity of the plant is 170 tons per day. The quality of the output is said to be 20 per cent. better mechanically than that of steel of the same chemical composition produced by the ordinary open-hearth process. The power consumption is about 150 kw-hr. per ton, and the cost of production is said to be less than that of the old method.—*Elec. Rec.*

Miscellaneous

"Regulation of Percentage of Carbon Dioxide in Furnace Gases," E. A. Barnes. Some practical points on the determination of the proportion of the above gas in the gases escaping from under a boiler, and the methods of regulating it so as to secure the least combustion.—*Gen. Elec. Rev.*

"Liability for Injuries from Electrical Machinery," J. L. Brady. A review of the trend of recent court decisions as to responsibilty of railway and industrial companies where their employees are injured. The usual uncertainty of American law in this respect is well illustrated in the cases cited.—*Elec. Wld.*

Comparative Estimated Costs of Steam and Gas Engine Power Plants

In a report upon the power situation in a large manufacturing plant, recently made by Mr. F. W. Dean, of Boston, the question of the relative first cost and running costs of steam and gas engine plants was worked out with the following results:

ESTIMATED FIRST COST 1000-HP STEAM PLANT.

Engine and condenser, $20 per horse-power.	$20,000
Foundations, $5.50 per horse-power.	5,500
Generators, $12 per horse-power.	12,000
Boilers, $7.50 per horse-power	7,500
Smoke flue, 75 cents per horse-power	750
Chimney, $2.50 per horse-power	2,500
Heater, $1 per horse-power	1,000
Pumps, 50 cents per horse-power	500
Buildings, $20 per horse-power	20,000
Total cost	$69,750

The cost per horse power is thus $69.50. The annual cost of operation was figured as follows, assuming 310 days of operation at nine hours per day:

The fuel consumption was based upon a steam plant consuming 1.75 lb. of coal per hp-hr., with a steady load during the hours of service.

The installation cost of a gas-producer electric plant consisting of two 300-kw. generators and engines, with anthracite producers, was figured at $67,500, which Mr. Dean considered substantially equivalent to a plant of 1000 i.h.p. The gas engines were to be of the horizontal, double-acting type, and the generators were taken as 220-volt, 60-cycle machines, with two exciters included. The installation cost was estimated as given below.

ESTIMATED FIRST COST 600-KW GAS-ENGINE PLANT.

Two gas engines	$21,000
Two 300-kw generators	6,600
Two exciter sets	3,000
Two anthracite producers	7,700
Freight and erection	3,800
Foundations	1,100
Buildings	20,000
Contingencies	4,300
Total	$67,500

The total fuel consumption was figured at 1786 tons for the year at a cost of $2.25 per ton in the locality

ANNUAL OPERATING COST PER HORSE-POWER, STEAM PLANT.

Fixed charges, 13 per cent. of $69.75	$9.07
Attendance	3.21
Oil, waste and supplies	.21
Fuel, 2,241 tons, at $2.75 per horse-power	6.71
Total	$19.19

where the plant was situated. As with the steam plant, operation for nine hours per day at steady load and for 310 days per year was assumed.

In view of the resulting close annual cost of the two plants per horse power, the report concluded with the recom-

ESTIMATED COST OF OPERATION, GAS-PLANT.

Fixed charges on plant, 14 per cent. of $57.50 (per horse-power)	$9.45
Attendance per horse-power per year	3.21
Oil, waste and supplies	.50
Coal, 2 lbs. per kw-hour, including stand-by losses	4.02
Total	$17.18

mendation that the establishment install the steam plant on account of its greater reliability and the more common experience which it has enjoyed.

Arc Lamp Illumination for Railway Shops

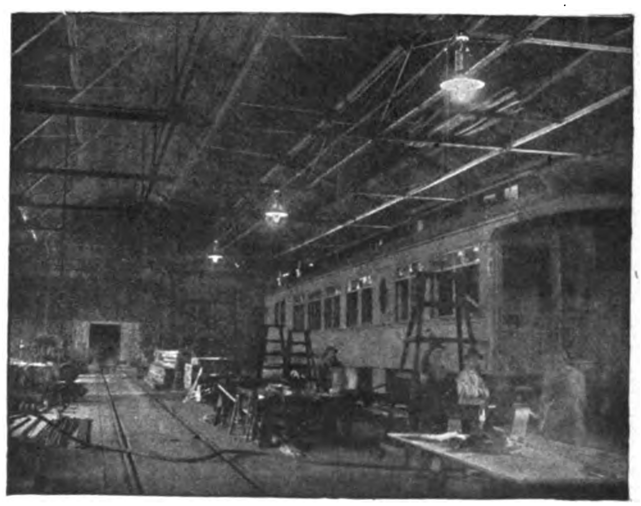
For the illumination of railway shops and train sheds arc-lighting practice has practically settled on indoor lamps, using approximately 5 amperes and 80 volts at the arc for direct current, and 6 amperes and 70 volts at the arc for alternating current. However, in some cases where operating conditions demand it, as in low-studded ceilings and rooms with objects throwing heavy shadows, enclosed arc lamps give better distribution and more even illumination with a rating of 3 amperes and 80 volts at the arc for direct current, and 4 amperes and 75 volts at the arc for alternating current.

The laying out of a lighting equipment for economical and efficient operation on indoor service demands careful attention. In every case the fundamental fact of illuminating engineering comes up, namely, that the proper utilization of light is quite as important as the production.

In order to determine the number of lamps for the lighting of any given area, it is not only necessary to know the exact area, height of ceilings and objects to be illuminated, but considerable attention should also be given to surroundings, because very frequently the color decorations and tinting of the walls play an important part. For instance, a dark wall absorbs more, and consequently reflects less light than a white one. On this account the personal experience and judgment of the illuminating engineer have to be considered important factors. Besides these varying conditions, there enters into consideration the source of energy that is available. This, however, due to the development of the enclosed carbon arcs both for direct- and alternating-current circuits is not a serious factor, for both types of lamps give good service.

The following illustration shows alternating-current installations at the Western of Alabama Railway Shops at Montgomery, Ala.:

For the inside shop service a 7½-ampere, 110-volt alternating-current lamp is used. This lamp is trimmed with one solid and one cored carbon, which remedies the unsteadiness resulting when two solid carbons are used. The installation is a typical one, using the latest types of the enclosed carbon arc lamp. These lamps have been in service for some time, and burn with a regular trim of about 100 hours. The layout of the system



ILLUMINATED RAILWAY SHOPS.

was very carefully planned by the illuminating engineers of the Western Electric Company, which company also supplied the lamps and transformers.

The other type of lamp which is used for illuminating the train sheds is a 6-ampere, 110-volt series, alternating. This lamp when not in service stands cut out, so that when the lamp is switched on and the current enters it a portion of the current is shunted through the starting resistance, thereby energizing the series magnets which open the path of current through the starting resistance. Since the entire current now passes through the series magnets, the carbons are separated and the arc established. When the voltage rises above normal the shunt magnet becomes more strongly energized, and by bringing the cut-out contacts into engagement short-circuits the arc. The winding of the shunt magnets is such that by connecting the coils in series the lamp can be operated on 60-cycle circuits, while by connecting the coils in multiple the lamp can be operated on 125-cycle circuits.

High-Tension Disconnecting Switches

As central-station capacities increase additional precautions must be taken to guard against accidents which will cause complete shut-downs, as continuity of service is of prime importance. A practice which is rapidly growing in favor is to place disconnecting switches in series with the bus-bar side of high-tension oil circuit-breakers or switches so that in case it becomes necessary to adjust or inspect the breaker mechanisms this can be accommmplished without danger to the operator. Another useful feature is that should the oil-breaker prove defective or develop short-circuits within itself the trouble can be localized by opening the disconnecting switches.

In high-tension lightning arrester installations the use of disconnecting switches is absolutely necessary, if it

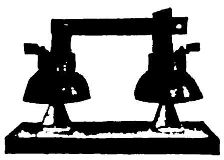


Fig. 1—DISCONNECTING SWITCH — STANDARD TYPE.

is desired to maintain the arresters in operative condition. By locating the switch between the line and arrester section a circuit can be opened and the units being entirely disconnected can be safely cleaned, inspected and adjusted.

Sectionalizing of high-tension bus bars is also most economically effected by location of disconnecting switches in the bus-bar compartments. Where the bus bars are carried through trenches of concrete or brickwork the switches can be secured to the floor or side walls, as desired.

When it is desired to mount disconnecting switches on cross-arms or poles the type employing petticoat insulators should be used in order to secure a permanently high insulation factor. For such service the supporting base is made of iron and so treated that it will not be effected by weather conditions.

Fig. 1 illustrates the standard type employing petticoat insulator and Fig. 2 illustrates the pillar type for use in switchboard construction or inside the station. A further development of the latter type of switch is shown in Fig. 3, which is a combination front and back connected device. For use where pipe framework construction is employed the switch shown in Fig. 4 is used and, as will be noted from the

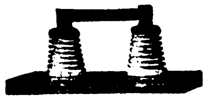


Fig. 2—DISCONNECTING SWITCH—PILLAR TYPE.

illustration, is provided with suitable clamps and grips for attaching to the iron framework.

While the standard types described above are usually employed, it frequently becomes necessary to design special types of such dimensions that they will not interfere with existing apparatus, the physical arrangement of which cannot be changed. A recent

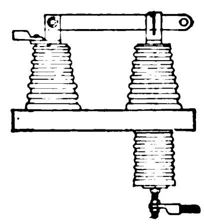


Fig. 3—DISCONNECTING SWITCH—REAR CONNECTED.

requirement for combination high-tension transfer and disconnecting switches in combination with choke coils was met by the design illustrated in Fig. 5.

The lower switch is of the single-pole, single-throw type and is arranged to be connected in series with the lightning arresters, thus permitting the arrester circuit to be opened for inspec-

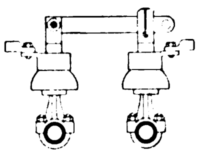


Fig. 4—DISCONNECTING SWITCH—PIPE MOUNTED.

tion and replacement of arrester units. The upper element of the device consists of double-blade, single-pole, double-throw transfer switch, enabling connection to be made to either the upper or lower contacts, as desired.

The use of the choke coil is obvious and its location on the switch studs effects an important saving in space. By the use of a double set of lever blades and contacts it is possible to transfer the circuit without interrupting or subjecting the switch to destructive arcing.

The switch is a combined front and back connected device and the lever blades are provided with off-set extensions, thus permitting them to be

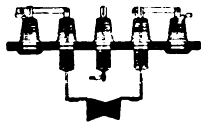


Fig. 5—DISCONNECTING SWITCH—COMBINATION TYPE.

operated in the usual manner by means of an insulated pole or hook.

The switches described above are being marketed by the Delta-Star Electric Co., Chicago, Ill. They are made in various ampere capacities to meet commercial conditions, and in all voltage capacities up to 110,000 volts.

A Big Water-Power Plant For Alabama

The Alabama Power Company, made up to a great extent of Alabama capital, has camped its corps of men on the bank of the Coosa River, 50 miles from Montgomery, to construct the big dam, No. 12, that will furnish the State with 50,000 h.p. in hydro-electric drive. The undertaking promises great things for Alabama's future manufacturing interests. The utilizing of the great power of this river supplied from a water shed of thousands of square miles in three States, has been an Alabama potentiality which has been wasted. The work is under way now, and the first 50,000-h.p. dam is only the beginning, for there are to be five more of the dams, supplying enough water-power to furnish all of Alabama with electric driving power.

The World's Petroleum Production

According to a German authority, the world's production of petroleum in 1908 amounted to 38,052,233 tons. In 1907 35,032,235 tons were produced. There was thus a material increase. The production in tons for the two years, itemized by countries, is given below. The United States is credited with an output about three times as great as that of any other country:

Country.	1908	1907
United States	23,942,997	22,149,862
Canada	70,400	105,200
Mexico	464,188	133,855
Peru	134,824	8,732
Russia	8,291,526	8,247,795
Dutch India	1,143,243	1,116,946
Galicia	1,754,022	1,175,974
Roumania	1,147,727	1,129,097
British India	672,938	579,346
Japan	276,124	268,129
Germany	141,900	106,379

Legal Notes

An important decision was lately made by the Reichsgericht (Supreme Court) of the German Empire regarding the rights of American holders of German patents. The patent laws of Germany require that the holder of a patent must exercise the rights conferred to an adequate extent within a given time, or else lose the patent. The treaty which went into force last year between the United States and Germany, as interpreted by the decision, frees American holders of German patents from the operation of this law on the ground that as there is no such clause in American patent law, they are entitled to that privilege, as the German holders of American patents of course would be. The decision, while eminently impartial, liberal and broadminded, is naturally resented in Germany, where it is pointed out that a German owning patents may evade the working clause by assigning the patents to an American.

In an action of the City of Milwaukee against the Milwaukee Electric Railway & Light Company to compel the latter to sprinkle between its tracks and one foot outside the outer rails, in compliance with an ordinance passed some years ago, the city won. The company will appeal the case to the Supreme Court.

Judge Smith McPherson, sitting in the United States Circuit Court of the St. Louis district, handed down an opinion March 4th, in the Wagner Electric Manufacturing Company's suit against the Century Electric Company covering alleged infringement of the Wagner single-phase motor patents; three patents were involved. The decision was favorable to the Wagner Company, every patent claim in the suit being sustained. The decision calls for an injunction against manufacture and sale, and an accounting for damages and profits, and appoints a master to take the testimony of the accounting.

Application was made by the Century Company to suspend the injunction pending an appeal to the United States Court of Appeals.

When two companies engaged in enterprises calling for the use of wires to carry electricity arrange for the joint use of a pole to sustain them, each company, the Supreme Court of Ohio holds, in Cincinnati Gas and Electric Company *vs.* Archdeacon, is, with respect to such use, charged with the same duty toward employees of the other as to its own, and the correlative duty of the employees to exercise due care for their own safety is the same as to both companies. There can be no recovery against an employer for an injury to an employee which he would not have sustained if he had not voluntarily and unnecessarily used an appliance for a purpose other than that for which he knew it to be intended.

Financial

According to the *Wall Street Summary*, there has recently been a great improvement in the earnings of public utility companies. The comparison of the earnings of 21 electric lighting and traction companies for January, 1910, as compared with those for the same month last year, shows average increases as follows: gross, 13.19 per cent.; net, 19.2 per cent.

A number of plants in Idaho, Oregon and Northern California, now owned by the Northwest Corporation and valued at $10,000,000, are to be taken over by the Electric Bond and Share Company.

The entire issue of first mortgage 5 per cent. bonds of the Southern Power Company, amounting to $3,000,000, has been sold.

The following Michigan hydro-electric companies are to be merged with the Commonwealth Power Company of Jackson, Mich.:

The Grand Rapids - Muskegon Power Company, the Grand Rapids Edison Company, The Pontiac Light Company, the Flint Electric Company, the Bay City Traction & Electric Company, the Bartlett Illuminating Company, and the Ausable electric light plant. The title of the new concern will be the Consumers' Power Company, and will involve the increase of the stock of merging company from $7,500,000 to $12,000,000 and the issuing of $35,000,000 of bonds.

A foreclosure sale of the property of the Third Avenue Railroad Company took place at the county court house in New York. There was but one bidder, namely, the Reorganization Committee, representing the holders of the $37,560,000 mortgage bonds issued in 1900. The entire physical property was bid in at $26,000,000. This sale wipes out the stock of Third Avenue, so far as any legal standing is concerned.

The Pacific Light and Power Corporation has been formed at Los Angeles, Cal., with a capitalization of $40,000,000, to take over the properties of the Pacific Light and Power Company, subject to outstanding bonds. The stock consists of $5,000,000 in first preferred stock, $10,000,000 in second preferred stock and $25,000,000 in common stock. The proceeds of the first million and a half dollars of the preferred stock sold will be used for the construction of a 10,000-kw. plant at Redondo, Cal., and for constructing distributing lines and other betterments, as well as for the taking up of the outstanding indebtedness of the Pacific Light and Power Company. Later, bonds to the amount of $40,000,000 will be issued to cover the bonded indebtedness of the old company and to make extensions.

A Southern Road Abandons Single-Phase Operation

After operating for nearly two years on a 6600-volt, alternating-current, single-phase system installed by the General Electric Company, the Washington, Baltimore & Annapolis Electric Railway has abandoned single-phase operation for high-voltage direct current. The change, which involved new car equipment throughout, as well as the installation of the usual direct-current substations at Ardmore, Naval Academy Junction, Annapolis and in Baltimore, was accomplished without a hitch.

The reason given for the change is that the 60-ton single-phase cars were too heavy to be operated on the underground trolley lines of Washington. The new direct-current passenger rolling stock is equipped with four 140-h.p., 600-1200-volt motors of the commutating pole type, with two motors permanently connected in series, and run directly through from the company's terminals in the heart of Baltimore to the Treasury Building in Washington. The change is said to have resulted in a decrease in the current consumption of 25 per cent., which is largely due to the use of lighter cars.

Examination For Assistant Physicist

The United States Civil Service Commission announces that an examination will be held on April 20, 1910, to secure eligibles for positions of laboratory assistant (in physics) and assistant physicist in the Bureau of Standards, Department of Commerce and Labor, at salaries varying from $900 to $1,200 per annum for laboratory assistant and from $1,400 to $1,800 per annum for assistant physicist.

The duties in connection with these positions are similar to those of assistants in the physical laboratories of scientific and technical institutions.

Business Notes

The well-known firm of Pierson, Roeding & Company, of San Francisco, Seattle and Los Angeles, has been appointed sales agent for the Pacific Coast of the Electric Storage Battery Company, of Philadelphia.

The United States Brake Shoe Company has located its general offices at 431 White Building, Buffalo, N. Y., to which address all communications should be sent.

Mr. Walter B. Snow, publicity engineer, 170 Summer Street, Boston, Mass., announces that his office facilities have been more than doubled by removal to more commodious quarters, in the same building; also that Mr. Benjamin Baker, A. B., formerly of *The Boston Transcript*, and late editor of *The Navy*, and Mr. Herbert M. Wilcox, S. B., chemical engineer, experienced in various industries, have been added to his staff.

F. S. Pearson & Co. have recently shipped to Brazil 800 American-made arc-lamp poles for use in Rio de Janeiro. The poles are of the New York Edison "Broadway" type made by the J. L. Mott Iron Works, and were purchased in competition with German manufacturers whose prices, it is understood, were lower. The superior quality of the Mott poles, however, obtained the order.

Miami Copper Co. have added to their Globe plant three 15-ton and one 5-ton Northern cranes, electric and hand power, made by the Northern Engineering Works, Detroit.

The Locke Insulator & Manufacturing Company, Victor, N. Y., has purchased the plant and business of the Lima Insulator Company, Lima, N. Y. The factory at Lima will be maintained, which will give the Locke Insulator Manufacturing Company four additional kilns.

The Robins Conveying Belt Company, of New York, have removed their executive offices and sales, engineering and purchasing departments to the quarters formerly occupied by them in the Park Row Building.

A 750-kw. low-pressure Westinghouse steam turbine is being added to the power plant of the Corr Manufacturing Company, East Taunton, Mass., to utilize the exhaust of Corliss reciprocating engines. The steam supplied the turbine is at nearly the pressure of the atmosphere, 15 lb. absolute, and the turbine is served by a Westinghouse-Leblanc condenser which maintains a vacuum of about 28 in. The generating apparatus driven by the low-pressure turbine is a 940-kw. ampere, turbine-type alternator, furnishing three-phase, 60-cycle current at 600 volts.

The Citizens Railway & Light Company, at Muscatine, Iowa, has recently added a 750-kw. Westinghouse turbo-generator set for its local light, power and railway service. A rotary converter set makes available direct current for the latter purposes. The condensing system is of the Leblanc jet type, manufactured by the Westinghouse Machine Company, East Pittsburg, Pa.

The Ball & Wood Company has received an order from the Maryland Steel Company for its Sparrow Point plant for two 750-kw. Rateau-Smoot low-pressure turbines and 250-volt generators, to be operated on exhaust steam from blowing engines.

In connection with its low-pressure steam-turbine generating equipment, the Maryland Steel Company has just installed a Westinghouse-Leblanc No. 18 condenser at its Sparrows Point, Md., plant. Direct current at 250 volts is supplied by the low-pressure turbine generating set, which is operated as an auxiliary to Westinghouse engine-driven equipment, effecting a considerable addition to the plant output without requiring additional steam-generating apparatus.

The Buffalo Foundry & Machine Company, Buffalo, N. Y., are about to spend $200,000 in building and equipping a large, new machine shop. This company is about to take up several other lines of manufacture in addition to those they are already in, and will also continue to make a specialty of general jobbing machine work.

The Standard Electric Lamp Company, of Newark, N. J., manufacturers of the "Shamrock" and "Newark" incandescent lamps, announce they are rapidly rebuilding their factory which was recently destroyed by fire, and that they will soon be in a position to make lamp deliveries.

The business heretofore carried on by the Eastern Carbon Works, Jersey City, N. J., will be conducted by the National Carbon Company, of Cleveland. The Jersey City works will be known as the Eastern Branch of the National Carbon Company.

The Jenney Electric Mfg. Company, formerly of Indianapolis, Ind., has removed to Anderson, Ind.

Hunt, Mirk & Co., of San Francisco, Pacific Coast agents for the Westinghouse Machine Company, have sold the largest Westinghouse-Parsons turbo-generator in this country to the Southern California Edison Company. It will be installed in a new power station, which is to be erected at one of the ocean beaches contiguous to Los Angeles. The contract calls for a 12,500-kw. machine with 75 per cent. overload capacity.

Among the Associations

The annual convention of the Michigan Electric Association will be held at Port Huron, August 16th, 17th and 18th.

The American Association of Electric Motor Manufacturers will hold its next annual convention at Hot Springs, Va., May 18.

The officers of the Westinghouse Electric Manufacturing Co. and the National Electric Light Association held a "Get-together" meeting in Pittsburg on March 2d. Approximately 150 men interested in central station development were present. The meeting was addressed by Mr. Frank W. Frueauff, President of the National Electric Light Association, Mr. Henry L. Doherty, Mr. T. C. Martin and Mr. H. H. Scott, Chairman of the National Electric Light Association Membership Committee.

The sales department of the Edison Electric Illuminating Company of Brooklyn enjoyed their annual dinner on Saturday evening, March 19th, at the Hof Brau Haus, Brooklyn. About fifty guests sat down and discussed an elaborate and very satisfactory menu. Mr. T. I. Jones, general sales agent, acted as toastmaster, and the guests of the department were the officers of the company—Messrs. W. W. Freeman, vice-president; W. F. Wells, general superintendent; P. R. Atkinson, treasurer; J. H. Evans, secretary, and R. D. Rubright, auditor. Interesting addresses were delivered by all of these gentlemen.

Reports from the secretary of the exhibition committee of the National Electric Light Association indicate that exhibition space for the approaching convention of the association has been taken up more rapidly than in previous years. With the exception of perhaps a dozen sections, the available space has been all subscribed for.

The National Electric Contractors' Association will get together for the tenth time at Atlantic City on July 20th.

Personals

Mr. W. S. Heger, manager of the Los Angeles office of the Allis-Chalmers Company, has taken over the management of the company's San Francisco office in place of Mr. R. B. Elder, who has resigned. Mr. Heger was for many years Pacific Coast manager for the Westinghouse Electric & Mfg. Company, and later assistant to the president of the Allis-Chalmers Company.

It is announced that Mr. F. X. Cleary has been appointed advertising manager of the Western Electric Company. Mr. Cleary has been with the Western Electric Company for about twenty years, and has held important positions connected with the execution of sales campaigns for the company.

Under Mr. Cleary's direction the advertising of the Western Electric Company, which has been so successful in the past, will be conducted and extended along the same general lines.

Mr. C. E. Hubbard, heretofore secretary to the general manager, and purchasing and claim agent of the Farmington Street Railway Company, of Hartford, Conn., has been appointed purchasing agent of the Mahoning & Shenango Railway, Light & Power Company, with headquarters at Youngstown, Ohio.

Mr. J. C. Elberson recently resigned as chief engineer of the Philadelphia & Western Railway Company to accept the position of engineer of the sales department of the Electric Storage Battery Company, of Philadelphia.

Mr. A. D. Miller, heretofore local manager and superintendent of the Reno Traction Company, of Reno, Nev., has been appointed manager of the Central California Traction Company, with headquarters at Stockton, Cal.

Mr. Walter McFarland, for some eleven years vice-president of the Westinghouse Electric & Mfg. Company, has resigned to go with the Babcock & Wilcox Company. Mr. McFarland was in charge of the Westinghouse Company's large contracts, as well as the advisory head of all the co-operative movements of the company with the associated Westinghouse Companies, involving literature, advertising and exhibition work. He has also been a frequent and valued contributor to the technical press.

Mr. Joseph Damond Whittemore recently resigned from the construction department of the General Electric Company, at Boston, to engage in industrial engineering work for the Rochester Railway Company.

Mr. C. L. Demuralt, of New York City, who has an international reputation as an engineer, has been appointed professor of electrical engineering of the University of Michigan. Mr. Demuralt is at present engaged in connection with the transmission of electrical current from Niagara Falls to Hamilton and Toronto, Ont. He has been more than once employed by the United States Government as consulting engineer.

Mr. H. G. Glass, recently with the electrical department of the H. W. Johns-Manville Company, at Pittsburg, has recently accepted a position in the industrial and power sales department of the Westinghouse Electric & Mfg. Company. He will act as a sort of a special agent, devoting his time to the promotion of cooperation between the central station and the manufacturer in building up day loads. His long experience in the central-station field and his wide acquaintance with central-station requirements well fit him for his new duties.

Mr. L. H. Conklin, recently general manager of the Scranton Electric Company, at Scranton, Pa., has been engaged by J. G. White & Company as an engineer in its operating department.

Mr. C. A. Greenidge, lately general manager of the electric department of the Utica Gas & Electric Company, has also joined the engineering staff of the operating department of J. G. White & Company.

Mr. Miles V. Stewart, formerly commercial engineer with the General Electric Company, of Schenectady, N. Y., has been appointed chief engineer for the Mexican General Electric Company, Mexico City, Mexico.

Mr. Robert Kann, consulting chemist to the Raritan Paper Works, Perth Amboy, N. J., has opened at 24 Cliff Street, New York City, a commercial laboratory, making a specialty of metallurgical analysis and research.

The Harvard Electric Company, Chicago, Ill., has issued a new catalogue, known as No. 20, which is descriptive of a part of the many electrical necessities made by them.

Obituary

Mr. Eugene I. Crawford, who two weeks ago was appointed general superintendent of the northwest division of the Chicago Railways Company, died on March 14th at his residence in Chicago, aged 57 years.

Mr. James J. Mahoney, long connected with the engineering and sales department of the General Electric Company, died March 19th at Holyoke, Mass., of acute Brights disease, in the 48th year of his age. He had been with the company since 1888, and was especially well known in railway circles.

Mr. Thomas J. Cushing, of the engineering staff of the Western Electric Company, died at his home in New York, aged 37.

Mr. Philip E. Elivier, superintendent of the electrical department of the Superior Water, Light & Power Company, Superior, Wis., died of cancer at his home in that city.

Mr. Frank J. Campbell, president and secretary of the Nevada-California Power Company, died in Denver, March 6th, after a short illness, from pneumonia. He was 55 years old, and one of the pioneer electrical men in the West.

Mr. Gardner C. Sims, president of the Harris Steam Engine Company, Providence, R. I., died of Brights disease, at his home in that city, in his 65th year. Mr. Sims was one of the designers of the well-known Armington Sims high-speed steam engines, and had done considerable engineering work for the United States Government.

Mr. John Heathcote, treasurer of the Russell Electric Manufacturing Company, of Providence, R. I., died at his home in that city on March 14th. Mr. Heathcote was 77 years of age, having been born in 1833 in Manchester, England. He has resided in this country since 1842.

Mr. Lazarus F. Minzesheimer, for 19 years general attorney for the Chicago City Railway Company, died on March 2, following an operation. Mr. Minzesheimer was born in New York on July 5, 1861. He was formerly connected with the city attorney's office, from which he was appointed attorney for the City Railway.

Trade Publications

"Power from Coal" is the title of a convincing little pamphlet neatly gotten up by the Electrical Testing Laboratories of New York.

The Crane Company, Chicago, devote the most of the latest issue of *The Valve World* to their newly housed San Francisco branch.

Bulletin No. 17 of the Pawling & Hornischfeger Company, Milwaukee, describes the small electric hoists, I-beam trolleys and chain-block traveling cranes that are this company's widely known specialties.

Westinghouse Electric & Mfg. Company has issued "Ad. Book No. 13" of its series of pointer-pamphlets on up-to-date advertising for central stations. This issue deals mostly with getting household business.

The Cutler-Hammer Mfg. Company, Milwaukee, in a recently issued folder, tells all about the many interesting features of its line of lifting magnets.

Mathias Klein & Sons, of Chicago, who make the "Goehst" wire and insulation cutting pliers, have issued a handsome folder telling of the merits of this time-saving device for wiremen.

The line of "Graphoil" lubricating devices turned out by the Graphoil Lubricator Sales Company, New York, is fully described in a neat folder that the company has recently sent out. The saving of lost power and reduction of oil consumption are among the chief advantages claimed for these lubricators.

The March issue of *The Glower*, the monthly of the Nernst Lamp Company, Pittsburg, Pa., sets forth the latest improvements of the Nernst lamp, and also an affecting obituary notice of "A. Tungsten Lamp."

The Pettingell-Andrews Company, of Boston, has, along with other information, a brief sketch, with portrait, of Volta in the March issue of its house organ, *Juice*.

C. W. Hunt Company, New York, has just issued a well-illustrated handy-size pamphlet, No. 101, recounting the innumerable uses to which the Hunt "Industrial" Railway is being put. It also gives complete description of the tracks, track specials, cars and locomotives that are made by this firm for industrial purposes.

Trumbull Cheer, the house organ of the Trumbull Electric Mfg. Co., Plainville, Conn., has its usual quota of wit, wisdom and information in the March issue.

The latest booklet of the Fort Wayne Engineering & Mfg. Company tells of the Paul electric pump for house service which was described in our last issue.

The latest of the always cleverly gotten up booklets of the Pacific Electric Heating Company, Chicago, sets forth the superior points of the company's line of electric irons, giving tests to prove the claims made for them.

The Jeffrey Mfg. Company, Columbus, Ohio, has issued booklets Nos. 35 and 36, describing the latest forms of its rubber belt and spiral conveyers and their necessary accessories.

The Duplex Metals Company, New York, has published a pamphlet describing its home office and mills, and giving particulars of the process of making the copper-clad steel wire that is the company's principal output.

The Pittsburg Transformer Company has issued bulletin No. 1100, describing its new line of transformer fuse blocks, and also bulletin No. 1102, descriptive of the bell-ringing transformer for furnishing low-voltage alternating current for operating bells, buzzers, annunciators and alarms and permitting the usual battery to be dispensed with.

The Kinney Mfg. Company, Boston, has out a leaflet giving general data on its line of positive-pressure power pumps, including prices and other details.

A well-arranged book filled with interesting information is catalogue No. 39 of the Chain Belt Company, Milwaukee, telling about its new chain-belt concrete mixers and other concrete-handling devices.

The last issue of the *Emerson Monthly*, the house organ of the Emerson Electric Mfg. Company, St. Louis, is devoted to small motors, fans and washing machines.

Gisholt Machine Company, of Madison, Wis., has issued another leaflet showing the furnishing of steam turbine discs on its 42-in. vertical boring mill.

The recent publishing output of the Western Electric Company includes bulletins No. 1110 on "Telephone and Signaling Apparatus for Mines," No. 5111 describing the Hawthorne type "LL" direct-driven, direct-current generators and balancing sets, and No. 5360 on Hawthorne small power motors of from 1/30 to 1/4 h.p., both alternating and direct current. The company has also issued handy-sized circulars and booklets devoted to some of its many kinds of detail apparatus, including the Western Electric interphone, cord circuit keys, Hawthorne fan motors, condulets, flaming arc lamps, "Improved Blue Bell" batteries and "Mazdaliers."

In connection with the lighting subject, an attractive bulletin entitled "How to Figure Illumination," which enables anyone, even those with no knowledge of illuminating engineering, to compute the amount of light required for lighting any space, has been recently placed in circulation by the company.

The Garner Ventilating Company, of New York, has distributed leaflets showing its No. 2 mechanical ventilators.

The Doubleday-Hill Company, Pittsburg, Pa., has issued a 775-page supply catalogue which covers the numerous lines of electrical apparatus that the company handles.

From the General Electric Company have come recent bulletins covering the following subjects:

No. 4716—Thomson Alternating- and Direct-Current Watthour Meters with Repayment Attachments.

No. 4717—G. I. Flame Arc Lamps.

No. 4719—Fan Motors and Small Power Motors.

No. 4720—Steam and Air Flow Meters.

No. 4721—Thomson Direct-Current Watthour Meters.

No. 4722—Electric Drive in Cement Plants.

The Sunbeam Incandescent Lamp Company, Chicago, Ill., has issued a booklet describing methods for determining illumination by means of incandescent lamps and prismatic reflectors.

The Robbins & Myers Company, Springfield, Ohio, has sent out a bulletin giving complete information concerning all types of fans for residence, office and hotel service. The motors of these fans are designed for operation at all standard voltages and frequency, and for direct and alternating current.


WESTINGHOUSE
FAN MOTORS
FOR ALTERNATING CURRENT
WESTINGHOUSE
FAN MOTORS
1910
WESTINGHOUSE
FAN MOTORS
FOR DIRECT CURRENT
1910

Classified Directory of Manufacturers

ADJUSTERS
- Morse, Frank W., Boston, Mass.

AIR AND GAS COMPRESSORS
- Allis-Chalmers Co., Milwaukee.
- American Air Compressor Works, N. Y.
- Blake Mfg. Co., Geo. F., New York.
- Chicago Pneumatic Tool Co., Chicago.
- Clayton Air Compressor Works, N. Y.
- Curtis & Co., Mfg. Co., St. Louis.
- Dean Bros. Steam Pump Wks., Indianapolis.
- Emerson Elec. Mfg. Co., St. Louis, Mo.
- Hall Steam Pump Co., Pittsburg.
- Ingersoll-Rand Co., New York.
- Knowles Steam Pump Works, New York
- Laidlaw-Dunn-Gordon Co., New York.
- McGowan Co., John H., Cincinnati.
- National Brake & Elec. Co., Milwaukee.
- Norwalk Iron Works, Norwalk, Conn
- Platt Iron Works Co., Dayton
- Providence Engine Works, Providence
- Snow Steam Pump Works, New York.
- Sullivan Machinery Co., Chicago
- Worthington, Henry R., New York.

ALTERNATORS
- Allis-Chalmers Co., Milwaukee, Wis.
- Crocker-Wheeler Co., Ampere, N. J.
- Fort Wayne Elec. Works, Indianapolis.
- General Electric Co., Schenectady, N. Y.
- National Brake & Elec. Co., Milwaukee
- Wesco Supply Co., St. Louis
- Western Electric Co., Chicago
- Westinghouse Elec. & Mfg. Co., Pittsburg

ANCHORS (GUY)
- Holden Anchor Co., Des Moines, Ia.
- Matthews & Bro., W. N., St. Louis, Mo

ANNUNCIATORS
- Central Electric Co., Chicago, Ill.
- Doubleday-Hill Electric Co., Pittsburg.
- Electric Appliance Co., Chicago.
- Haines, J. Allen, Inc., Chicago.
- Manhattan Elec. Supply Co., New York
- Ostrander & Co., W. R., Chicago.
- Van Dorn-Elliott Elec. Co., Cleveland
- Wesco Supply Co., St. Louis.
- Western Electric Co., Chicago

ATTACHMENT PLUGS
- Hubbell, Harvey, Bridgeport, Conn.

BATTERIES—PRIMARY
- Bunnell & Co., J. H., New York.
- Burnley Battery & Mfg. Co., Painesville Ohio.
- Central Electric Co., Chicago
- Doubleday-Hill Elec. Co., Pittsburg.
- Eastern Carbon Works, Jersey City, N. J.
- Edison Mfg. Co., New York.
- Elec. Motor & Equipment Co., Newark N. J.
- French Battery Co., Madison, Wis.
- Gordon Battery Co New York.
- Lawrence Elec. Co., F. D., Cincinnati, O.
- Leclanche Battery Co., New York.
- Manhattan Electrical Supply Co., Chicago.
- Waterbury Battery Co., Waterbury. Conn.
- Wesco Supply Co., St. Louis, Mo
- Western Electric Co., Chicago.

BATTERIES—STORAGE
- American Battery Co., Chicago.
- Doubleday-Hill Electric Co., Pittsburg.
- Electric Storage Battery Co. Philadelphia.
- General Storage Battery Co., New York.
- Gould Storage Battery Co., New York.
- National Battery Co., Buffalo, N. Y.
- Railway Safety Service Co., Springfield, Mass.
- Universal Electric Storage Battery Co., Chicago.
- Willard Storage Battery Co., Cleveland.

Classified Directory of Manufacturers—Cont'd

BELLS
Central Electric Co., Chicago.
Manhattan Electrical Supply Co., New York and Chicago.
Ostrander & Co., W. R., New York
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.

BELT DRESSING
Cling Surface Mfg. Co., Buffalo
Dixon Crucible Co., Jos., Jersey City, N. J.

BELTING
Boston Belting Co., Boston.
Eureka Fire Hose Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Philadelphia.
Pittsburg Gage & Supply Co., Pittsburg.
Robins Conveying Belt Co. New York.

BLOWERS
Allis-Chalmers Co., Milwaukee.
American Blower Co., Detroit.
American Gas Furnace Co., New York.
Buffalo Forge Co., Buffalo.
Chicago Flexible Shaft Co., Chicago.
Crocker-Wheeler Co., Ampere, N. J.
Dean Bros. Steam Pump Works, Indianapolis.
Green Fuel Economizer Co., Matteawan, N. Y.
Platt Iron Works, Dayton, O.
Smith, J. D., Fdy. Supply Co., Cleveland
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

BLUE PRINT MACHINERY
Buckeye Engine Co., Salem, O.
Keuffel & Esser Co., New York.
Kolesch & Co., New York
Resolute Machine Co., New York
Wagenhorst & Co., J. H., Pittsburg.

BOILERS
Atlantic Works, East Boston, Mass.
Babcock & Wilcox Co., New York.
Harrison Safety Boiler Works, Phila.
Heine Safety Boiler Co., St. Louis.
Platt Iron Works, Dayton, O.
Riter-Conley Mfg. Co., Pittsburg.
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.
Walsh's Holyoke Steam Boiler Co., Holyoke, Mass.
Wetherill & Co., Robt., Chester, Pa.

BOXES—JUNCTION
Bossert Electric Construction Co., Utica.
D. & W. Fuse Co., Providence, R. I.
Steel City Electric Co., Pittsburgh

BOXES—OUTLET
Bossert Electric Const. Co., Utica, N. Y.
Steel City Electric Co., Pittsburgh

BRUSHES—CARBON
Central Electric Co., Chicago.
Eastern Carbon Works, Jersey City, N. J
Holmes Fibre-Graphite Mfg. Co., Germantown, Pa.
Le Valley Carbon Brush Co., New York.
National Carbon Co., Cleveland.
Speer Carbon Co., St. Mary's, Pa.
Western Electric Co., Chicago.

BUSHINGS-OUTLET
Steel City Electric Co., Pittsburgh

CABLE HANGERS
Barron & Co., Jas. S., New York
Bissell Co., F., Toledo, O.
Standard Underground Cable Co., Pittsburg.
Steel City Electric Co., Pittsburg.
Wesco Supply Co., St. Louis, Mo
Western Electric Co., Chicago.

CABLE JOINTS
Dossert & Co., Inc., New York

CARBONS
Central Electric Co., Chicago.
Eastern Carbon Works, Jersey City, N. J
National Carbon Co., Cleveland.
Reisinger, Hugo, New York.
Speer Carbon Co., St. Marys, Pa.
Wesco Supply Co., St. Louis.

CASTINGS
American Steel Foundries, Chicago.
Alton Machine Co., New York.

Classified Directory of Manufacturers—Cont'd

Lunkenheimer Co. Cincinnati.
New England Butt Co., Providence, R. I.
Phosphor-Bronze Smelting Co., Ltd., Philadelphia.

CHAINS FOR ARC LAMPS
Oneida Community, Ltd., Oneida, N. Y

CIRCUIT BREAKERS
Cutler-Hammer Mfg. Co., Milwaukee.
Cutter Electrical Mfg. Co., Philadelphia
Doubleday-Hill Electric Co., Pittsburg.
Fort Wayne Electric Works, Fort Wayne, Indiana
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
La Roche Co., F. A., New York.
Sundh Electric Co., New York.
Switchboard Equip. Co., Bethlehem, Pa
Ward Leonard Electric Co., Bronxville, N. Y.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co. Pittsburg.

CLAMPS—CABLE
Matthews, W. N., & Bros., St. Louis.

CLEATS
Blake Signal & Mfg. Co., Boston, Mass.
Imperial Porcelain Works, Trenton, N. J.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.

CLIMBERS
Klein & Co., Mathias, Chicago.

CLUSTERS
Benjamin Elec. Mfg. Co., Chicago
Hubbel, Harvey, Bridgeport, Conn.

COAL AND ASH-HANDLING MACHINERY
Brown Hoisting Machinery Co. land
Case Mfg. Co., Columbus, O.
Hunt Co., C. W., New York.
Jeffrey Mfg. Co., Columbus, O.
Link Belt Co., Philadelphia.
Mead-Morrison Mfg. Co., Boston.
Northern Engineering Works, Detroit
Robins Conveying Belt Co., New York.

COILS—INDUCTION
Ostrander, W. R., & Co., New York.
Splitdorf, C. F., New York.

COMMUTATOR LUBRICANT
Allen & Co., L. B., Chicago.
Dixon Crucible Co., Jos., Jersey City.

COMMUTATORS
Homer Commutator Co., Cleveland, O.

CONDENSERS—ELECTRIC
Marshall, William, New York.

CONDUIT RODS
Barron & Co., Jas. S., New York.
Cope, T. J., Philadelphia.
Doubleday-Hill Electric Co., Pittsburg

CONDUITS
American Circular Loom Co., Chelsea, Mass.
The Gillette-Vibber Co., New London, Conn.
American Conduit Co., Chicago.
American Vitrified Conduit Co., N. Y.
Camp Co., H. B., New York.
Doubleday-Hill Electric Co., Pittsburg.
Gest, G. M., New York.
National Conduit & Cable Co., N. Y.
National Metal Molding Co., Pittsburg
Orangeburg Fibre Conduit Co., Orangeburg, N. Y
Sprague Electric Co., New York.

CONDUIT FITTINGS
Steel City Electric Co., Pittsburgh

CONDUIT REAMERS
Steel City Electric Co., Pittsburg.

CONDUIT TOOLS
Cope, T. J., Philadelphia.
Steel City Electric Co., Pittsburg.

CONTROLLERS
Allis-Chalmers Co., Milwaukee.
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Cutler-Hammer Mfg. Co., Milwaukee.
Elec. Controller & Supply Co., Cleveland

Classified Directory of Manufacturers—Cont'd

N. Y. Electric Controller Co., New York.
Simplex Electric Heating Co., Cambridge, Mass.

COPPER CASTINGS
Anderson Mfg. Co., A. & J. M., Boston.
Ward-Leonard Co., Bronxville, N. Y.

CRANES
Northern Engineering Works, Detroit.

CROSS ARMS
Locke Insulator Mfg. Co., Victor, N. Y.

CUT-OUTS AND SWITCHES
Bissell Co., The F., Toledo, O.
Bossert Electric Const. Co., Utica, N. Y.
Central Electric Co., Chicago.
Crouse-Hinds Co., Syracuse, N. Y.
Cutter Elec. & Mfg. Co., Philadelphia.
Ft. Wayne Elec. Wks., Inc., Fort Wayne.
General Electric Co., Schenectady, N. Y.
Hart Mfg. Co., Hartford, Conn.
Manhattan Elec. Supply Co., New York.
Sorenson, P., Brooklyn.
Switchboard Equip. Co., Bethlehem, Pa.
Trumbull Elec. Mfg. Co., Plainville, Conn
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

DIRECT MOTOR DRIVE FOR PLANERS
The Electric Controller & Supply Co., Cleveland.

DRILLS
Morse Twist Drill & Machine Co., New Bedford, Mass.

DRYING MACHINERY
Aiton Machine Co., New York.
Buffalo Foundry & Machine Co., Buffalo.
Devine Co., J. P., Buffalo.
Sturtevant Co., B. F., Boston.

DYNAMOS AND MOTORS
Allis-Chalmers Co., Milwaukee.
American Engine Co., Bound Brook, N. J.
Bogue Electric Co., C. J., New York.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Central Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Electric Co., Pittsburg.
Eck Dynamo & Motor Wks., Belleville, N. J.
Electro-Dynamic Co., Bayonne, N. J.
Elwell-Parker Electric Co., Cleveland.
Emerson Electric Mfg. Co., St. Louis.
Fort Wayne Electric Works, Fort Wayne.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
National Brake & Elec. Co., Milwaukee
New England Motor Co., Lowell, Mass.
Ridgway Dynamo & Motor Co., Ridgway, Pa.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Boston.
Triumph Electric Co., Cincinnati.
Wagner Electric Mfg. Co., St. Louis.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

ELECTRIC RAILWAY SUPPLIES
Railway Safety Service Co., Springfield, Mass.

ELECTROMAGNETS
Acme Wire Co., New Haven, Conn.
Schureman, J. L., Co., Chicago.
Splitdorf, C. F., New York.

ELEVATORS
American Tool & Machine Co., Boston
Caldwell & Son Co., H. W., Chicago.
Jeffrey Mfg. Co., Columbus.
Link Belt Eng'g Co., Philadelphia.
Obermayer Co., S., Cincinnati.
Otis Elevator Co., N. Y.
Poole Eng'g Mch. Co., Baltimore.

ENGINEERING CONSTRUCTION
Elm City Engineering Co., New Haven Conn

The American Conduit Company, New York, manufacturer of bituminized fiber conduit, has issued a booklet on underground conduit construction for electric light and telephone work, which includes many diagrams and valuable information.

In its bulletin No. 117, the Electric Storage Battery Company, Philadelphia, give up-to-date information regarding the installation, care and operation of storage batteries in signal and car-lighting service.

The great increase in the use of mechanical draft and the fine points involved in its application, together with a description of the turbine blowers and fans that make its use possible, are some of the features involved in a book entitled "Mechanical Draft," published by the Buffalo Forge Company, of Buffalo, N. Y.

The Dayton-Globe Iron Works Company, of Dayton, Ohio, has recently issued catalogues on their "New American Turbine" for the development of water power. The turbines are of the reaction type, vertical or horizontal, and, according to requirements, are furnished with either balanced flutter, wicket or cylinder gates. Two classes of wheels are made: those for low head from 3 to 50 ft., diameters from 10 to 60 in., and outputs up to 2363 h.p.; and those for a high head of 50 to 200 ft. The largest turbine listed operates with a 200-ft. head and a 72-in. wheel, and delivers 6784 h.p. at a speed of 179 to 238 rev. per min. and a discharge of 22,380 cu. ft. per min.

Of more than usual interest and value is bulletin No. 381 of the Triumph Electric Company, Cincinnati, Ohio, which is arranged as a complete guide to a printer in the selection of motors for driving each type and size of print-shop machine.

Flexible non-metallic tubing for covering wires in electric lighting installation is described in a folder of the National Metal Molding Company, Pittsburg, Pa.

Watson-Stillman Company, 50 Church Street, New York, has ready for distribution its catalogue No. 78, containing data and illustrations of the W-S hydraulic valves and fittings.

Classified Directory of Manufacturers—Cont'd

ENGINES—GAS AND GASOLINE
Allis-Chalmers Co., Milwaukee.
Buckeye Engine Co., Salem, O.
Carlisle & Finch Co., Cincinnati, O.
De La Vergne Machine Co., New York.
Elbridge Engine Co., Rochester, N. Y.
Marine Engine & Machine Co., N. Y.
Mietz, A., N. Y.
Otto Gas Engine Works, Philadelphia.
Power & Mining Machinery Co., Cudahy Wis.
Westinghouse Machine Co., Pittsburg.
Wood & Co., R. D., Philadelphia.

ENGINES—STEAM
Allis-Chalmers Co., Milwaukee.
American Blower Co, Detroit.
Am. Engine Co., Bound Brook, N. J.
Ball Engine Co. Erie, Pa.
Blake Mfg. Co., Geo F., New York.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo.
Frick Co., Waynesboro, Pa.
Hooven, Owens, Rentschler Co., Hamilton, Ohio.
Mecklenburg Iron Wks., Charlotte, N. C.
Providence Eng'g Works, Providence
Shepherd Eng'g Co., Franklin, Pa.
Southwark Fdy. & Mch. Co., Philadelphia.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass
Watertown Eng. Co., Watertown, N. Y
Westinghouse Machine Co., Pittsburg.
Wetherill, Robert & Co., Chester, Pa

EXHAUST HEADS
American Spiral Pipe Works, Chicago.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Pittsburg Gage & Supply Co., Pittsburg
Sturtevant Co., B. F., Hyde Park, Mass
Watson & McDaniel Co., Philadelphia.
Wright Mfg. Co. Detroit.

FANS AND MOTORS
Century Electric Co., St. Louis.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Elec. Co., Pittsburg.
Eck Dynamo & Motor Wks, Belleville, N. J.
Elec. Motor & Equip. Co., Newark, N. J
Emerson Electric Mfg. Co., St. Louis.
Ft. Wayne Elec. Works, Ft. Wayne, Ind
General Electric Co., Schenectady, N. Y
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Wesco Supply Co., St. Louis.
Western Electric Co. Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg.

FANS—EXHAUST AND VENTILATING
Allen Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Emerson Elec. Mfg. Co., St. Louis.
Green Fuel Economizer Co., Matteawan.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Boston.
Western Electric Co., Chicago.

FIXTURES—GAS AND ELECTRIC
Benjamin Elec. Mfg. Co., Chicago.
Cleveland Gas & Fixture Co., Cleveland
Gail-Webb Mfg. Co., Buffalo
Goodwin & Kintz, Winsted, Conn
Wells Light Mfg. Co., New York

FLASHERS
Advertising Mirrograph Co., Brooklyn
Campbell Electric Co., Lynn, Mass.
Elec. Motor & Equip. Co., Newark, N. J
Haller Machine Co., Chicago.
Reynolds Elec. Flasher Mfg. Co., Chicago

FLEXIBLE SHAFTS
Chicago Flexible Shaft Co., Chicago.
Stow Flexible Shaft Co., Philadelphia
Stow Mfg. Co., Binghamton, N. Y

FRICTION TAPE AND CLOTHS
Massachusetts Chemical Co.

FUSES
Arknot Co., Hartford, Conn.
Chase-Shawmut Co.
Chicago Fuse Wire & Mfg. Co.
D. & W. Fuse, Providence, R. I.
Johns-Manville Co., H. W., New York

Classified Directory of Manufacturers—*Cont'd*

GAS ENGINE SPECIALTIES
Lunkenheimer Co.

GAUGES—PRESSURE, STEAM, WATER
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston.
Bristol Co., Waterbury, Co., Conn.
Hohmann & Maurer Mfg. Co., Rochester.
Manning, Maxwell & Moore, New York.
Pittsburg, Gauge & Supply Co., Pittsburg.
Star Brass Mfg. Co., Boston.
Walworth Mfg. Co., Boston.

GEARS
New Process., Rawhide. Co.
Nuttal Co., R. D. Pittsburg

GERMAN SILVER
Seymour Mfg. Co Seymour, Conn.

GLASS
Phoenix Glass Co., New York

GLOBES, SHADES, ETC.
Holophane Glass Co., New York.
Phoenix Glass Co., New York.

GRAPHITE
Dixon Cruc. Co., Jos., Jersey City, N. J.

GUARDS—INC. LAMPS
Gail-Webb Mfg. Co., Buffalo.
Hubbell, Harvey, Bridgeport
Matthews & Bro., W. N., St. Louis.

HANGER BOARDS
Ft. Wayne Elec. Works, Ft. Wayne, Ind-

HANGERS—CABLE
Chase-Shawmut Co., Newburyport, Mass.
Standard Underground Cable Co., Pittsburg.

HEATING DEVICES, ELECTRIC
American Elec'l Heater Co., Detroit.
Barr Elec. Mfg. Co., W. J., Cleveland.
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Electric Heating Co., Chicago

HEATING—EXHAUST STEAM
Am. District Steam Co., Lockport, N. Y
Diamond State Fibre Co., Elsemere, Del.
Mica Insulator Co New York

HOISTS AND CONVEYORS
Hunt, C. W., Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Northern Engineering Works, Detroit.

HYDRAULIC MACHINERY
Dayton Globe Iron Works Co., Dayton.
Dean Bros. Steam Pump Wks., Indianapolis.
Leffel & Co., James, Springfield, O.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co., Dayton, O.
Risdon-Alcott Turbine Co., Mount Holly, N. J.
Smith Co., S. Morgan, York, Pa.

IMPREGNATING APPARATUS
Buffalo Foundry & Machine Co., Buffalo
Devine Co., J. P., Buffalo.
Hubbard's Sons, Norman, Brooklyn.

INDICATORS
American Steam Gauge & Valve Mfg Co.

INSTRUMENTS—ELECTRICAL
American Instrument Co., Philadelphia.
Atwater Kent Mfg. Co., Philadelphia.
Baillard, E. V., New York.
Biddle, James G., Philadelphia.
Bristol Co., Waterbury, Conn.
Clark Electric Meter Co., Chicago.
Connecticut Telephone & Electric Co., Meriden, Conn.
Cutter Elec. & Mfg. Co., Philadelphia.
Dongan Instrument Co., Albany, N. Y.
Duncan Elec. Mfg. Co., Lafayette, Ind.
Eldredge Elec. Mfg. Co., Springfield, Mass.
Foote-Pierson & Co., New York.
Fort Wayne Electric Works, Ft. Wayne Ind.
General Electric Co., Schenectady.
Keystone Elec. Instrument Co., Phila
Leeds & Northrup, Philadelphia.
Machado & Roller, New York.
Pignolet, Louis M., New York.
Queen & Co., Philadelphia.
Robert Instrument Co., Detroit.
Sangamo Electric Co., Springfield, Ill.

The Westinghouse Electric and Manufacturing Company's New Repair Department

The new eight-story building, with approximately 220,000 ft. of floor space, devoted partly to the manufacture of detail electrical apparatus and partly to repair work, which the Westinghouse Electric & Manufacturing Company not long ago placed in service, contains a new department whose entire attention is devoted to the handling of repair work.

On account of the fact that there was no large space on the company's 47-acre plot unoccupied, it was necessary, in the erection of a new building, to depart from the established two-story type of structure and erect a higher building. The available space was 110 ft. wide by 420 ft. long, and the building is 70 ft. by 400 ft. The distance from the ground to the top of the cornice is 130 ft. The building is of skeleton self-contained steel and brick construction, and is as near fireproof as a building can be made.

To facilitate the handling of material from floor to floor, one exceptionally large freight elevator and five high-speed combination elevators are employed. They are all operated electrically by means of Westinghouse motors and controlled by automatic elevator controlling apparatus.

The building affords working space for approximately 1500 people. In addition to providing for practically doubling the present output of detail apparatus, it affords ample room for handling in the most expeditious manner a large volume of repair work.

In keeping with the well-established standards of the company, the same high-grade and carefully-selected material that entered originally into the apparatus will be used in work entrusted to the repair department. Expert workmen, under the guidance of engineers of long experience, perform the work, and repaired apparatus is subjected to the same rigid tests as new apparatus. The facilities of the department enable repairs to be made in the most economical manner, and assure its redelivery in the shortest time consistent with good workmanship.

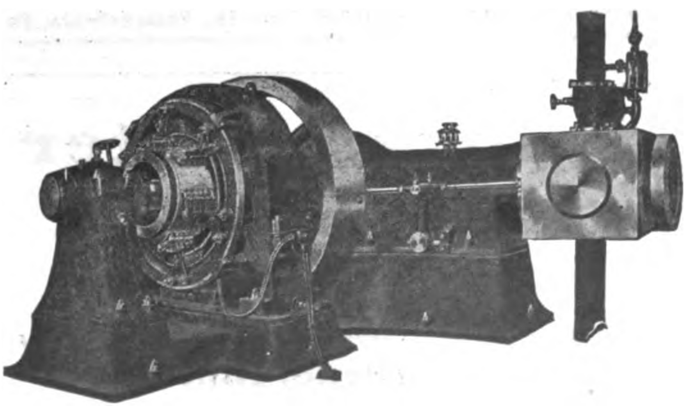
Walhope Company's Plant

The incorporation of the Walpole Rubber Co., Ltd., with a capital of $250,000, is announced.

The factory of the company at Granby, Quebec, is nearing completion; the general sales offices are in the Eastern Township Bank building in Montreal.

The officers and directors of this new company are, for the most part, officers and directors of the Massachusettes Chemical Co., operating the Walpole Rubber Works, the Walpole Varnish Works and the Walpole Shoe Supply Works at Walpole, Mass., U. S. A.

The Walpole Rubber Co., Ltd., of Canada will operate upon similar lines to the parent company, producing all kinds of rubber splicing, insulating and friction tapes and miscellaneous rubber sundries, together with the well-known varnishes and insulating compounds, such as armalac and insulac.



Classified Directory of Manufacturers—Cont'd
Schaeffer & Budenberg, New York
Simplex Co., Newark, N. J.
Wagner Electric Mfg. Co., St. Louis.
Westinghouse Elec. & Mfg. Co., Pittsburg
Weston Elec. Instr. Co., Newark, N. J.
Whitney Elec'l Instr. Co., New York.

INSULATING MACHINERY
Aiton Machine Co., New York.
New England Butt Co., Providence, R. I.

INSULATING MATERIAL COMPOUNDS—CLOTH AND PAPER
Anderson Mfg. Co., A. & J. M., Boston.
Johns-Manville Co., H. W., New York.
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—COMPOUNDS PAINTS AND VARNISHES
Macon-Evans Varnish Co., Pittsburg.
Massachusetts Chem. Co., Walpole, Mass.
Standard Paint Co., New York.
Sterling Varnish Co., Pittsburg.

INSULATING MATERIAL—FIBRE
Am. Vulcanized Fibre Co., Wilmington.
Diamond State Fibre Co., Elsmere, Del.
Kartavert Mfg. Co., Wilmington, Del.
Morris Elec. Co., Wilmington, Del.
United Indurated Fibre Spec. Co., Lockport, N. Y.
Wilmington Fibre Spec. Co., Wilmington.

INSULATING MATERIAL—LAVA
American Lava Co., Chattanooga, Tenn.
Kruesi, P. J., Chattanooga.
Steward Mfg. Co., D. M., Chattanooga.

INSULATING MATERIAL—MICA
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—PORCELAIN
Imperial Porcelain Works, Trenton, N. J.
Locke Insulator Mfg. Co., Victor, N. Y.
National Porcelain Co., Trenton, N. J.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATING MATERIAL—TAPE
Amer. Electrical Wks., Philipsdale, R. I.
Massachusetts Chem. Co., Walpole, Mass
Morgan & Wright, Detroit
New York Insulated Wire Co., N. Y.
Okonite Co., Ltd., New York
Schott, W. H., Chicago.
Standard Underground Cable Co., Pittsburg.

INSULATORS—GLASS
Hemingway Glass Co., Louisville
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.

INSULATORS—PORCELAIN AND COMPOSITION
Anderson Mfg. Co., A. & J. M., Boston.
Imperial Porcelain Works, Trenton, N. J.
Johns-Manville Co., H. W., New York.
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATOR SUPPORTS
Steel City Electric Co., Pittsburgh

JACKS
Watson-Stillman Co., New York.
Henderer's Sons, A. L., Wilmington, Del.

JUNCTION BOXES
Standard Underground Cable Co., Pittsburg, Pa.
Bossert Elec. Const. Co., Utica, N. Y

KNIFE SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

LAMPS—ARC
Adams-Bagnall Elec. Co., Cleveland.
Am. Arc Lamp Co., Kalamazoo, Mich.
Anderson Mfg. Co., A. & J. M., Boston.
Beck Flaming Lamp Co., New York.
Excello Arc Lamp Co., New York.
Ft. Wayne Electric Works, Ft. Wayne.
General Electric Co., Schenectady.
Hamburger, Felix, New York.
Helios Mfg. Co., Philadelphia.
Marquette Elec. Mfg. Co., Chicago.
Toerring Co., C. J., Philadelphia.
Warner Arc Lamp Co., Muncie, Ind

Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LAMPS—INCANDESCENT
American Electric Lamp Co., Phila., Pa.
Banner Electric Co., Youngstown, O.
Bay State Lamp Co., Danvers, Mass
Boston Incandescent Lamp Co., Danvers, Mass.
Brilliant Electric Lamp Co., Cleveland.
Bryan-Marsh Co., New York.
Buckeye Electric Co., Cleveland.
Columbia Inc. Lamp Co., St. Louis.
Economy Electric Co., Warren.
Edison Dec. & Min. Lamp Co., Harrison, N. J.
General Electric Co., Harrison, N. J.
New York & Ohio Co., Warren.
Novelty Incandescent Lamp Co., Emporium, Pa.
Rooney Elec. Lamp Co., New York.
Shelby Electric Co., Shelby, O.
Stuart Howland Co., Boston.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LIGHTNING ARRESTERS
Anderson Mfg. Co., A. & J. M., Boston.
D. & W. Fuse Co., Providence, R. I.
Electric Service Supplies Co., Phila.
Lord Electric Co., New York.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LINE MATERIAL
Anderson Mfg. Co., A. & J. M., Boston.

LOCKERS
Edward Darby & Sons Co., Philadelphia
Merritt & Co., Philadelphia.

LOCOMOTIVES—INDUSTRIAL
Goodman & Co., Chicago

A Fire-proof Substitute For Wood

A booklet describing one of their products, "Transite Asbestos Wood," has been issued by the H. W. Johns-Manville Company, of New York City. This material is mineral in character, being made from asbestos fiber and binding cements. It has the same physical characteristics as ordinary wood, except that it is harder and takes a higher polish. Among the advantages urged for this product are its adaptability to manipulation by means of woodworking tools, its fiber strength under transverse loads of 3500 lb., and its absolutely fire-proof qualities, it having withstood the most severe tests by fire without being warped, distorted or weakened in any way. The manufacturers specially recommend its use for flooring, sheathing, partitions, fire doors, fire-proof cabinets and gages. A special form of the product, called "Ebony Asbestos Wood," is made to combine

[*Continued on page* 24.]

Classified Directory of Manufacturers—*Cont'd.*

Jeffrey Mfg. Co., Columbus, O
Porter Co., H. K., Pittsburg
Vulcan Iron Works, Wilkesbarre, Pa

LUBRICANTS
Dixon Cruc. Co., Jos., Jersey City, N J

MAGNET WIRE
Acme Wire Co., New Haven, Conn
Griffin, Frank B., Oshkosh, Wis.
Roebling & Sons, Trenton, N J
Seymons Mfg. Co., Seymons, Conn

MALLEABLE CASTINGS
Jeffrey Mfg. Co., Columbus, O.

METAL POLISH
Hoffman, George W., Indianapolis, Ind.

METALS
American Platinum Wks., Newark N J.
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

MICA—(See Insulating Material.)

MINING MACHINERY
Allis-Chalmers Co., Milwaukee
Dean Bros. Steam Pump Wks., Indianapolis
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
Power & Mining Machinery Co., Cudahy.

PINS—STEEL
Locke Insulator Mfg. Co., Victor, N. Y.

PLATINUM
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

PLUGS
Dickinson Mfg. Co., Springfield, Mass.
Freeman Elec. Co., E. H., Trenton, N. J
General Mfg. & Sup. Co., Trenton, N J.
Paiste Co., H. T., Philadelphia.

PLUGS—ATTACHMENT
Hubbell Harvey, Bridgeport, Conn.

POLES—ARC LAMP
Mott Iron Works, J. L., New York

POLES, BRACKETS, PINS, ETC.
Bissell Co., F., Toledo, O.
Cresap Co., The, Bristol, Tenn.
Humbird Lumber Co., Sandpoint, Ida.
Kellogg Switchboard & Sup. Co. Chicago.
Sand Point Cedar Co., Sandpoint, Ida.
Southern Exchange Co., New York.
Worcester Co., C. H., Chicago

PORCELAIN—(See Insulating Machinery).

POWER TRANSMISSION MACHINERY
Case Mfg. Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Phila., Pa
Mead-Morrison Mfg. Co., Boston, Mass
Robins Conveying Belt Co., New York.

DRESSES, DIES AND SPECIAL MACHINERY
Watson-Stillman Co., New York.

PULLEYS
Rockwood Mfg. Co, Indianapolis, Ind.

PUMPS—ELECTRIC
Allen Electric Co., Chicago, Ill.
Allis-Chalmers Co., Milwaukee, Wis.
Conover Condenser Co., Paterson, N. J.
Dean Bros. Steam Pump Wks., Indianapolis.

PUMPS—STEAM
Dean Bros. Steam Pump Wks., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Platt Iron Works Co., Dayton, O.
Quimby, Wm. E., New York.
Watson Machine Co., Paterson, N. J.
Worthington, H. R., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Deming Co., Salem, O.
Morris Company, I. P., Philadelphia, Pa
Platt Iron Works Co., Dayton, O.

PUMPS—VACUUM
Alberger Condenser Co., New York.
Dean Bros. Steam Pump Wks., Indianapolis.
Hubbard's Sons, Norman, Bklyn., N Y.
Platt Iron Works Co., Dayton, O.

Classified Directory of Manufacturers—Cont'd

PUSH BUTTONS
- Dunbar Bros., Bristol, Conn.
- Sarco Company, New York.

RAIL-BONDS
- Chase-Shawmut Co., Newburyport, Mass
- Lord Electric Co., New York.
- Roebling's Sons Co., J. A., Trenton, N. J

RECEPTACLES
- Benjamin Electric Mfg. Co., Chicago, Ill.
- Freeman Elec. Co., E. H., Trenton, N. J
- Paiste Co., H. T., Philadelphia, Pa.

RECORDING INSTRUMENTS
- Bristol Co., Waterbury, Conn.
- Bristol, Wm. H., New York.

REFLECTORS
- Frink, I. P., New York.
- Goodwin & Kintz, Winsted, Conn.
- National X Ray Reflector Co., Chicago. Ill.
- Phoenix Glass Co., New York.

REPAIRING
- Gregory Electric Co., Chicago, Ill.
- Heck, Louis, Newark, N. J.
- Van Dorn-Elliott Electric Co., Cleveland, Ohio.
- Ward, Leonard Electric Co., Bronxville, N. Y.

RESISTANCE UNITS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Simplex Electric Heating Co., Cambridge, Mass.

RHEOSTATS
- Automatic Electric Co., Chicago, Ill.
- Cutler-Hammer Mfg. Co., Milwaukee.
- Schureman & Co., J. L., Chicago, Ill.
- Sundh Electric Co., New York.
- Ward Leonard Electric Co., Bronxville, N. Y.

ROSETTES
- General Mfg. & Supply Co., Trenton
- Hart Mfg. Co., Hartford, Conn.
- Paiste Co., H. T., Philadelphia, Pa.
- Pass & Seymour, Inc., Solvay, N. Y
- Sears, Henry D., Boston, Mass
- Trumbull Elec. Mfg. Co., Plainville, Conn.

RUBBER MACHINERY
- Aiton Machine Co., New York.

SEARCHLIGHTS
- Bogue Elec. Co., C. J., New York.
- Carlisle & Finch Co., Cincinnati, O.

SECOND-HAND APPARATUS
- Bender, George, New York.
- Chicago House Wrecking Co.. Chicago.
- Dustin Co., Chas. E., New York.
- Gas & Electric Development Co., N. Y.
- Gregory Electric Co., Chicago, Ill.
- Linder, H. J., New York.
- Richter, Eugene, Philadelphia, Pa.
- Station Equipment Co., Chicago, Ill.
- Thompson, Joseph H., Jr., New York.
- Toomey, Frank. Philadelphia, Pa.
- Yearsley & Levene, Philadelphia, Pa.

SHADE HOLDERS
- Hubbell, Harvey, Bridgeport, Conn.
- J. E. M. Shade Holder Co., New York.

SHADES
- Holophane Co., New York.
- Hubbell, Harvey, Bridgeport, Conn.
- J. E. M. Shade Holder Co., New York.

SIGNS—ELECTRIC
- A. & W. Sign Co., Cleveland, O.
- Day & Night Sign Co., Easton, Pa.
- Elec. Motor & Equip. Co., Newark, N. J.
- Haller Machine Co., Chicago, Ill.
- Jackson Elec. Co., H. C., Parkersburg. W. Va.
- Metropolitan Engineering Co., N. Y.
- Reynolds Elec. Flasher Mfg. Co., Chicago, Ill.

SIGN LETTERS
- Day & Night Sign Co., Easton. Pa.
- Elec. Motor & Equip. Co., Newark, N. J.
- Haller Machine Co., Chicago, Ill.
- Jackson Elec. Co., H. C, Parkersburg, W. Va.
- Matthews & Bro., N W., St. Louis, Mo.

high electrical insulating capacity with its fireproof properties. It is somewhat similar in structure to the regular product, but it is saturated with a special insulating compound. When finished it resembles ebony. For example, it may be used for switchboards, panelboards, switch and fuse bases, insulating barriers, duct linings, car-floor linings, electric heater insulation, and rheostat tops.

Classified Directory of Manufacturers—Cont'd

SLEEVING
- Belden Mfg. Co., Chicago, Ill.
- Benjamin Electric Mfg. Co., Chicago, Ill.
- Bryant Electric Co., Bridgeport, Conn.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Electrical Mfg. Co., Rochester.
- Crouse-Hinds Co., Syracuse, N. Y.
- Dunton & Co., M. W., Providence, R. I.
- Federal Electric Co., Chicago, Ill.
- Freeman Electric Co., E. H., Trenton.
- General Mfg. & Supply Co., Trenton.
- Johns-Manville Co., H. W., New York.
- Marshall Elec. Mfg. Co., Boston, Mass.
- Pass & Seymour, Solvay, N. Y.
- Peru Electric Mfg. Co., Peru, Ind.
- Porcelain Electrical Mfg. Co., Trenton.
- Stanley & Patterson, New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn.
- Weber Electric Co. (Henry D. Sears, General Sales Agent, Boston, Mass.).
- Yost Electric Mfg. Co., Toledo, O.

SOLDER
- Belden Mfg. Co., Chicago, Ill.
- Walworth Mfg. Co., Boston, Mass.
- Western Electric Co., Chicago, Ill.

SOLDERING FLUX
- Allen Co., L. B., New York.
- Dunton & Co., M. W., Providence.
- Uebelmesser, Chas. R., Bayside, N. Y.

SOLDERING IRONS
- Simplex Electric Heating Co., Cambridge, Mass.
- Vulcan Elec. Heating Co., Chicago, Ill.

SOLENOIDS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Schureman, J. L., Co., Chicago, Ill.

SPEED INDICATORS
- Schaeffer & Budenberg, New York.

SPRINGS
- Barnes Co., Wallace, Bristol, Conn.
- Dunbar Bros. Co., Bristol, Conn.
- Manross, F. N., Forestville, Conn.

SUPPLIES—ELECTRICAL
- Am. Elec'l Supply Co., Chicago, Ill.
- Central Electric Co., Chicago, Ill.
- Central Electric Supply Co., New York.
- Cobb, H. E., Chicago, Ill.
- Commercial Electrical Supply Co., St. Louis, Mo.
- Dearborn, Electric Co., Chicago, Ill.
- Doubleday-Hill Elec. Co., Pittsburg, Pa.
- Electric Appliance Co., Chicago, Ill.
- Electrical Material Co., Baltimore, Md.
- Erner & Hopkins Co., Columbus, O.
- Ewing-Merkle Elec. Co., St. Louis, Mo.

Classified Directory of Manufacturers—Cont'd

- Garton Co., W. R., Chicago, Ill.
- Hudson Electric Supply Co., New York.
- Latham & Co., E. B. New York.
- Machado & Roller, New York.
- Manhattan Elec'l Supply Co., New York.
- Metropolitan Elec'l Supply Co., Chicago.
- Nagel Electric Co., W. G., Toledo, O.
- Novelty Electric Co., Philadelphia, Pa.
- Ostrander & Co., W. R., New York.
- Patrick, Carter & Wilkins Co., Phila., Pa.
- Pettingell-Andrews Co., Boston, Mass.
- Robertson Electric Co., Buffalo, N. Y.
- Sherman-Brown-Clements Co., N. Y.
- Stuart-Howland Co., Boston, Mass.
- Union Electric Co., Pittsburg.
- United Electric & Apparatus Co., Boston.
- Wesco Supply Co., St. Louis, Mo.
- Western Electric Co., Chicago.

SUPPLIES—TELEPHONE
- Am. Elec. Telephone Co.
- International Teleph. Mfg. Co.
- Kellogg Switchboard & Supply Co., Chicago.
- Western Electric Co., Chicago.

SWITCHBOARDS
- Adam Electric Co., Frank, St. Louis, Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Burke Electric Co., Erie, Pa.
- C. & C. Electric Co., Garwood, N. J.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Crescent Elec'l Mfg. Co., Rochester, N.Y.
- Crocker-Wheeler Co., Ampere, N. J.
- Crouse-Hinds Co., Syracuse, N. Y.
- D'Olier, Jr., Co., Henry, Philadelphia.
- Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
- General Electric Co., Schenectady, N. Y.
- Grady Co., S. S., Cambridge, Mass.
- Hill Electric Co., W. S., New Bedford, Mass.
- Ideal Elec. & Mfg. Co., Mansfield, O.
- Jones Electrical Co., New York
- La Roche Co., F. A., New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn.
- Westinghouse Elec. & Mfg. Co., Pittsburg.

SWITCHES
- Anderson Mfg. Co., A. & J. M., Boston
- Dickinson Mfg. Co.

ARC LIGHTS
- Sarco Co., New York.

CANOPY
- Sarco Co., New York.

CEILING
- Jones Electrical Co., New York.
- Krantz Mfg. Co., H., Brooklyn, N. Y.
- Sorensen, P., Brooklyn, N. Y.

CLOCK
- A. & W. Electric Sign Co., Cleveland, O.
- Campbell Electric Co., Lynn, Mass.
- Elec. Motor & Equip. Co., Newark, N. J.
- General Electric Co., Schenectady, N. Y.
- Hartford Time Switch Co., Hartford.
- Manhattan Elec'l Supply Co., New York.
- Prentiss Clock Improvement Co., N. Y.
- Specialty Mfg. Co., Youngstown, O.
- Sorensen, P., Brooklyn, N. Y.
- Trumbull Elec. Mfg. Co.. Trumbull, Conn.

SWITCHES— KNIFE
- Adam Electric Co., Frank, St. Louis. Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Mfg. Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Elec'l Mfg. Co., Rochester, N. Y.
- Crouse-Hinds Co., Syracuse, N. Y.
- Garton Co., W. R., Chicago, Ill
- General Electric Co., Schenectady, N. Y.
- Hill Electric Co., W. S., New Bedford, Mass.

Classified Directory of Manufacturers—Cont'd

Ideal Elec. & Mfg. Co., Mansfield, O.
La Roche Co., F. A., New York.
Lang Electric Co., J., Chicago, Ill
Lundin Electric & Machine Co., Boston.
Manhattan Elec'l Supply Co., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Mutual Electric & Machine Co., Wheeling, W. Va.
Ohio Brass Co., Mansfield, O.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Solvay, N. Y.
Trumbull Elec. Mfg. Co., Plainville Conn.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

OIL

Adam Electric Co., Frank, St. Louis, Mo.
Condit Elec'l Mfg. Co., Boston, Mass.
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
Helios Mfg. Co., Philadelphia, Pa.
Hill Electric Co W. S., New Bedford, Mass.
Pettingell-Andrews Co., Boston, Mass.
Trumbull Elec. Mfg. Co. Plainville, Conn.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

SNAP

Bissell Co., F., Toledo, O.
General Electric Co., Schenectady N. Y.
Hart Mfg. Co., Hartford, Conn
Sarco Company, New York.

PENDANT

Sarco Company, New York

TACHOMETERS

Schaeffer & Budenberg, New York.

TAPE

American Elec'l Wks., Philipsdale, R. I.
Boston Woven Hose & Rubber Co. Cambridge, Mass.
Brixey, W. R., New York.
Diamond Rubber Co., Akron, O.
Dunton & Co., M. W., Providence.
Electric Appliance Co., Chicago.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goodrich Co., B. F., Akron, O.
Goodyear Tire & Rubber Co., Akron, O
Hartford Rubber Works, Co., Hartford, Conn.
Johns-Manville Co., H. W., New York
Knowles, C. S., Boston, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
Massachusetts Chem. Co., Walpole, Mass.
Mica Insulator Co., New York.
Morgan & Wright, Chicago, Ill.
National Insulator Co., Boston, Mass.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Pennsylvania Rubber Co., Jeannette, Pa.
Republic Rubber Co., Youngstown, O.
Revere Rubber Co., Boston, Mass.
Standard Paint Co., New York.

TELEPHONES

American Bell Telephone Co., Boston.
Connecticut Telephone & Electric Co., Meriden, Conn.
Couch Co., S. H., Boston, Mass.
Electric Goods Mfg. Co., Boston, Mass.
Gail-Webb Mfg. Co., Buffalo, N. Y.
Manhattan Elec'l Supply Co., New York.
Novelty Electric Co., Philadelphia, Pa.
Russell Electric Co., Danbury, Conn.
Schmidt-Wilckes Elec. Co., Weehawken, N. J.
Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
Vote-Berger Co., La Crosse, Wis.
Wesco Supply Co., St. Louis, Mo
Western Electric Co.

THEATER DIMMER

Campbell Electric Co., Lynn, Mass.
Cutler-Hammer Mfg. Co., Milwaukee

Russian Electric Railway Exposition

An international exposition of "Electricity as Applied to Railway Service" will be held in St. Petersburg during the month of August. It is stated that through this exposition the Russian Government desires to fix its ideas concerning the electrification of Russian railways. A special trial track has been provided, on which all exhibits of electric railway motor cars will be tested on the level and with varying grades and loads. The exhibitors will be permitted to sell an exhibit during the display or at the conclusion of the exposition. The president of the organizing committee is General Sitenko, 24 Sadovaja, St. Petersburg, to whom inquiries in English may be addressed by intending exhibitors. It is to be hoped that American railway material and apparatus will be fully represented.

Economy of Low Pressure Turbine

The saving of the low-pressure turbine yoked with an efficient engine is of small and doubtful value. Where the low-pressure turbine is coupled with a wasteful steam engine, such as is used commonly in haulage, pumping and mill work, the saving may amount to as much as 25 or 30 per cent. Rateau has conclusively demonstrated these facts in his continental work.

Classified Directory of Manufacturers—Cont'd

Simplex Electric Heating Co., Cambridgeport, Mass.
Union Elec. Mfg. Co., Milwaukee, Wis.
Universal Electric Stage Lighting Co. New York.
Ward Leonard Electric Co., Bronxville N. Y.
Wirt Electric Co., Philadelphia, Pa.

TIME SWITCHES
Anderson Mfg. Co., A. & J. M., Boston

TRANSFORMERS
Am. Transformer Co., Newark, N. J
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind
General Electric Co., Schenectady, N. Y
Irwin & Co., O. C., Crawfordsville, Ind.
Kuhlman Electric Co., Elkhart, Ind.
Lafayette Electrical Mfg. Co., Lafayette Ind.
Moloney Electric Co., St. Louis, Mo.
Packard Electric Co., Warren, O.
Peerless Transformer Co., Warren, O.
Pittsburg Transformer Co., Allegheny, Pa
Wagner Elec. Mfg. Co., St. Louis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

TROLLEY WHEELS
Anderson Mfg. Co., A. & J. M., Boston.

TURBINES—STEAM
Allis-Chalmers Co., Milwaukee, Wis.
Am. Turbine Eng. Co., Washington, D. C
Ball & Wood Co., New York.
De Laval Steam Turbine Co., Trenton.
General Electric Co., Schenectady, N. Y.
Hooven, Owens, Rentschler Co., Hamilton, O.
Morris Co., I P., Philadelphia, Pa.
Westinghouse Mach. Co., Pittsburg Pa

VALVES
Am. District Steam Co., Lockport N. Y
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston, Mass.
Crane Co., Chicago, Ill.
Crosby Steam Gauge & Valve Co., Boston.
Fairbanks Co., New York.
Homestead Valve Mfg. Co., Homestead, Pa
Jarecki Mfg. Co., Erie, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Valve and Fitting Co. Pittsburg, Pa.
Powell Co., W. M., Cincinnati, O.
Schutte & Koerting Co., Philadelphia.
Walworth Mfg. Co., Boston, Mass.

VARNISH—ARMATURE AND COIL
Calman & Co., Emil, New York.
Eagle Paint & Varnish Co., Pittsburg
Growthwell, A., New York.
Macon-Evans Varnish Co., Pittsburg, Pa.
Massachusetts Chem. Co., Walpole, Mass
Sherwin-Williams Co., Cleveland.
Standard Paint Co., New York.
Standard Varnish Works New York
Sterling Varnish Co., Pittsburg, Pa.

WATER WHEELS
Allis-Chambers Co., Milwaukee, Wis.
Dayton Globe Iron Works, Dayton, O.
Doble & Co., Abner, San Francisco, Cal
Leffel & Co., James, Springfield, O.
Lombard Governor Co., Ashland, Mass.
Morris Co., I. P., Philadelphia, Pa.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co. Dayton, O.
Risdon-Alcott Turbine Co. Mt. Holly, N. J.
Smith Co., S. Morgan, York, Pa.
Trump Mfg. Co., Springfield, O.

WATTMETERS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.
Diamond Meter Co., Peoria, Ill.
Duncan Electric Mfg. Co., Lafayette, Ind.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Helios Mfg. Co., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
Keystone Electrical Inst. Co., Phila., Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Classified Directory of Manufacturers—Cont'

Weston Elec'l Inst. Co., Newark, N. J.
Whitney Electrical Inst., Co., New York.

WIRE—

COPPER

Am. Electrical Heater Co., Detroit, Mich.
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill
Ansonia Brass & Copper Co., New York
Bishop Gutta Percha Co., New York.
Chicago Insulated Wire Co., Chicago.
Crescent Insulated Wire & Cable Co., Trenton, N. J.
Hazard Mfg Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Monarch Electric & Wire Co., Chicago.
Moore, Alfred F., Philadelphia, Pa.
National Conduit & Cable Co., New York
Phillips Insulated Wire Co., Pawtucket R. I.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg Co. Seymour. Conn.
Standard Underground Cable Co., Pittsburg, Pa
Western Electric Co., Chicago.
Wire & Telephone Co. of America, Rome, N. Y.

MAGNET

Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill.
Ansonia Brass & Copper Co., New York.
Belden Mfg. Co., Chicago, Ill.
Chicago Insulated Wire Co., Chicago.
D. & W. Fuse Co., Providence, R. I.
Driver-Harris Wire Co., Harrison, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Moore Alfred F., Philadelphia, Pa.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg. Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg, Pa
Stuart-Howland Co., Boston, Mass.
Washburn Mfg. Co., Phillipsdale, R. I.
Waterbury Brass Co., Waterbury, Conn.
Western Electric Co., Chicago, Ill.
Wire & Telephone Co. of America, Rome.

RUBBER COVERED

Am. Electrical Wks., Phillipsdale, R. I
American Steel & Wire Co., Chicago.
Atlantic Ins. Wire & Cable Co., New York.
Bishop Gutta Percha Co., New York
Boston Insulated Wire & Cable Co., Boston, Mass.
Brixey, W. R., New York
Crescent Insulated Wire & Cable Co., Trenton, N. J.
General Electric Co., Schenectady, N Y.
Hazard Mfg. Co., Wilkesbarre, Pa.
India Rubber & Gutta Percha Insulating Co., New York.
Indiana Rubber & Insulated Wire Co., Jonesboro, Ind
Lowell Insulated Wire Co., Lowell, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
National India Rubber Co., Bristol, R I.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Phillips Insulated Wire Co. Pawtucket, R. I.
Reed Electrical Cordage Co., Syracuse, N. Y.
Roebling's Sons Co., John A., Trenton.
Safety Ins. Wire & Cable Co., New York.
Simplex Electrical Co., Boston, Mass.
Standard Underground Cable Co., Pittsburg.
Waterbury Co., New York.
Wire & Telephone Co. of America, Rome

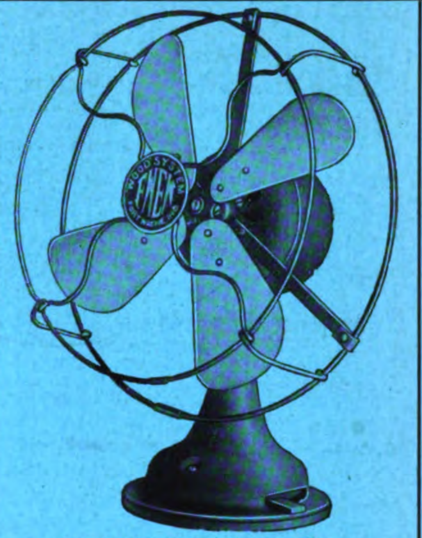
DIRECTORY

EMBRACING THE LEADING AMERICAN ENGINEERS, CONTRACTORS AND ARCHITECTS

THIS IS NOT HOT AIR

But it is a Strong Statement

You cannot handle a better or more profitable line of Fan Motors this season than the Fort Wayne.



8 in. Desk and Bracket Fan Motor

We are well aware, as a reputable concern, that it would be foolish to advertise such a claim if we couldn't back it up with proof.

Send for our proposition and compare it with others. That's a fair method, isn't it?

We can't list and illustrate all our types and sizes here or go into details concerning their many points of superiority. We do all that in the catalog we supply you, with your name on for distribution. We think this is a pretty "nifty" booklet and you can be proud to send it to your customers.

We have already secured more contracts this year than ever before but perhaps you have preferred to wait until the snow was gone before placing your order. There are some advantages in this method but you can't afford to put it off much longer.

Therefore we repeat—**Fort Wayne Fans for 1910 are the best ones you can handle,** and it's to your advantage to investigate our proposition and see if we are telling the provable truth. We will supply you with any information you want on the next mail after we hear from you.

Fort Wayne Electric Works

"WOOD SYSTEMS"

1611 Broadway, Fort Wayne, Ind.

Atlanta, Ga. Boston, Mass. Charlotte, N. C. Chicago, Ill. Cincinnati, O. Cleveland, O. Dallas, Tex. Grand Rapids, Mich. Kansas City, Mo. Madison, Wis. Milwaukee, Wis. New Orleans, La. New York, N. Y. Pittsburg, Pa. Philadelphia Pa. Syracuse, N. Y. San Francisco, Cal. Seattle, Wash. St. Louis, Mo. Yokohama, Japan

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DEANE OF HOLYOKE

Electrically Operated Pumps for Every Service

AUTOMATIC SWITCHES AUTOMATIC STARTERS
PRESSURE REGULATORS

THE DEANE STEAM PUMP CO.

115 Broadway, New York
Works: Holyoke, Mass.

If you have a broken article made of Cast Iron don't throw it away! Clean and fasten together with binding wire, then put in fire till cherry red—throw some brass on the place to be brazed together with a little

C. R. U. Brazing Salt

and your cast iron will be brazed and mended just the same as had it been Steel or Brass.

$1.00 per pound **12 pounds $10.00**

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JUST PERFECTED

Variable Speed Alternating and Direct Current Motors

Send for Booklet "C" covering Printing Press Equipments, Forge Blowers, Dental Engines, Jewelers' Power and Buffing Machines. We have 900 Second-hand Dynamos and Motors in stock and would like to quote you.

GUARANTEE ELECTRIC CO.
Clinton and Adams Streets, Chicago

Our New Catalogue

IS NOW READY FOR DISTRIBUTION

It lists and illustrates our complete line of Solderless Connectors, Cable Taps and Terminals, including many new designs, and presents the information on Dossert Joints more fully and in better shape than ever.

If you are interested, send us a postal, and we will send the catalogue.

DOSSERT & CO., Sole Manufacturers
242 West 41st Street, New York

ELECTRICAL AGE

Established 1883

THE ELECTRICAL AGE COMPANY, 45 E. 42d Street, NEW YORK

Vol. 41
No. 4

MAY, 1910

$1.00 per Year
15 Cents per Copy

The Continuous Efficiency and Reliability of

Allis-Chalmers Steam Turbine Units

Has been demonstrated under the most severe conditions of service

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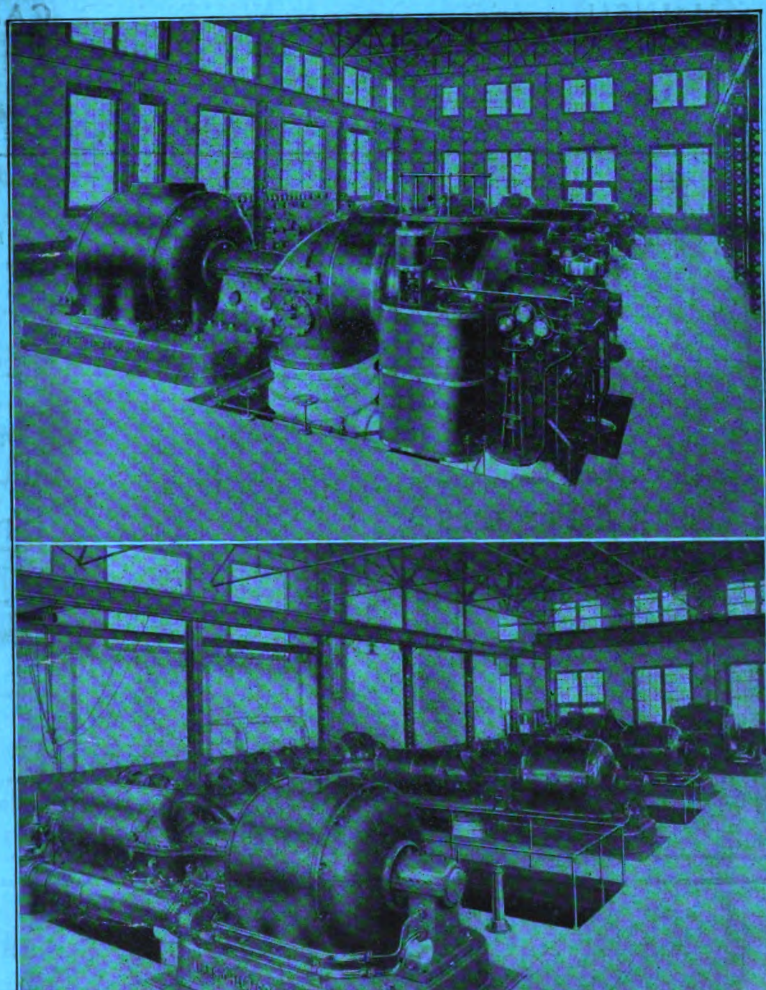
ECONOMICAL OPERATION



HIGH GRADE MATERIAL

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Allis-Chalmers Steam Turbine Units Installed

The Operating Record of Allis-Chalmers Steam Turbines is their best recommendation

Write to ALLIS-CHALMERS COMPANY

FOR FULL INFORMATION

GENERAL OFFICES, MILWAUKEE, WISCONSIN

DISTRICT OFFICES IN ALL LARGE CITIES

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Classified Index, page 15.

LOOKING AHEAD

Are you anticipating, ten years from to-day, an Event or an Actuality—an Actual Occurrence that will Actually Occur, whereby one man will create a Foundation, either on Character, Honor, Respect—or seek to Commercialize a Legal Right, National (Washington, D. C., or State) that will give him the privilege of building, not Only, Universities—Libraries—Churches, leading to the Moral Good of All; but Electric Light Plants? Many and many cities Need One—Many a better One—the Good Improved.

Is there a man in the United States who will Enlist the Services of Two Leading Engineers to Examine Actual Conditions, that Demand or Need Improvement for the Public Good, just as Much as Universities and Churches in their Respective Spheres? (You know—Light, Day and Night, Essential.) I mean Lighting— either from the standpoint of Municipal or Private Electric Plants.

I mean simply this, Mr. Philanthropist—seeking now the modern method of Foundations—incorporated, State and National Protection:—Surely, Just as Great Honors can be Yours as to the Man Who has Succeeded in Establishing a National Reputation in Other Lines, Also to the Man or Men Who will Donate a New Electric Light Plant (making it Obligatory upon the City to see that it is Run Properly, the same as it is Obligatory upon the City to see that Libraries are Properly Conducted) so that all in that City can at least have Improved Light Sufficient to Read Books Donated, whether in Library, Public School or Church.

For a number of years I have been hoping that there would be One Man, at Least, who would come out of the "West," if not "East" (whether he could Play Golf or not), who would take just as much pleasure in Donating Electric Light Plants as the Men Who have Attained the Top Pinnacle of Fame—in Name, Standing, Reputation, Financially, Morally, Socially, Commercially, Religiously, and I might add consistently—Politically.

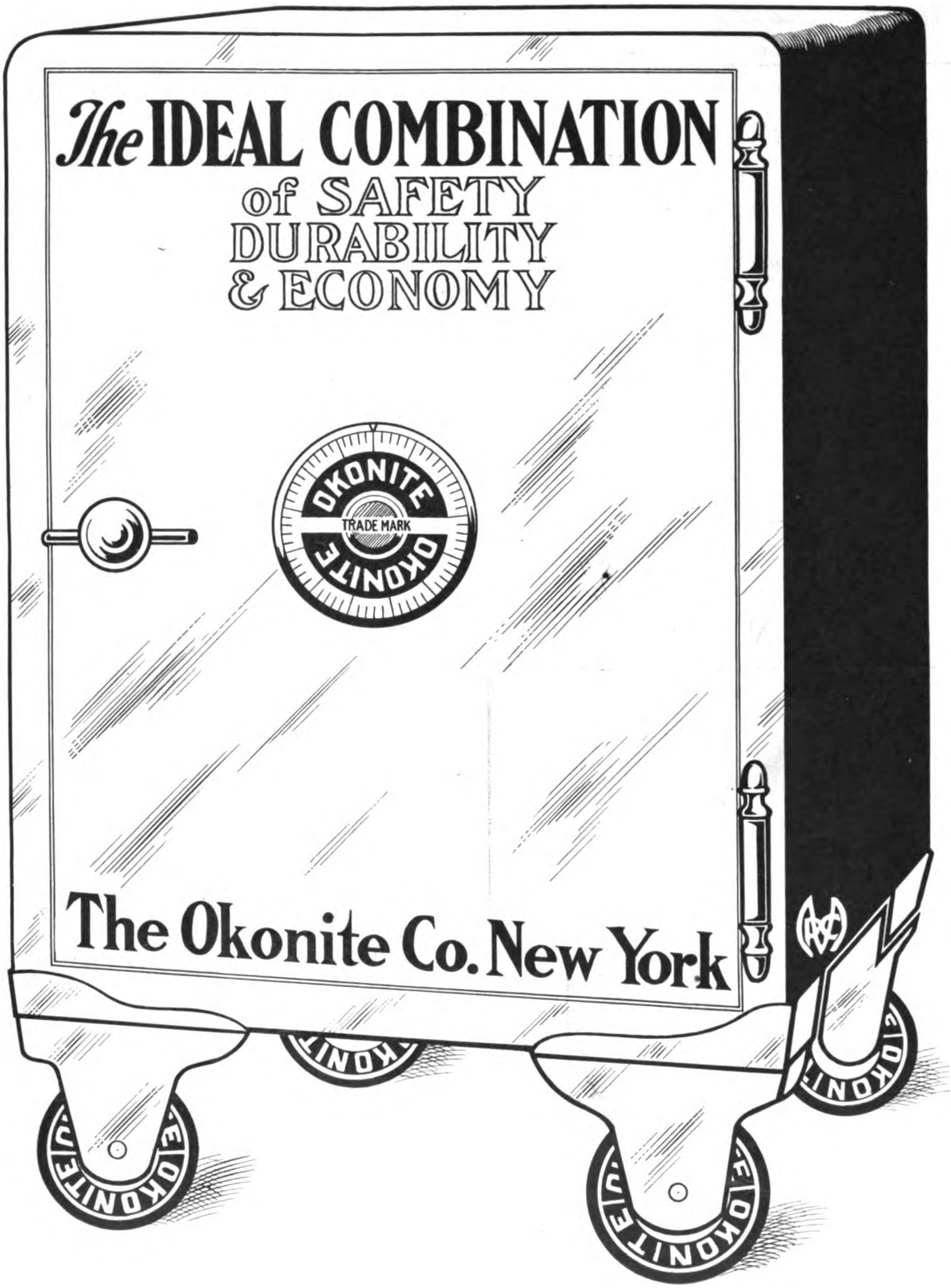
To that Man or Men I Offer My Services, without Charge—without Price, in amount not to exceed One Dollar Annually, until July 1, 1913. On that day I expect to leave an organization, in control of others, with Talent and Brains Sufficient to Carry Out My Project, to the End that Others are Satisfied with all the Honors, Honorably Attained or Achieved, as stated above. From that Day I expect to Play Golf—have a Yacht, not alone for my personal pleasure, but for what I may be able to do in making happy others, as others have done, and Many More to Come.

Yours respectfully,

Robert C. Finch.

President COLONIAL ILLUMINATING CO.
1146-48 Marbridge Bldg., 34th Street and Broadway
New York, N. Y.

Electric Light Plants Bought and Sold, and Money Loaned on Same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of SAFETY
DURABILITY
& ECONOMY
OKONITE
TRADE MARK
OKONITE
The Okonite Co. New York

INDEX TO ADVERTISERS

ELECTRICAL AGE

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New York.

ESTABLISHED 1883

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NOTICE TO ADVERTISERS

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CONTENTS

EDITORIAL

LEADING ARTICLES

National Electric Light Association

The quarter century of the National Electric Light Association at St. Louis next week rounds out a period of marvellous achievement, unrivalled by the intellectual conquests of man.

Within this period a comparatively small group of workers has taken out about thirty thousand patents, developed several thousand pieces of machinery, more or less complicated, evolved several complete and different types of generating machinery, each worked out from different principles, discarding the present for new with such reckless abandon that the investment of money in electrical securities for a long time was classed as "wild-catting."

In the same town we have seen many separate central stations created by hot enthusiasts, brought after a feverish struggle, to a common ownership. The fierce cost of invention and replacement had worn them down. Then the separate plants were abandoned for a single large central station of increasing size, becoming at last unwieldy and to a certain extent lessened in its reliability by its very bulk.

It is well to set up the mark and look back over the wild, ceaseless and costly struggle of deified invention.

The St. Louis convention is likely to be such a mark.

The creation of the power transmission section is the signal event in the history of the Association. It marks the turn from a study of the single distribution system to the study of the possibilities of connecting separate systems.

This means greatly increased profit under common ownership and unified operation.

It means, too, getting that profit with slight expenditure.

Also the connecting up of the distribution networks means the ultimate passing of the small central station.

The art of power transmission now moving swiftly in what we still awkwardly call the central-station field is swiftly placing the development of electric energy upon a solid foundation.

Less and less shall we see the exploitation of freak inventions at the expense of little non-dividend-paying stations. Less and less can inefficiency, slothfulness and ignorance remain in the new régime.

More and more stations are being connected together. Wider and wider spreads the network of distribution. Where before a group of little stations were, each losing money in the ceaseless struggle with swift and uncertain invention, there appears a single distributive company of size, single management and profitable to its owners.

Those of us familiar with the telephone industry will remember that the turn of its fortune was almost coincident with the connecting up of the various cities and towns, and that the growth in the telephone service bounded rapidly upward.

A community of ownership having been largely worked out, there were fairly large and stable operating companies to deal with.

The little fellows were gobbled up quickly—they contributed to the income, and they hardly added to the general expense sheet. The purchase of these small telephone plants was always profitable.

Electric Lamps

There has recently appeared an excellent work on electric lamps from the pen of Maurice Solomon, an English authority on lamps who has the unusual claim to our attention of being at-first-hand familiar with manufacturing processes.

Those who have had the privilege of knowing Mr. Solomon's work and personality naturally expected his book would become the classic in its field, and in this they have not been disappointed. From the first page to the last the reader feels the grip of a specialist's mind ceaselessly working to collect and present in lucid form the best information on the subject of electric illumination. Yet there is no evidence of compilation, for the work is readable throughout and is written in a clear, flowing style, bespeaking not only the engineer, but also the scholar.

The work opens with a clear and authoritative statement of the principles of artificial illumination which ought to be read by many other people than those to whom the remainder of the book will appeal. In the chapter on the production of artificial light occurs what is probably the only complete and lucid explanation in print of the black-body standard of radiation. This chapter quotes very largely from the work of Lummer and Pringsheim, whose excellent work on radiation has not met in America with the recognition it deserves.

The subject of photometry and testing is treated in 68 pages, which have the unusual quality of combining literary merit and convenience for reference. Attention is drawn to the lack of agreement between the comparative tests on the various units of illumination, a fact which emphasizes the necessity of a rational and convenient standard. The various values are given as follows:

	CANDLE	HEFNER	CARCEL
National Physical Laboratory	1	0.914	0.982
Reichsanstalt	1	0.917	0.991
Laboratoire Centrale	1	0.929	1.000
Laboratoire d'Essais	1	0.928	0.996

Further it is stated that the value of the candle in terms of the Hefner unit, hitherto generally accepted, is 0.88, four per cent. too small. The figures in the above table also show that the Pentane and Hefner lamps are distinctly preferable to the Carcel lamp for accuracy of reproduction.

An interesting paragraph on page 54 tells of the application of illumination photometers to the photometry of vapor lamps. "For example, the mercury-vapor lamp, and still more, the Moore tube lamp, are extremely difficult to photometer in the ordinary way on account of the fact that, having light sources of very large area, the inverse square of the distance law cannot be applied. In order to determine the illuminating value of these lamps recourse has been had to the following method: A given space, for example, a large room, is illuminated by one (or more) of these lamps, and the value of the illumination at different points is measured by means of an illumination photometer. The room is then illuminated by lamps, the candle-power of which can be determined in the usual way, and the illumination under these conditions is again measured. From the known candle-power of these lamps the equivalent candle-power of the original lamp can then be calculated." The author then proceeds to explain that this method is subject to important inaccuracies.

In the chapter on carbon-filament lamps Mr. Solomon, unlike most Englishmen, gives credit to Edison for important work in the development of the incandescent lamp. He proceeds to give a clear description of the manufacturing processes and tests and of the physical properties of filaments of various kinds and conditions.

The chapter on Nernst lamps is entirely too thorough, presenting more data than the commercial importance of the lamp deserves. But Mr. Solomon knows so much about Nernst lamps that, we suppose, he had to get it out of his system, and he does so in 38 pages of matter, which would be of the most momentous interest if somebody hadn't invented the tungsten lamp. He says, however, that the Nernst lamp has "undergone but little modification since the first satisfactory types were produced in 1900 and 1901 and it has decidedly failed to achieve the results anticipated at its first introduction."

RATIO OF STARTING TO RUNNING CURRENT

The subject of metallic-filament lamps is treated with somewhat less authority than the remainder of the book, but is probably the best exposition of the subject extant. The overrush of current when a metallic-filament lamp is switched on is calculated from resistance curves or observed with an oscillograph. The results by the two methods do not agree, however, and Mr. Solomon leaves the reader without an explanation of this discrepancy. The figures are as follows:

LAMP	RATIO OF STARTING CURRENT TO FINAL CURRENT	
	Calculated from resistance curves	Observed with oscillograph
Carbon	....	0.569 to 1
Tantalum	5.73 to 1	4.74 to 1
Tungsten	12.43 to 1	7.33 to 1

The electric arc is treated in a very thorough way with frequent reference to the work of Mrs. Ayrton, wife of the late Prof. W. E. Ayrton, to whom the book is dedicated. Mrs. Ayrton's work on the electric arc must rank with that of Mme. Curie on radium, as the most important work done by women, in the field of physical science, and we believe that Mr. Solomon was an assistant to Mrs. Ayrton in some of her classic researches. Anyone who wants to know all about the alleged back-E.M.F. and negative resistance of the arc will find it lucidly treated in Chapter VIII.

COST OF ELECTRIC LIGHT

Among the miscellaneous lamps the Moore vapor lamp is given special consideration, it being stated that the Moore tube probably represents "the most beautiful form of electric lighting yet developed, producing, as it does, a steady, evenly distributed illumination with a source of low, intrinsic brilliancy." Mr. Solomon has probably never seen a Moore tube operating on a circuit of such low periodicity as 60 cycles per sec. or he would surely say that this alternating light is not extremely pleasant to work by.

Assuming energy at 10 cents per kw-hr., the cost per 1000 candle-hours for various illuminants is found from the book to be as follows, the cost of carbons and renewals being included in the arc and incandescent lamp figures respectively:

Moore tube	18	cents
Mercury vapor	4	"
Magnetite arc	8	"
Flame arc, yellow	4.4	"
Flame arc, white	7.4	"
Enclosed arcs	23.6	"
Open arcs, retort carbons	14.4	"
Tantalum (direct current)	20.0	"
Tungsten (1000 hrs.)	16.2	"
Carbon filament	39.6	"

The above table is taken from a very elaborate series of tables in the last chapter. Here the cost of illuminating with lamps of different types is fully worked out. The author very wisely leaves out the trimming costs and depreciation of arc lamps, as these vary greatly with the locality and had better be calculated for each case. It is worth while to have the book for this chapter alone, if one is interested in the *economics* of electric lighting. In conclusion Mr. Solomon gives the share of the various nations in advancing the cause of electric lighting and we have compiled the following table to give the substance of his remarks:

TYPE OF LIGHT	INVENTOR	NATIONALITY
Arc light	Davy	England
Incandescent lamp	Edison	U. S. A.
Incandescent lamp	Swan	England
Arc, commercial	Carré	France
Cored carbon	Siemens	Germany
Flame carbons	Bremer	Germany
Magnetite arc	Steinmetz	U. S. A.
Mercury arc	Arons	Germany
Mercury arc	Cooper-Hewitt	U. S. A.
Quartz lamp	Heraeus	Germany
Vacuum tube lamp	Moore	U. S. A.
Metallized filament	Howell	U. S. A.
Nernst lamp	Nernst	Germany
Osmium lamp	Welsbach	Germany
Tantalum lamp	Siemens	Germany
Tungsten lamp	Welsbach	Germany
Tungsten lamp	Just	Austria

As a moral to this comparative study in national activity, the Briton is incited to hustle and catch up with his friends(?) across the sea. Doesn't the moral also apply to us in America, too? Are we not being pushed hard by the Germans, too?

Just as everyone engaged in electrical engineering must have a standard handbook, and everyone interested in heavy electrical engineering must have Del Mar's Electric Power Conductors, so everyone engaged in the broad field of electric lighting cannot afford to be without Solomon's Electric Lamps.

Distant Control Switchgear

STEPHEN Q. HAYES

PART III—Continued

Switchboard panels, pedestals and control desks having been described in Part I of this paper; apparatus, circuit-breakers, etc., having been covered by Part II, the structures for breakers and bus bars, as well as the general station layouts, will be treated in this Part III.

This part will be arranged in sections as follows:

A. General features of all circuit-breaker and bus-bar structures.
B. General features of European structures.
C. General features of American structures.
D. Typical examples of European structures and station layouts for various voltages.
E. Typical examples of American structures and station layouts for various voltages.
F. Details of apparatus.

These main sections are susceptible of further subdivision, but they cannot be gone into as fully as their importance might warrant in the short space available in this paper.

SECTION "A"—GENERAL FEATURES

The early electrical power plants contained a few machines of small output and moderate voltage that were readily controlled by simple, inexpensive, exposed switch gear mounted on the station walls or on a switchboard. As voltage and output increased, it became necessary to utilize more space for the switch gear than could be found on the station walls, or on a switchboard proper, and to take more precautions to safeguard the attendants and to localize the trouble that might occur due to defect in the switch gear. The main features of distant control with their reasons and advantages having been covered rather thoroughly in the first sections of Parts I and II, consequently it will not be necessary to dwell on these points at any length in this section. Many of the remarks made in Section B apply equally well to Section C and vice versa.

SECTION "B"—GENERAL FEATURES OF EUROPEAN STRUCTURES

Distant mechanical control was adopted for switch gear at an early date in Europe and, as a matter of precaution, the switch gear, bus bars and connections were generally enclosed in cabinets or located in masonry structures or otherwise placed out of reach. The equipment was usually so arranged as to be accessible to the proper parties in case of necessity, but under ordinary conditions was inaccessible to the casual visitor or the unauthorized attendant.

As the voltage and amount of power to be handled in the stations increased, various switching devices as described in Part II were developed from time to time to handle the circuits of large power and high voltage, but in Europe and America the oil switch and oil circuit-breaker have practically superseded all other types of switch gear for alternating-current service.

The essential feature of the oil switch or breaker is the opening of the circuit under oil and the smothering of the arc in a rather restricted space, and it was soon found that explosions in the oil switch would occasionally occur when circuits of large power were being opened under load, and that frequently oil would be blown out of the breaker and occasionally the breaker itself would be destroyed by the explosion.

The amount of power that could safely be handled by an oil circuit-breaker, as explained in Part II, depended, among other things, on the strength of its tanks, the amount of the oil, the arrangement of the breaking contacts and similar features of design, but even with the most careful design oil would occasionally be blown out of the breaker and sometimes its tanks destroyed.

Due to the throwing of oil and the trouble occasionally arising from explosions in the tanks of the breaker, it has been found advisable in many instances to locate the oil circuit-breaker and some of the other apparatus, either on a framework away

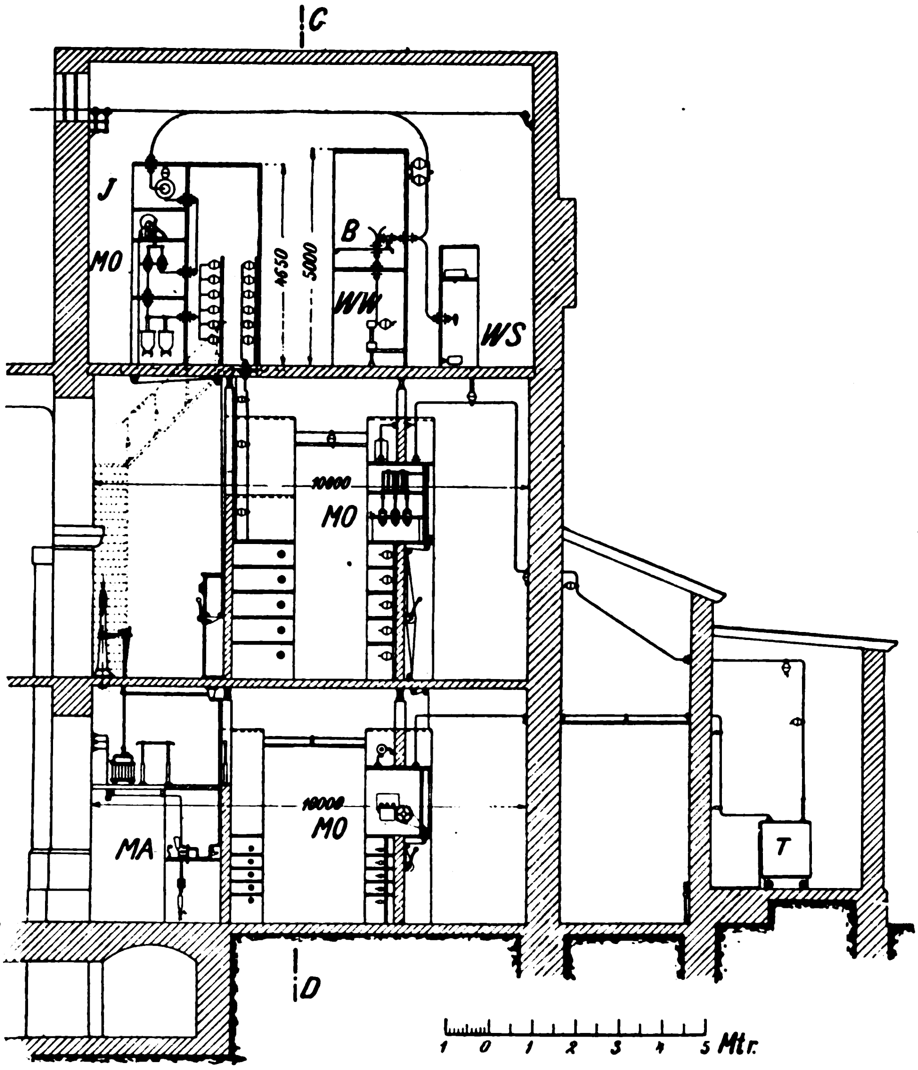


Fig. 1.—TRANSVERSE SECTION—OBERMATT GENERATING STATION

from other portions of the switch gear or in a masonry compartment, usually of concrete, so that even if the oil is thrown out of the breaker or the breaker itself destroyed by an explosion, little other additional harm will occur.

In Europe it is customary in all plants, except those of very high power or extremely high voltage, to use circuit-breakers having all three sets of contacts for a three-phase circuit in one tank, and consequently most of the European structures have been designed with this point in view.

In many cases, however, the circuit-breakers, particularly for high voltage, are arranged with each pole of the breaker in a separate compartment, and the bus bars and connections are almost invariably arranged so that each phase occupies a separate compartment.

While in America switch-gear compartments have been built out of brick, slate, soapstone and other materials, as well as concrete; in Europe concrete has been used almost exclusively, and due to the use of excellent material and high-grade workmanship, very elaborate and intricate forms have been made in concrete construction and horizontal shelves as well as vertical septums and barriers are made of this material.

In an article of this length it is, of course, impracticable to attempt to show and describe all of the various forms which these concrete switch-gear compartments take in European construction, so this paper confines itself to a few examples collected from plants that have been installed in France, Switzerland, Italy and Spain by the "Machinenfabrik Alioth," the "Brown Boveri Company" and the "Maschinenfabrik Oerlikon."

It might be stated, however, that the concrete construction of these firms does not differ materially from that employed by other European manufacturers.

SECTION "C"—GENERAL FEATURES OF AMERICAN STRUCTURES

The question of cellular construction for plants of 13,000 volts or less and the reasons for the open construction on higher voltages having been discussed previously, it is unnecessary to repeat here the reasons for such construction.

As the main idea of the cellular scheme for circuit-breaker and bus structures is to provide an insulating fire-proof barrier between leads of opposite potential in heavy capacity plants, the nature of the material to be used for the structures, barriers and other parts is of the utmost importance. While in Europe concrete is used almost exclusively, in Ameri-

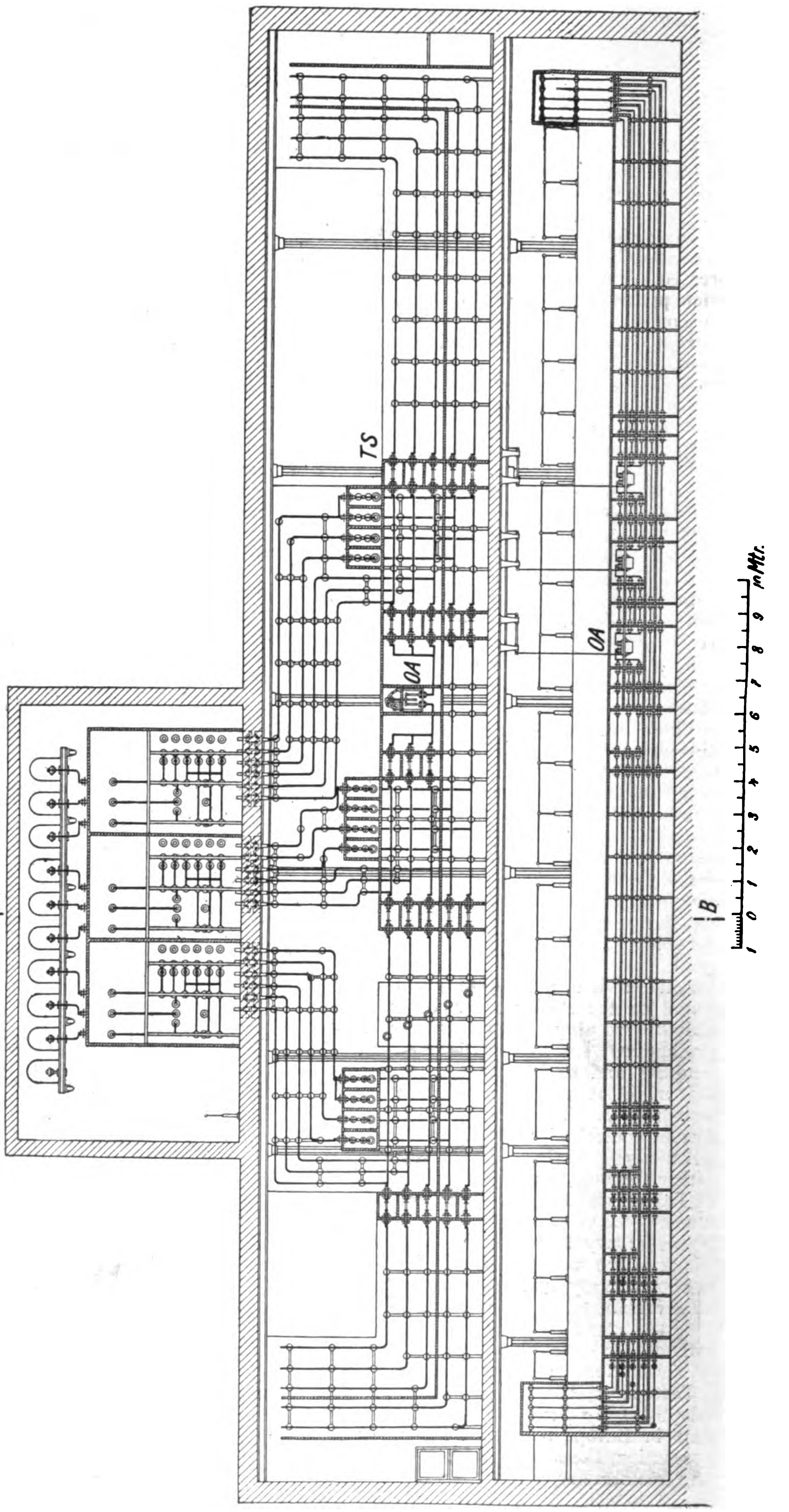


Fig. 2.—HORIZONTAL SECTION—OBERMATT GENERATING STATION

ca, until very late years, the vertical walls and septums of the circuit-breaker and bus-bar structures usually have been built of brick or concrete, while the horizontal shelves between the bus bars ordinarily have been made of concrete, soapstone, slate or marble. In some instances the bus-bar structures have been made of asbestos lumber, transite or similar material.

The brick used for structural work of this kind is usually a good class of pressed brick, fire-brick, or enamelled brick put up with cement mortar and presenting a fine appearance. In order to keep down the cost, it is sometimes arranged to use the finer grades of brick for such portions of the structure as are visible from the operating-room or noticeable to the average visitor, while a cheaper grade is used for such other parts as are normally not seen. The advantages of brick in America for this class of work are that it has ample strength to support the weight and to stand the jar of opening a heavy breaker, and it is easy to secure good bricklayers in almost any locality. Its disadvantages are chiefly due to its relatively fixed dimensions, the difficulty of reinforcing thin walls of any considerable height and the trouble experienced in locating conduits for control leads or other purposes, as well as the fact that it is practically impossible to make the horizontal shelves of the same material as the vertical walls when brick is used.

Concrete possesses most of the advantages of brick without the disadvantages of relatively fixed dimensions and as it can be easily reinforced and can be made into horizontal shelves for bus-bar work, it is rapidly becoming a favorite material for such structures in America, as well as in Europe. When concrete is used it is a simple matter to imbed the conduit for the control leads, the tie rods for the breakers, the bolts for switch bases, transformers, etc., in the structure. Concrete, however, is somewhat more apt to absorb moisture than brickwork, but when dry is a comparatively good insulator and resists the destructive effects of an arc as well as anything used for the purpose.

Horizontal shelves between bus bars are made of marble, slate, soapstone, sandstone, concrete or similar material, and historically they have been used about in the order named, which is also the order of their decreasing cost. Marble is undoubtedly the best material, as far as insulation and absorption qualities go, but its high cost and its crumbling when exposed to a bad arc has caused the adoption of cheaper materials of slightly poorer insulating qualities. Slate—the next material tried—is a very uncertain insulator for high-voltage work, and it has been superseded by soapstone, sandstone or concrete and where space is at a premium, soapstone is used almost exclusively, as it can be better drilled, machined and worked; smaller clearance distances can be used than would be permissible with sandstone or concrete.

Between disconnecting switches and in places where the barrier wall does not carry any additional weight, asbestos board, wire glass and similar materials have sometimes been used.

Masonry structures for bus-bar work and made either semi-enclosed or entirely enclosed. In the former case the wall of the structure which separates the horizontal bus bars and the vertical bus bars is made practically continuous. The back of the bus-bar shelves are built into this wall while pilasters spaced approximately 4 ft. apart support them in the front. Except for these pilasters the bus-bar structure is open in the front, and the septums in the rear that separate the leads are usually left open. This scheme leaves the bus bars and con-

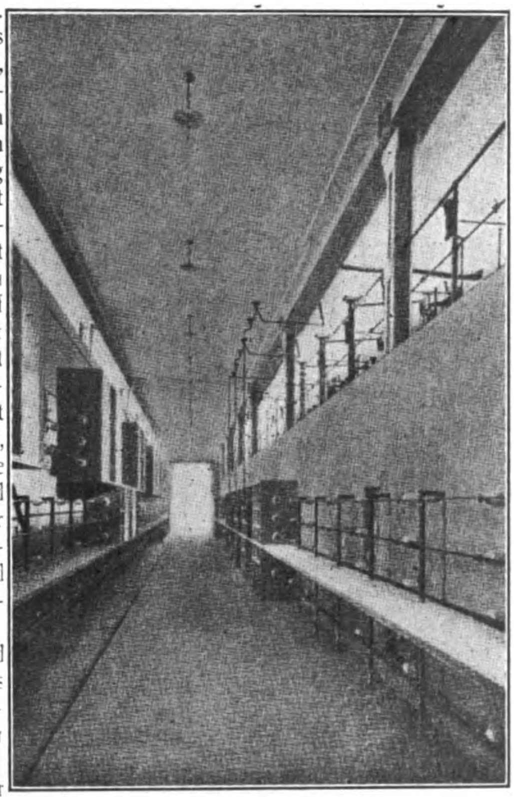


Fig. 4.—6000-VOLT BUS BARS

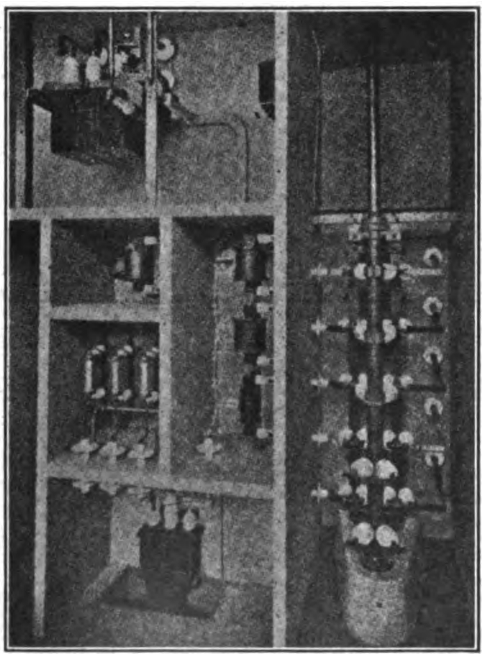


Fig. 3.—GENERATOR CONTROL APPARATUS

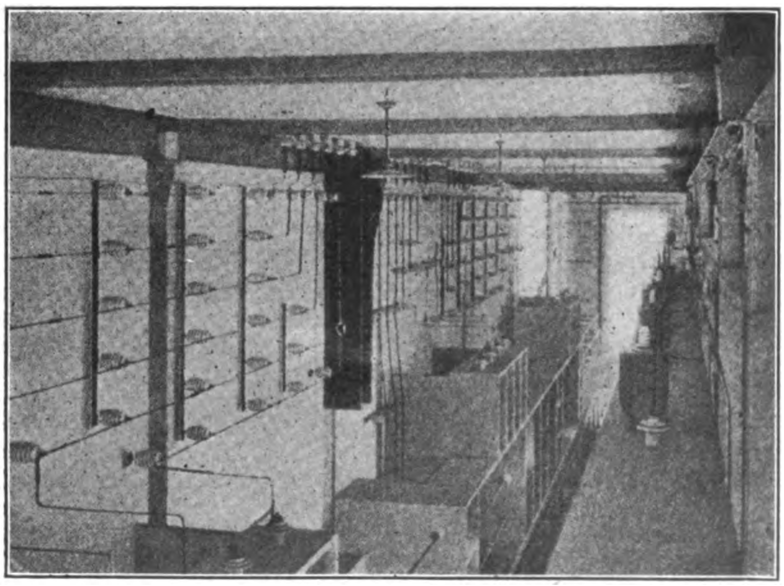


Fig. 5.—27,000-VOLT BUS BARS

nections readily accessible and well ventilated, but makes it possible for a careless visitor or attendant to come in contact with the bus or connection.

flame passing from one compartment to the next, but is more expensive and more subject to insulation trouble than the latter.

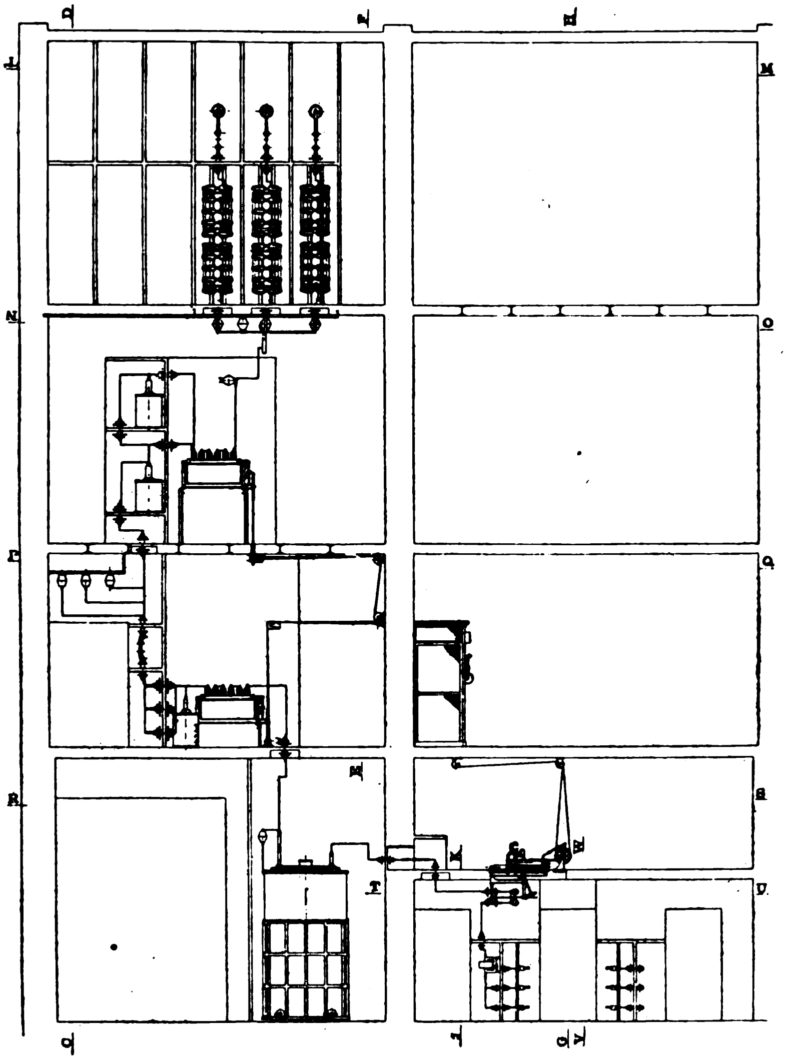


Fig. 6.—TRANSVERSE SECTION OF BRESCIA TRANSFORMER STATION

A modification of this scheme uses a continuous wall instead of pilasters as a support for the front of the shelves and the bus bars and connections are almost completely enclosed except for openings provided with doors or slides where necessary. With this arrangement it is impossible for anyone to touch any live metal parts without removing a door, but the buses and connections are not so accessible or so well ventilated as with the more open arrangement.

Where the leads pass through the floor or the back wall of a bus-bar structure, either of two schemes may be adopted. With the first, porcelain bushings are used to give the necessary insulation, while with the other scheme holes of generous dimensions are made and the lead run through the middle of this hole. In one case porcelain insulation is used, and in the other, air. The former makes a tighter joint with less likelihood of smoke or

For bus bars and connections where the currents exceed 600 or 800 amperes it is usual to employ laminated copper straps, while for smaller currents, cable, wire rod or tubing is used. Cable, and to a certain extent wire, is used for connections involving bends or long runs through conduit, while for straight runs or simple bends rod or tubing can be used. Tubing, while more costly than rod or wire for the same section, is stiffer and can often be flattened out for making connections to studs, bars and leads without the necessity of additional terminals.

The bus bars, when not too heavy, can be supported by the bushing for the lead through the wall, as shown in some of the cuts, while for heavier work or where bushings are not used the bus bars are supported on porcelain pillars, petticoat insulators or similar devices resting on the bus-bar shelf or attached to the wall.

While local conditions of available space and clearance are determining factors in settling on the design of the structures and the general arrangement of the station, the examples that follow will at least give some idea as to the space required and the arrangements recommended for different types of breakers operating at various voltages.

SECTION "D"—TYPICAL EXAMPLES OF EUROPEAN STRUCTURES AND LAYOUTS

Fig. 1 shows a transverse section through the switch galleries of the Obermatt generating station of the Engelburg-Lucerne transmission plant installed by the Maschinenfabrik Oerlikon.

This generating station is divided into three long rooms, containing the machines, the transformers and the switching apparatus. The switch-room, about 180 ft. long, 34 ft. wide and 68 ft. high, has been designed to accommodate the switch gear for one 600-h.p. generator, six 2000-h.p. generators, of which four are installed, and three 150-h.p. exciter sets, of which two are installed, and the building can be extended to take the apparatus for eight generators.

The exciters have a normal output of 100 kw. at 100 volts, with a maximum voltage of 150, and a speed of 700 rev. per min. As an additional source of excitation in case of emer-

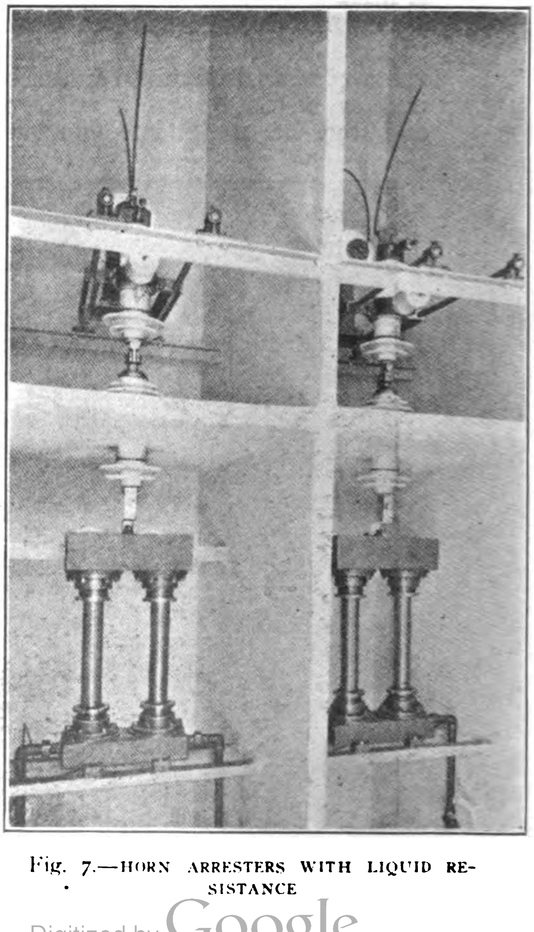


Fig. 7.—HORN ARRESTERS WITH LIQUID RESISTANCE

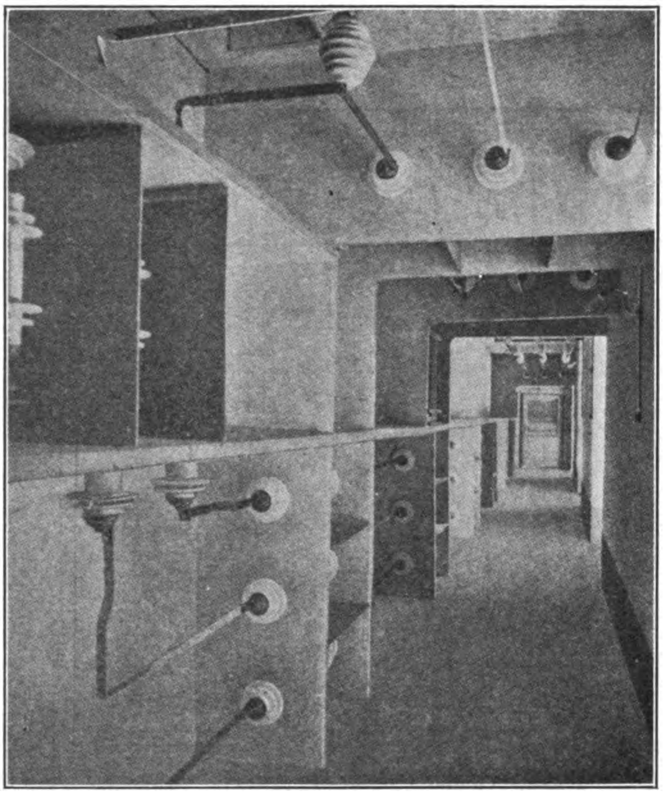


Fig. 8.—46,000-VOLT BUS BARS WITH SECTIONALIZING SWITCHES

gency, a storage battery of 56 cells with a capacity of 1000 ampere-hr. is installed. This is charged from one of the exciters and a motor-operated end cell switch with a column type indicator is furnished.

The generator for railway service is connected to the 600-h.p. turbine operating at 490 rev. per min. and has an output of 520 k. v. a. at 780 volts 32½ cycles, and has an efficiency of .94 per cent. at full load, 100 per cent. power factor and 91 per cent. at full load, 75 per cent. power factor.

The 50-cycle main generators can be used either as single-phase or three-phase machines and each machine can develop 1850 k. v. a. three-phase, or 1380 k. v. a. single-phase 6000 volts, 300 rev. per min. with 100 volts field excitation.

In order to step up the voltage from 6000 to 27,000 there are two banks, each of three 700-k. v. a. single-phase transformers with one spare for the three-phase service and three units of the same size for single-phase.

Fig. 2 shows a longitudinal section through the switching portion of the same station and is a section along the line "AB" of Fig. 1, which in turn is a section along the center line "CD" of Fig. 2. In both of these cuts the following symbols were used:

"MA" Overload air break circuit-breaker in exciter circuits.
"MO" Overload oil break circuit-breakers in the 6000 and 27,000-volt circuits.
"CA" Oil circuit non-automatic in bus junction circuits.
"T" Step-up transformers.
"J" Choke coil.
"TS" Sectionalizing knife switches.
"B" Horn lightning arresters.
"WW" Liquid resistance in lightning arrester circuits.
"WS" Water jet discharger for surges.

The general scheme of connections is such that any of the 50-cycle generators can feed through an overload oil circuit-breaker and suitable knife type disconnecting switches, either the single-phase or three-phase 6000-volt bus. These bus bars are arranged to form two complete rings with knife switches for sectionalizing the rings. The three-phase bus is also provided

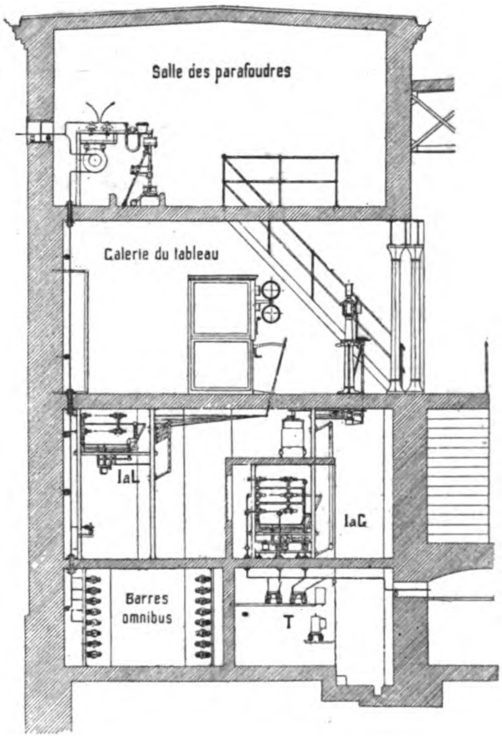


Fig. 31. — Coupe transversale de l'annexe du tableau

Fig. 9.—TRANSVERSE SECTION OF SWITCHBOARD GALLERIES

with an oil breaker for sectionalizing and the two banks of step-up transformers are connected on each side of this section breaker. The three-phase groups are connected delta-delta and knife switches are provided for cutting out any one transformer of either group and cutting in the spare transformer.

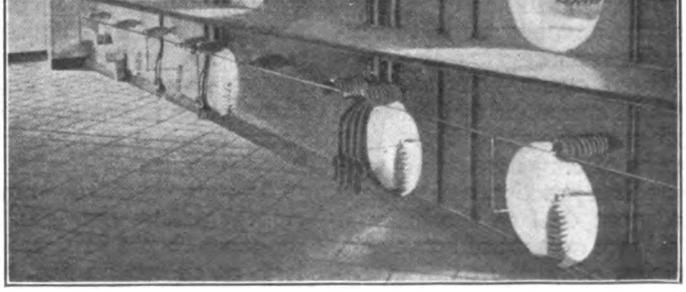


Fig. 10.—52,000-VOLT BUS-BAR STRUCTURE

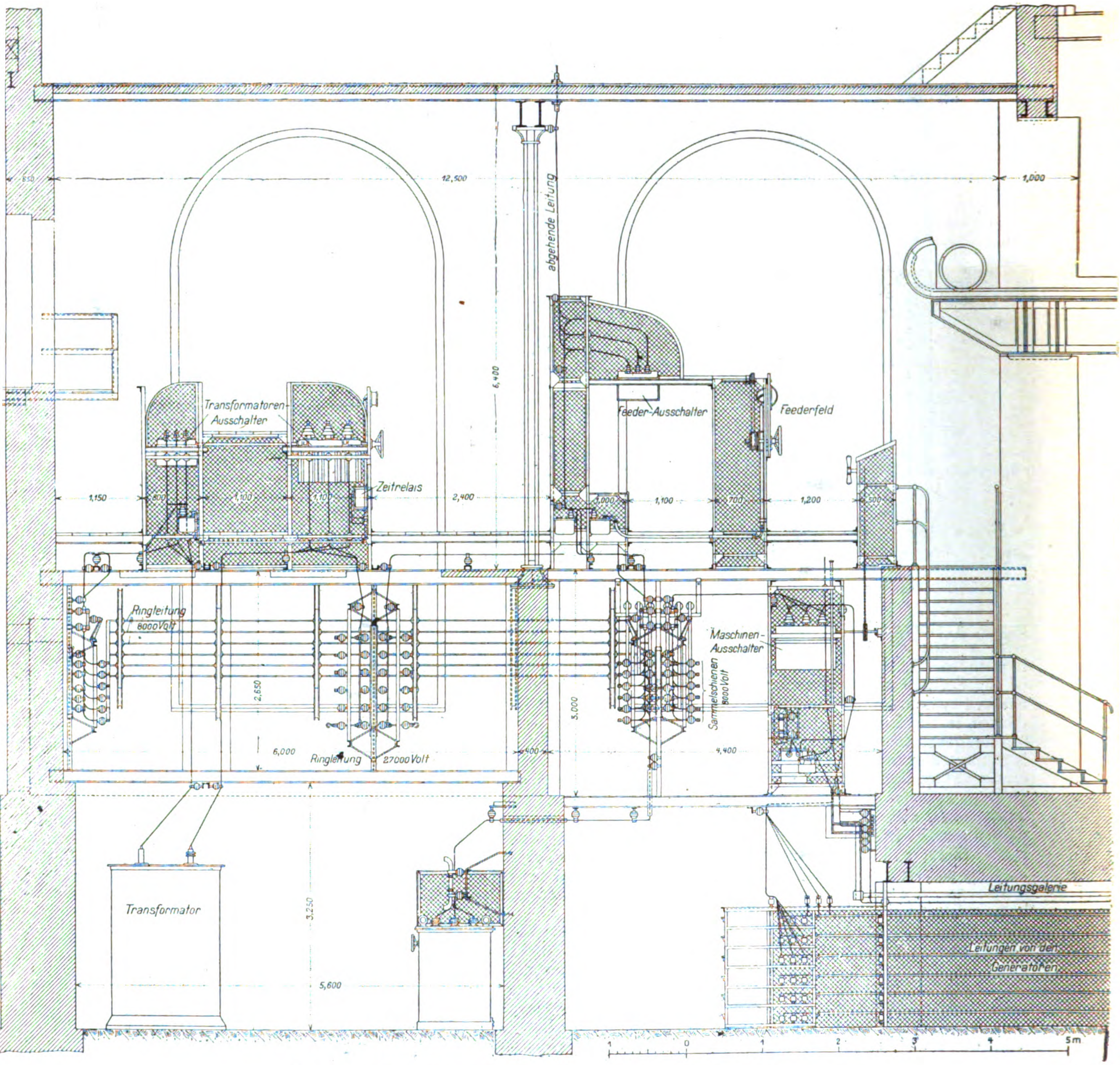


Fig. 11.—SECTION THROUGH SWITCHING GALLERIES—BEZNAU STATION

The high-tension side of the step-up transformer connects to three-phase or single-phase ring bus bars and the three 27,000-volt outgoing feeders can be connected to either the three-phase or single-phase bus.

This series of ring bus bars is typical of European practice, and while it permits a great deal of flexibility it occupies a large amount of space and, in the opinion of most American engineers, the same number of switches and the same or smaller amount of material can usually be utilized to better advantage in a double-throw system. The entire separation of the single-phase lighting load from the three-phase power load involves more complication than would usually seem to be justified.

As may be noted from Fig. 1, the control gallery overlooks the generator-room to the left, and in this gallery, as shown on Fig. 16 of Part I of this article, are placed the generator control columns and the outgoing line panels. The generator columns on the right contain suitable instruments, and the levers to operate the oil circuit-breakers, switches for light and power, rheostat handwheels and the carbon-breakers of the field circuits.

A very ingenious arrangement of the levers makes it necessary for the attendant to perform his various operations in proper sequence. The oil circuit-breaker cannot be closed if the field switch is open and, conversely, unless the oil circuit-breaker is open the field switch cannot be opened nor the knife switches connecting to the bus manipulated. The voltmeters and wattmeter are automatically connected by the movement of the operating lever in such a way as to give proper indication without any further trouble. A white lamp shows when the breaker is closed and a red one, when open. An acoustic signal operates on the opening of a breaker, but this can be cut out immediately by hand if desired.

from these handles, suitable pulleys being furnished for turning the various corners. The choke coil "J," the horn gaps "B" with their liquid resistances "WW" and the water jet dischargers "WS" are located on the top gallery for furnishing lightning protection to the three 27,000-volt outgoing lines.

The operating handles for the low-tension transformer breakers are located on the main floor and operate the 6000-volt breakers on the same floor and the 27,000-volt breakers on the floor above. In a similar manner the operating handles for the high-tension breakers also control the low-tension ones in such a manner as to insure closing the primary and secondary circuits at the same time.

with porcelain fuse-holders appear at the left, while four current-transformers are in the center and are used, one for the ammeter, one for the wattmeter and two for the three-pole automatic oil circuit-breaker that is located in the upper left-hand cell. After passing through the breaker the current goes either to the lighting bus or to the power bus, depending on the position of the double-throw switch in the right-hand compartment. As may be noted, the cellular construction is used with the horizontal and vertical barriers of concrete. The right-hand lead from the cable bell passes through a porcelain bushing in the horizontal shelf to the three-series transformers in the central compartment and then through a bushing in the vertical back wall to a compartment that contains the connections to the oil circuit-breaker. The central and left-hand lead from the cable bell pass through bushings in the back wall, and then up to the circuit-breaker, one of the leads passing back and forth through this wall to the fourth series-transformer. The leads to and from the circuit-

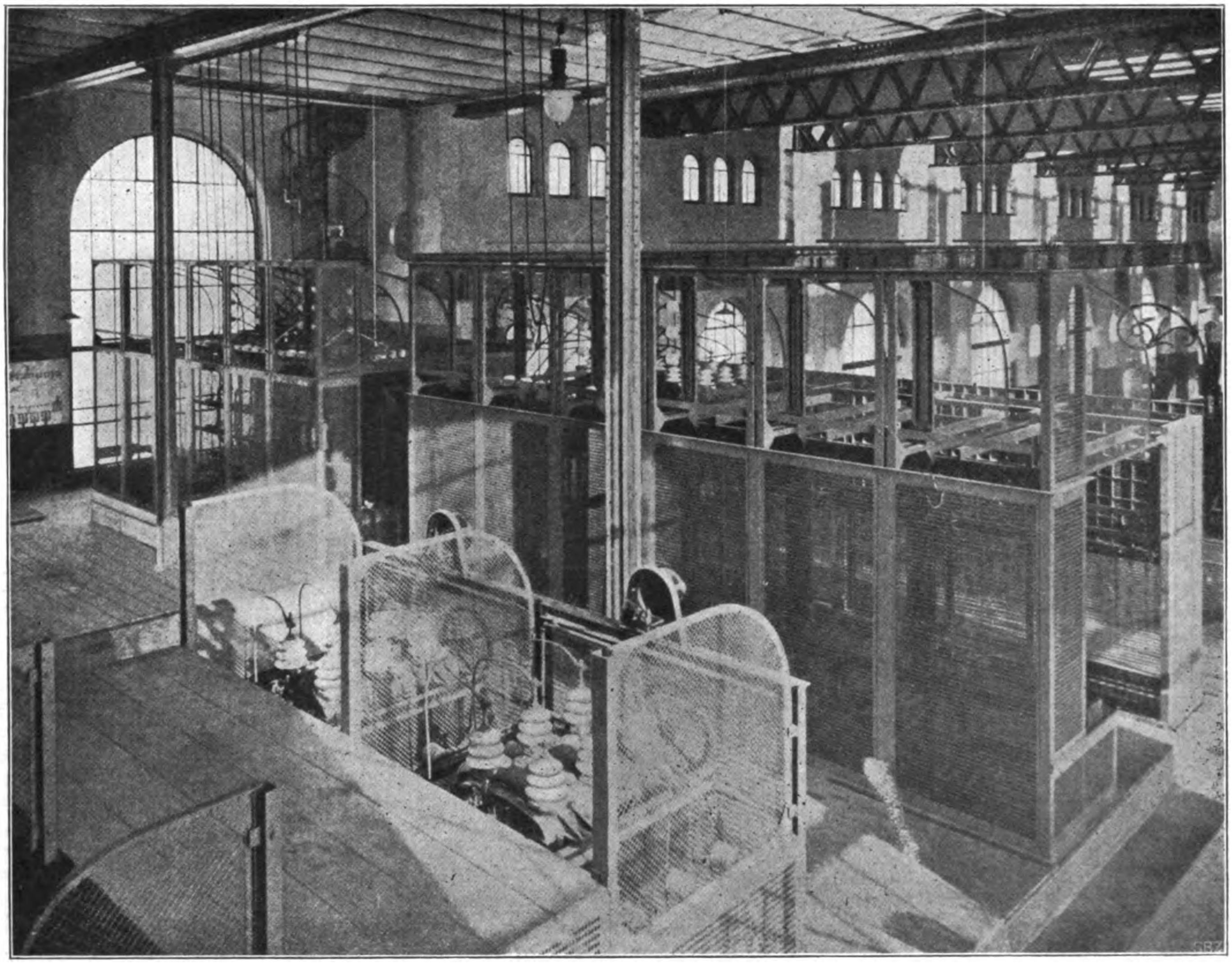


Fig. 12.—ARRANGEMENT OF SWITCH GEAR—BEZNAU STATION

The rheostat and field-switch equipment located on the mezzanine gallery was shown in Fig. 39 of Part II of this article.

The sectionalizing switches in the main bus bars are operated from this control platform in the manner indicated in Fig. 2, where they are marked by the symbol "OA."

A panel switchboard, seen to the right of the generator pedestals, controls the outgoing lines. The handles for the breakers are placed on the panel board, while the breakers "MO" on the top gallery are rope-driven

As a sample of the concrete cellwork used in this plant for the oil circuit-breakers and connections, Fig. 3 shows the apparatus provided for the control of one of the main generators. The generator leads are brought as a three-cord cable to the bell shown in the bottom left-hand compartment. A three-phase voltage transformer

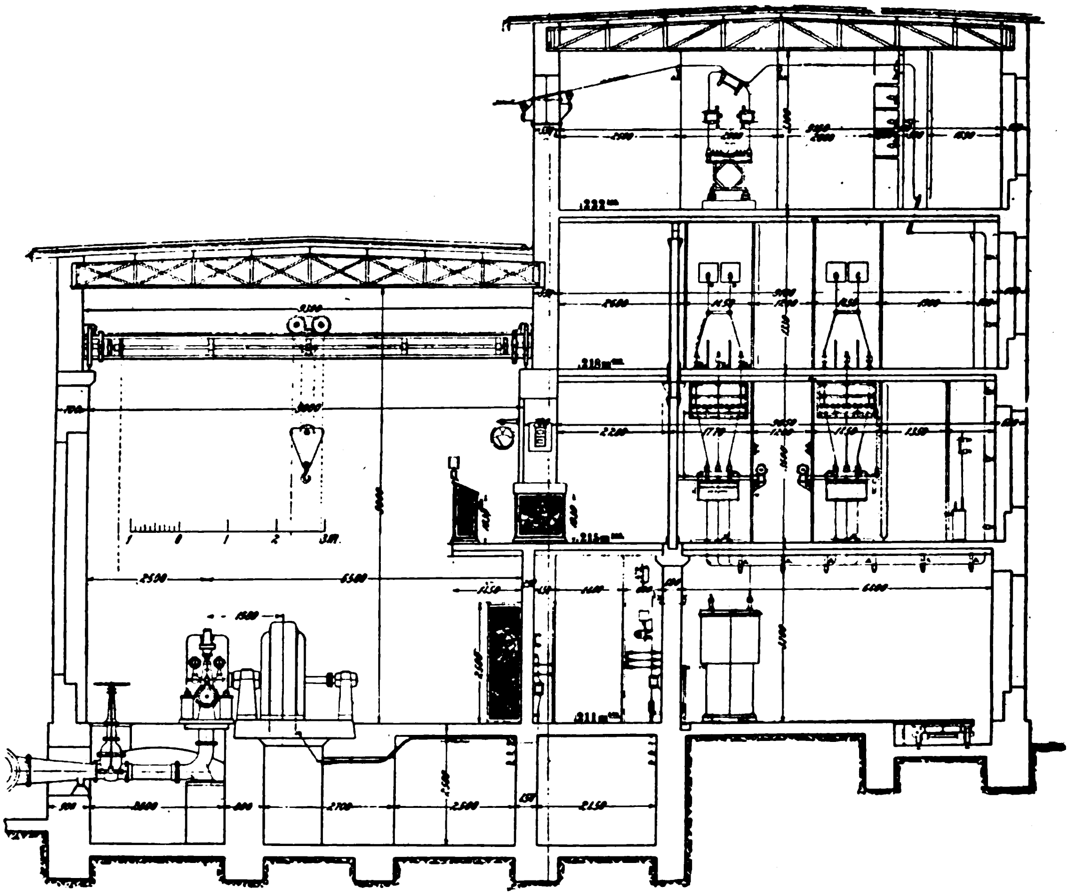


Fig. 13.—CROSS-SECTION OF GENERATING STATION AT GORDOLA

breaker also pass through the back wall to the wiring compartment. The secondary leads to the trip coil of the breaker are run in a concrete-covered conduit, as shown.

Fig. 4 shows the 6000-volt bus bars which are placed in the central portion of the ground floor. The generator breakers are located on the far side of the right-hand wall, while the transformer breakers are placed on the far side of the left-hand wall. The busses of bare copper strap mounted on porcelain insulators form a complete ring with the generators feeding in on one side and the Engelberg line and the low-tension end of the transformers feeding out on the other side. The mechanism for operating the bus sectionalizing switches can be seen at the right, near the center.

Fig. 5 shows the upper part of the 27,000-volt bus bars with the connections that run through the ceiling to the line breakers and protective devices that are located on the floor above. The corrugated pillar insulators for supporting this wiring are typical of European practice for this voltage. The concrete cellwork is remarkably well done.

The circuits from the step-up transformers are brought in through the series transformers to the breakers and the bus on the right-hand side. The ring bus is continued around the left-hand side and feeds up through the floor to the line-breakers controlled from the cabinet panels appearing back of the pedestals on the operating gallery shown in Fig. 1. The leads that pass up through the floor are connected through a double-throw knife switch to series transformers, then through the oil circuit-breakers and choke coils to the outgoing line circuits.

Fig. 6 shows a transverse section of the Brescia transformer station equipped by the Oerlikon Company and arranged for the control of two 40,000-volt incoming lines from the Caffaro station, two 46,000-volt outgoing lines to Brescia and Cremono, three 2750-k. v. a. 46,000-3600 volt three-phase step-down transformers with provision for three additional transformers, and a 3600-volt distributing feeder. Both the high-tension and the low-tension bus bars are arranged in a ring system with sectionalizing knife switches in the bus bars.

The lines from Caffaro enter the top floor of the building through windows closed with glass plates with brass tubes in them, these tubes being supported on insulators inside and outside of the window. This top floor also contains horn-gap lightning arresters with liquid resistances, the water in these resistances flowing continuously from a conduit fed by a reservoir. Fig. 7 shows these horn-gap arresters with their liquid resistances mounted in concrete cells. The comparatively small size of the porcelain bushings in the shelf between the horn gap and the resistance is particularly noticeable, and can be attributed partly to the excellent quality of the porcelain and partly to the insulating characteristics of the carefully made concrete shelves.

In the far side of the back wall of the structure containing the horn-gap arresters and the liquid resistances are placed the multigap-lightning arresters with their disconnecting switches that appear on the top floor of Fig. 6. These are also placed in concrete compartments and are normally left continuously in circuit to equalize small atmospheric discharges and surges in the station, while the horn gaps and water columns are only connected in circuit at times of thunder storms.

On the floor below the lightning arresters are placed spiral choke coils and from these the current passes to the 46,000-volt line circuit-breakers and thence to the oil-immersed series transformers for the ammeters and relays. On this same floor are placed the circuit-breakers and protective devices for the outgoing feeders to Brescia and Cremona. The power for these

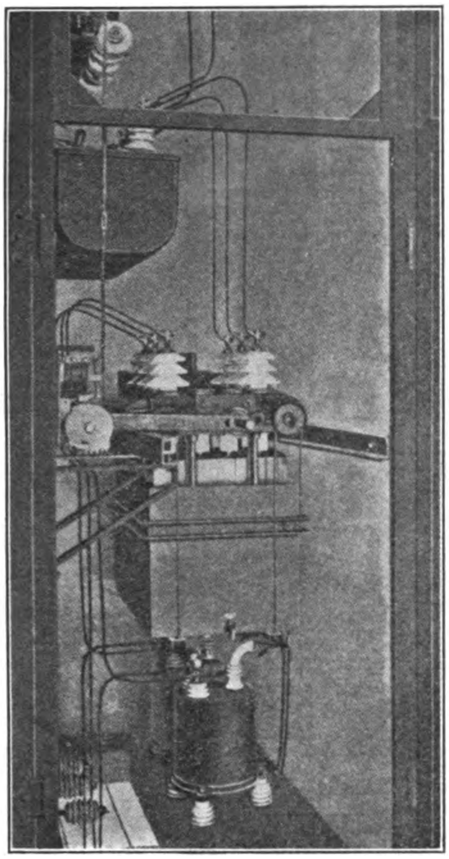


Fig. 14.—24,000-VOLT SWITCH CELL

outgoing feeders is recorded on a wattmeter fed from 40,000-120-volt shunt transformers and suitable series transformers.

On the next floor are placed the 46,000-volt ring bus bars shown in detail in Fig. 8. The various incoming and outgoing line circuits, as well as the leads to the high-tension side of the step-down transformers connect to the bus bars along the left-hand wall, which bus is sectioned between the various circuits by means of knife switches located between the vertical concrete barrier walls. Overhead is shown the bus that closes the ring and this connects to the lower bus at each end through the porcelain-covered blade switches that can be seen at the left. The concrete shelves, septums and barriers are very well made, and the porcelain bushings are typical of European construction.

This floor also contains the circuit-breakers in the high-tension transformer circuits. These oil-breakers, as well as those for the line circuits, are of the type shown in Fig. 17, Part II, and are rope-driven from the cabinet type switchboard on the same floor.

The bottom floor contains three 2750-k. v. a. 46,000-3600 volt three-phase oil insulated water-cooled transformers with provision for three future transformers. The cases of these transformers made of cast iron are rectangular in shape and divided into three parts. The top porton has two walls and the interior portion is made of corrugated sheet iron to increase the surface in contact with the oil. The space between the two walls of the upper portion of the case is divided by partitions in such a manner as to secure proper circulation of the cooling water. These transformers are of the core type and weigh 10,000 kg. without oil or case, which weigh 12,000 kg. The tested efficiencies at full load were 98.5 per cent. at 100 per cent. power factor and 98.2 per cent. at 75 per cent., with corresponding regulations of ½ per cent. and 4¼ per cent. Thirteen litres of cooling water give a temperature rise of 45 degrees.

This bottom floor also contains the plunger switches rope-driven from the cabinet switchboard that control the low-tension sides of the transformers. It also has the 3600-volt ring bus bars, which are sectionalized and which supply current over a single three-phase feeder furnishing power to a connecting station that contains four 750-h.p. three-phase motors driving 3000-ampere 125-volt direct-current generators used for the manufacture of soda.

The 3600-volt switches correspond closely with those shown in Fig. 3 of Part II. This same type of plunger switch, designed for 13,500 volts, is used on the La Dermier generating station of the Compagnie Vaudoise. This station, equipped in 1903 by the Oerlikon Company, supplies power to various points in the Canton of Vaud, Switzerland. It contains two exciter turbines of 150 h.p. and five 1000-h.p. turbines of the Pelton type connected to 13,500-volt three-phase 50-cycle generators running at 375 rev. per min.

Fig. 9 shows a section through the switching galleries of this station. The leads from the generators are run in the basement in insulators and are brought to the mechanically operated overload automatic plunger switches on the floor above. From these switches the circuit is brought back to the basement and passes through series transformers to a three-pole triple-throw knife switch (shown in Fig. 37 of Part II), whence it passes to a single-phase, or either of two three-phase bus bars. These bars, sectioned by means of other knife switches, form complete rings, returning near the outside wall, where connections are run through floor insulators to the automatic feeder switches on the floor above.

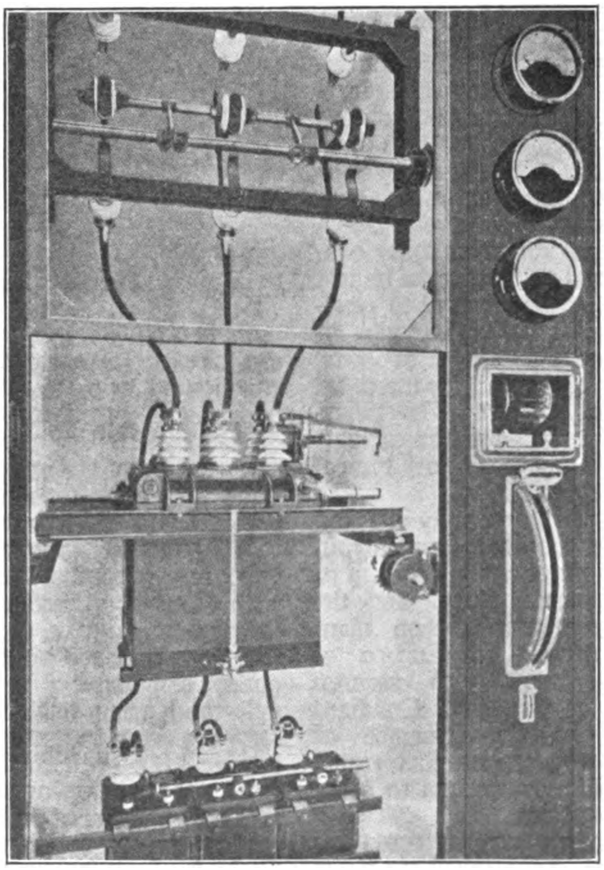
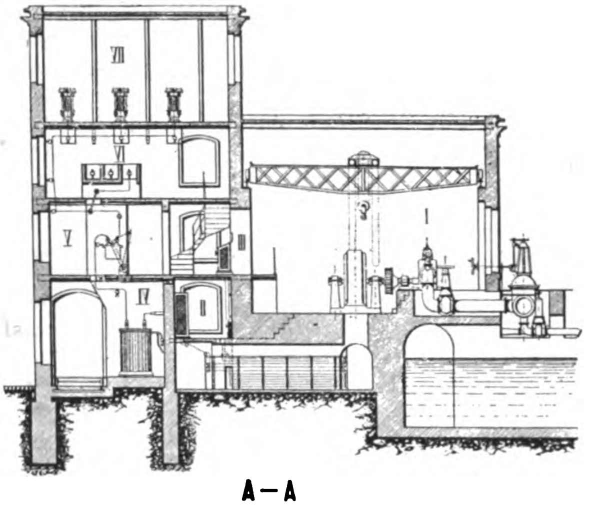


Fig. 15.—3600-VOLT SWITCH CELL

On the main operating floor are placed the pedestals for the generator control and the cabinet-type switchboard for the feeder control. The arrangement of the gas-pipe mechanism for operating the plunger switches, generator, rheostats and similar de-



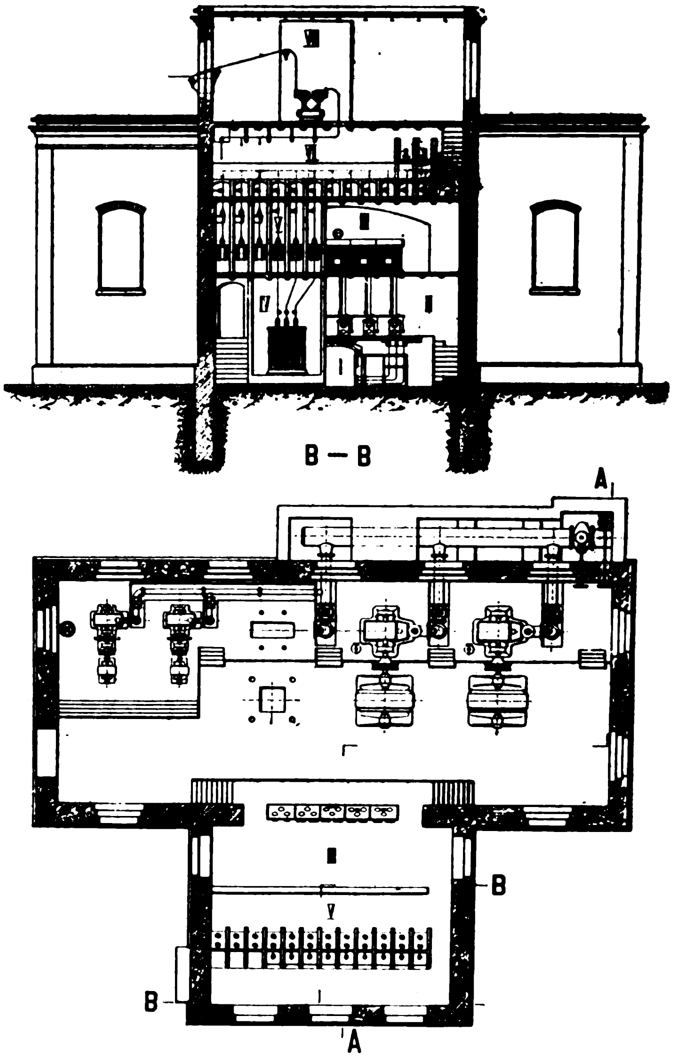


Fig. 16.—SECTION AND PLAN OF GROMO GENERATING STATION

vices is clearly shown.

The top gallery contains the lightning-protective devices, comprising spiral choke coils, horn gaps and water jet resistances and the outgoing lines pass through glass plates and are supported on insulators inside and outside of the glass.

As a final example of the station design of the Oerlikon Company, Fig. 10 shows the 52,000-volt bus bars in the generating station of the Gaucin-Seville transmission system and clearly indicates the arrangement of the horizontal barriers, the bus bars, bus-bar supports, etc. The fourth bus bar in the lower compartment is the neutral connection of the various transformers, this neutral point being connected to ground. It would be almost impossible to find in American practice horizontal concrete barriers of this size without pilasters or some similar means of supporting the outer edges of these shelves. The pillar-type insulators used for the support of the bus bars and wiring are typical of European construction.

This plant, when originally installed in Spain by the Oerlikon Company, in 1906, to transmit power a distance of 125 km. at 52,000 volts, was the highest potential transmission plant actually in service in Europe at that time. Power was secured from a fall in the river Guadiaro near Caucin in the Province of Malaga, and the power was transmtted to Seville, as well as to other intermediate stations.

The generating station contained three 1300-k.v.a. 5000-volt three-phase 40-cycle generators, with two banks each of three 6000-k.v.a. transformers having a ratio of 5000 volts to 30,000 volts, these transformers being connected in star for operation on a 52,000-volt circuit.

A good example of a combined water-turbine and steam-turbine plant is that installed by the Brown-Boveri Co. at Beznau on the Aar in the northern part of Switzerland. This station contains 11 vertical-shaft water turbines running at 66 2/3 rev. per min., direct connected to 900-kw. 8000-volt 50-cycle 90-pole three-phase generators; two vertical-shaft turbines for the exciters, and two 2400-kw. 8000-volt 50-cycle 4-pole three-phase 7500 rev. per min. turbo-generators, with direct-connected exciters; seven three-phase, oil-insulated, water-cooled transformers, each of 2000-k. v. a. capacity, stepping up from 8000-27,000 volts and some smaller transformers stepping down to 250 volts for station service. 8000-volt feeder circuits are run to Wehr, Dottingen, Baden, Beznau and Unbenufzt, while 27,000-volt feeders are run to Rhinefelden, Ober-Seebach, Lentzburg and Unter-Seebach.

Fig. 11 shows a cross-section taken through the switchhouse which has a height of about 45 ft., a width of about 42 ft. and length of 61 ft., being divided into three floors. The general scheme of connections is to have the generators connect to either of two sets of three-phase bus bars arranged in the form of a ring, and the various feeder and low-tension transformer circuits also to connect to these busses, which are so sectionalized as to secure great flexibility. The high-tension sides of the step-up transformers also connect to two sets of ring bus bars that supply current to the 27,000-volt feeders.

The generator cables are run in a tunnel on suitable racks closed in by grill-work and pass up through the floor to the machine oil circuit-breaker which, with its instrument transformers, is placed in a grill-work compartment. From the machine-breaker the circuit passes through knife switches to the two sets of 8000-volt ring bus bars that are mounted on insulators attached to a structural iron frame.

From the 8000-volt bus bars one set of leads passes up through the feeder oil circuit breakers with their transformers. Another set of leads goes to an auxiliary set of bus bars, whence the current passes through suitable disconnecting switches to the oil circuit-breaker on the low-tension side of the step-up transformers. The high-tension side of the transformer

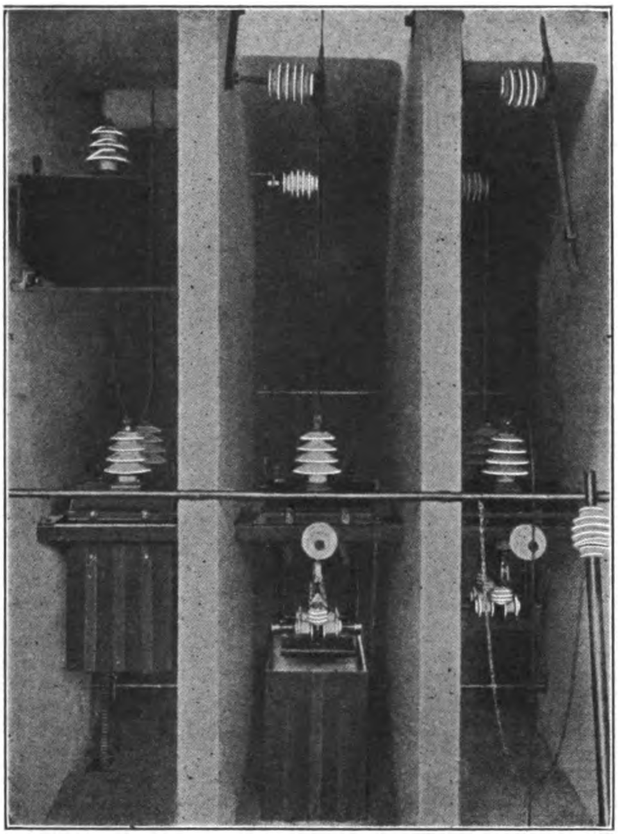


Fig. 17.—CONCRETE SWITCH STRUCTURE—40,000 VOLTS

feeds through the high-tension breaker and suitable disconnecting switches to the high-tension ring bus bars.

As may be noted, the generator-breakers are controlled from hand-wheels placed on a desk containing the generator instruments. The 8000-volt feeder-breakers are operated by hand-wheels on the feeder board, and in a similar manner the transformer-breakers are controlled from hand-wheels on the transformer board.

Fig. 12 shows the general appearance of the switch-gear compartment looking toward the generating station. The oil circuit-breaker in the lower left-hand part of the picture are those in the 27,000-volt circuits from the transformers. The grill-work partitions between the leads and the round pattern ammeters mounted on the steel framework are wide departures from American practice. The structure for the 8000-volt feeder circuits can be noticed in front of the transformer switch structure.

Fig. 13 shows a section taken through the Gordola plant of the Verzasca system. This station, equipped by the Brown-Boveri Co., contains two 125-h.p. exciters, two 1000-h.p., 500 rev. per min. turbines coupled to 920-k.v.a., 4200-volt, 50-cycle, 75 per cent. power factor generators, feeding 850-k.v.a. transformers that step up the voltage to 25,000 for two outgoing lines. The station will ultimately contain a total of six generators, six transformers and four lines.

The operating platform is provided with a control desk so located that the station attendant can readily watch the machine he is controlling. Each section contains edgewise instruments on a post. The field rheostats are controlled from the hand-wheels on the front of the desk.

The three conductor leads from the generator pass under the station floor to a cable rack and connect through knife switches to a bus and

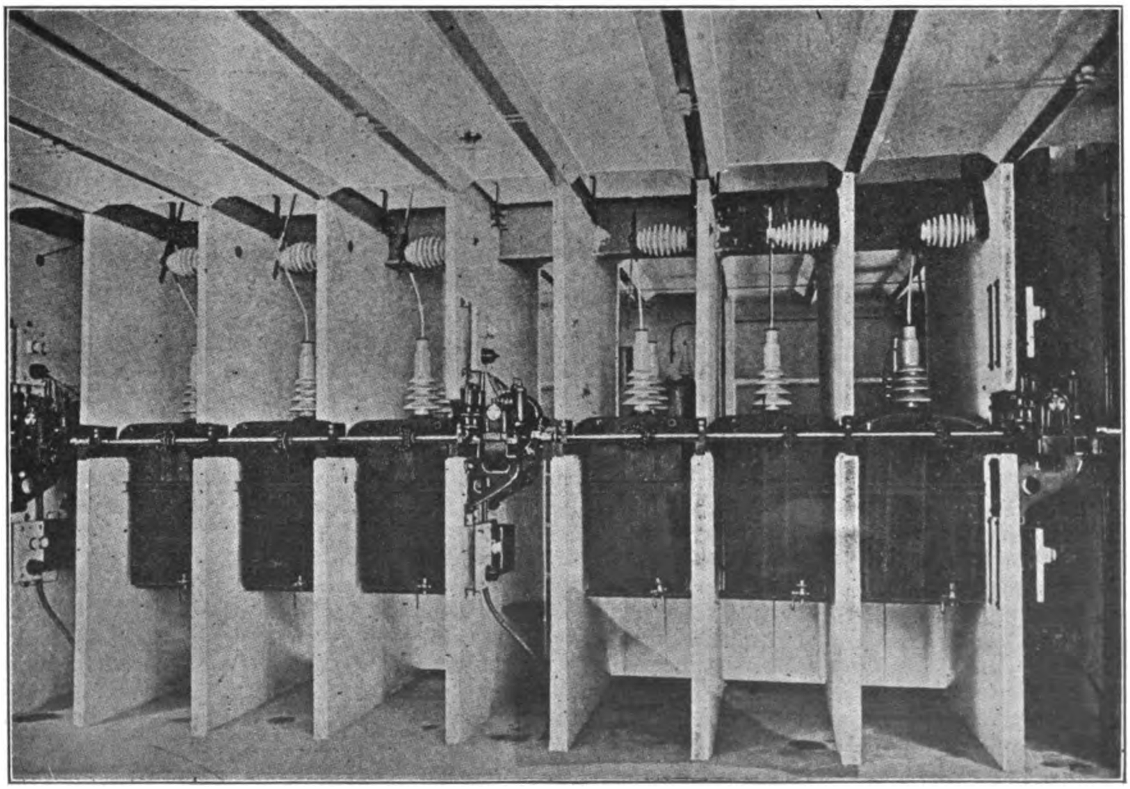


Fig. 19.—45,000-VOLT CIRCUIT-BREAKER

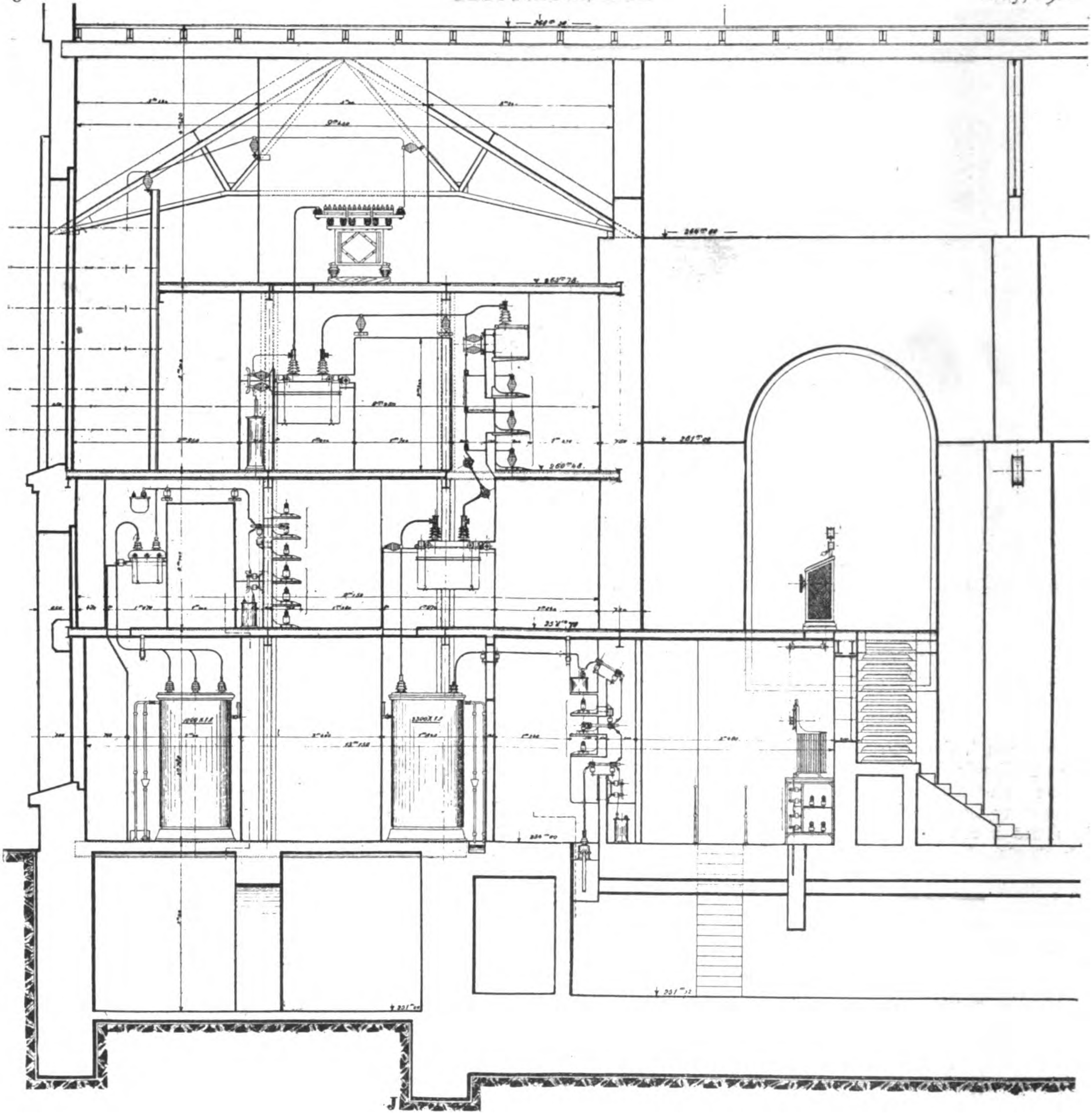


Fig. 18.—SECTION OF PIEDIMULERA STATION

to the low-tension side of the step-up transformers. Suitable series and shunt transformers are furnished for use with the instruments in the generator circuit.

The high-tension side of the step-up transformers connects through automatic oil-breakers to the high-tension bus which supplies the outgoing feeders. Provision is made for additional oil-breakers and a second set of 25,000-volt bus.

Sheet metal doors cover the leads, switches, breakers and similar devices and rather elaborate interlocking devices are provided between the breakers and switches.

Most of the power from the Gordola generating station is transmitted to a substation at Massagno on the outskirts of Lugano, where the power is stepped down from 24,000 to 3600 volts.

Fig. 14 shows the compartment containing the 24,000 volts of the incoming switch gear. The porcelains for the disconnecting switch appear in the top of the picture, and this switch is chain-driven from the locking device in such a manner that the door cannot be opened if these disconnecting switches are closed. There are two sets of series transformers of the oil-immersed type and a three-pole oil circuit-breaker. The drain cock and the tank-lowering device for the breaker are clearly indicated.

The mechanical construction of these cabinets with their steel framing and brackets and concrete walls is an example of the thoroughness with which such details are designed.

Fig. 15 shows the compartment containing the 3600-volt transformer switch gear in the Massagno substation. A three-pole mechanically operated switch in the upper left-hand portion of the picture isolates the oil switch and other apparatus from the overhead bus bars. The three blades of this switch are attached to insula-

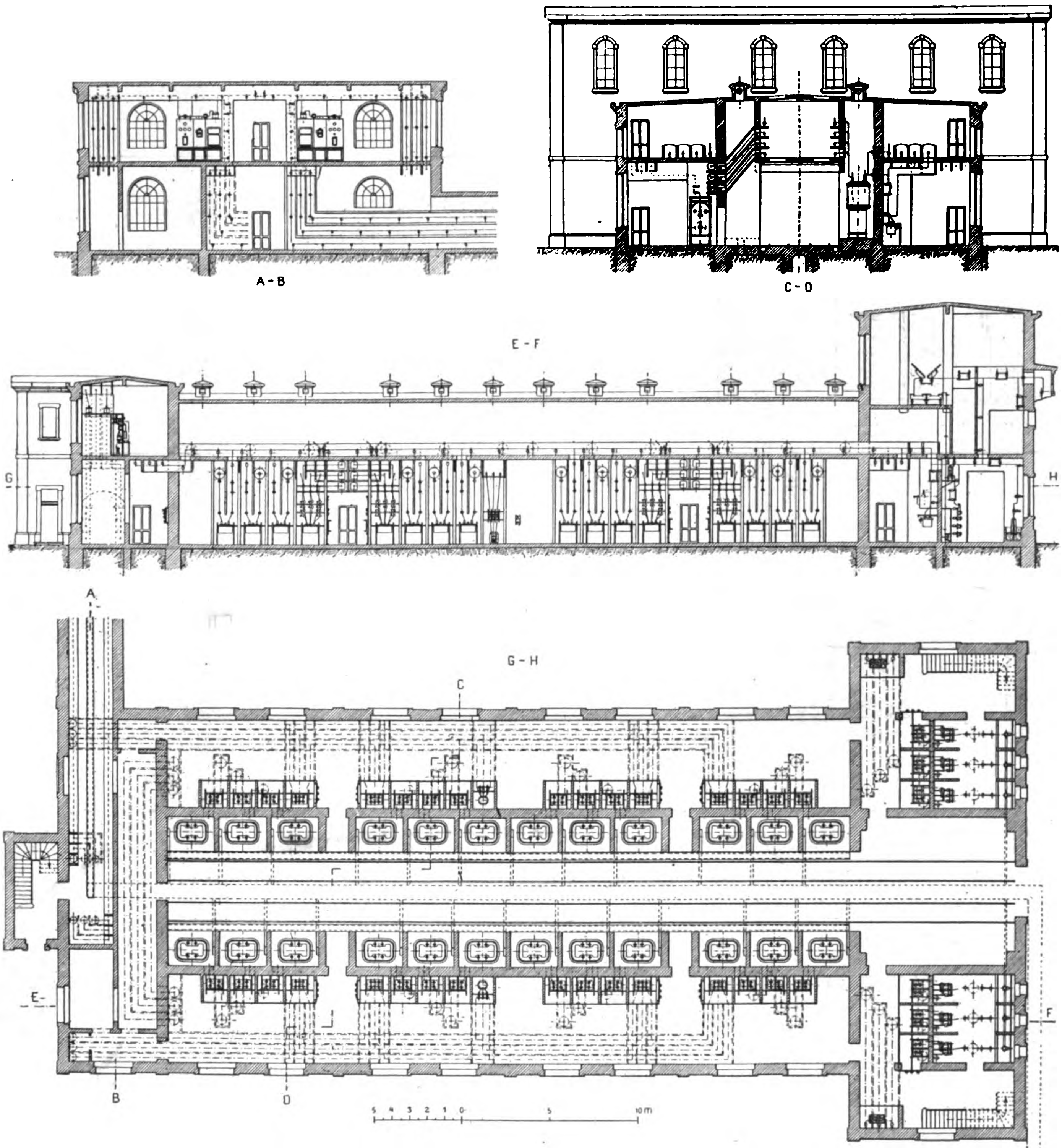


Fig. 21.—PIATTAMALA TRANSFORMER STATION

tors mounted on a shaft which is operated by chain-drive from a shaft in the compartment to the left, which shaft in turn is driven by the bevel gear apparatus to the right of the oil circuit-breaker. The shaft of the bevel gear device has a square end and projects through the sheet metal door that ordinarily encloses all of the switch gear, and before the door can be opened this shaft must be turned by a socket wrench in such a manner as to operate the disconnecting switch and isolate the apparatus from the bus. This is typical of the precautions taken to safeguard the attendants in European plants.

The oil circuit-breaker is operated by a rotary motion obtained from a shaft projecting through the right-hand wall and driven by a chain actuated by the handle through the large sector to the right. The smaller handle below actuates the tripping device of the breaker. A device, shown more clearly in the cut of the 24,000-volt breaker, is provided for lowering the oil tank to obtain access to the contents and oil gauge in the front shows the height and condition of the oil.

Series transformers of the oil-immersed type are located at the bottom of the compartment and supply current to the ammeters and overload relay on the adjacent section.

The various transformer and feeder compartments for the 3600-volt circuits form a practically continuous switchboard on the floor above the transformer and below the bus bars.

Fig. 16 shows a section, elevation and plan, through the Gromo generating station of the Gromo-Nembro plant.

This plant, located in the northern part of Italy, was equipped by Brown-Boveri Company, and the generating station is provided with three 1000-h.p., 4000-volt, 80 per cent. power factor, 50-cycle generators, each connecting to its own three-phase, 750-k.v.a. transformer, stepping up from 4000 volts to 40,000 volts.

In this cut the symbol I shows the turbine and generator-room; II is the room containing the field rheostats and the 4000-volt fuses and instrument transformers; III is the switchboard gallery with its control desk; IV is the transformer compartment; V the 40,000-volt switching compartment; VI is the bus-bar room, and VII the lightning-arrester room.

The leads froom the generators in room I pass through single-pole fuses with removable tubes and blow-out horns, and series transformers located back of an embossed sheet grating in room II to the low-tension side of the step-up transformers in room IV, the leads passing through heavy glass

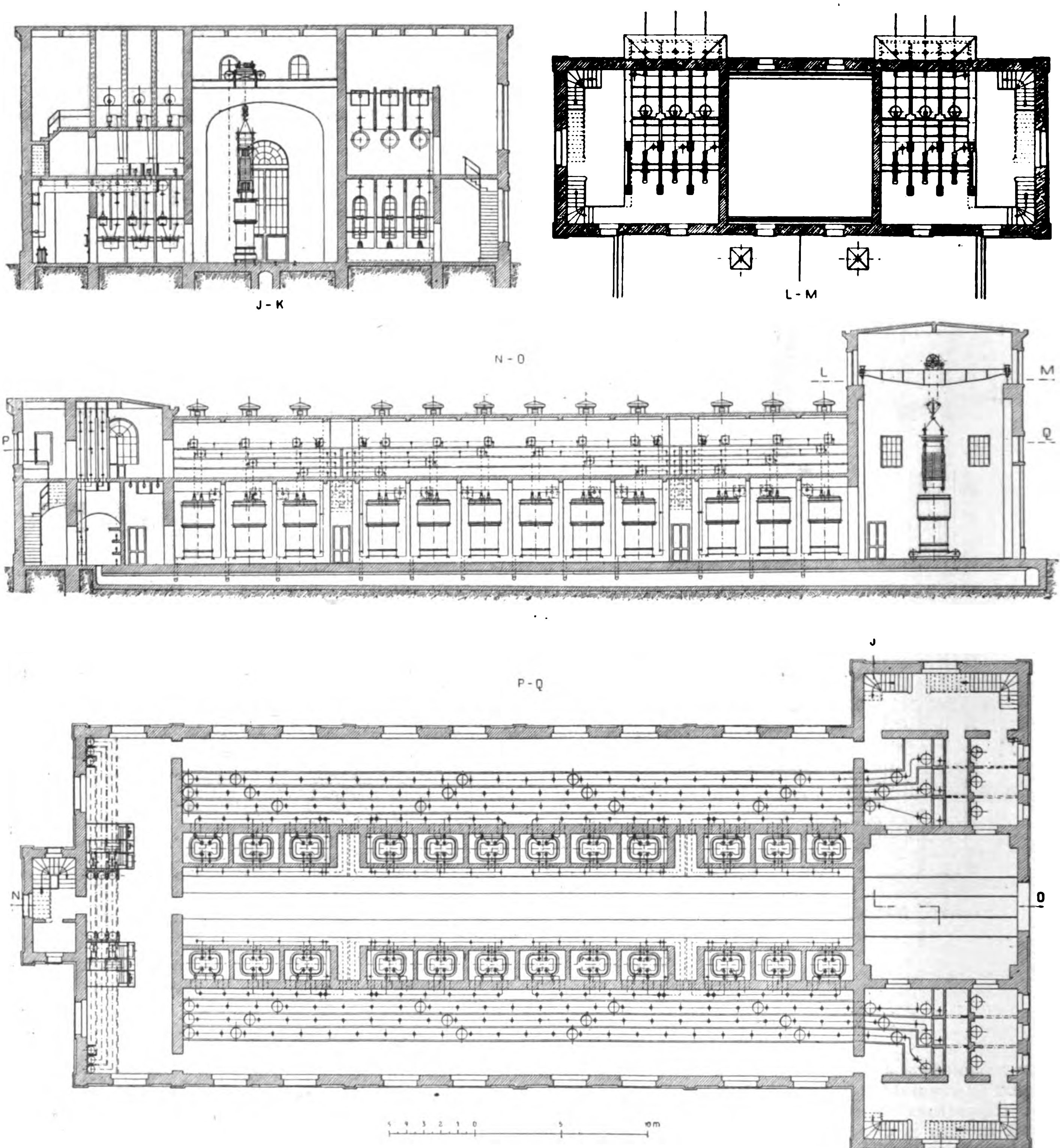


Fig. 22.—PIATTAMALA TRANSFORMER STATION

tubes in the wall. The high-tension transformer leads pass up through the floor to the 40,000-volt breakers in room V, thence through disconnecting switches to the bus bars in room VI. Returning from the bus bars, the leads again pass through the floor to the line breaker in room V and then back along the wall and upward through the floor to room VII, which contains the protective devices and line outlets. The protective devices are choke coils combined with a series of non-arcing metal cylinders of the Wurtz type. Each line leaves the power-house through one of the glass panes of the window. On both sides of the glass pane a stout glass tube projects through which the conductor leaves the building. The tube is kept in place by two copper hoods soldered to the conductor.

Fig. 17 shows the concrete structure that contains the 40,000-volt automatic oil switches, and as an excellent example of masonry work. As may be noted, these switches are arranged with each pole in a separate masonry compartment. The pole shown on the left is one pole of a three-pole switch for the transmission line, while the two poles on the center and on the right are part of the three-pole switch of the high-tension side of the step-up transformers. In the left-hand compartment the pole of the breaker is shown with its tank on, and the series transformer of the oil-immersed type placed on a bracket above the circuit-breaker.

The central pole is shown with the tank dropped to the floor, while the right-hand pole is shown with the tank completely removed. In the central compartment, as well as the right-hand compartment, the knife-type disconnecting switches for isolating the circuit-breaker appear above the oil-breaker, while the operating pole with its grounding chain is seen near the right-hand compartment.

Fig. 20—FEEDER AND BUS-ROOM—HAUTERIVE STATION

It may be noted that these oil circuit-breakers, like most European breakers for this voltage, are provided with several breaks in series.

The oil switches in this installation are operated from a distance by means of hand-wheels placed on the main switchboard and they are actuated by a rotating motion. It may be of interest to state that the 40,000-volt oil circuit-breakers in this installation break the circuit simultaneously in six places, although the travel of the moving contact is only eight centimeters, the total effective oil break 35 centimeters after allowing for the overlapping of the contact which are provided with auxiliary contacts to take the final break, these auxiliary contacts being readily renewable. As may be noted, a common release spindle is provided for actuating the tripping mechanisms of the individual poles of the breakers, the movement of the spindle being due to the falling of a weight that is controlled to turn by a solenoid.

Fig. 18 shows a section taken through the switching galleries of the Piedimulera generating station of the Dellanza system in the northern part of Italy. The generating station contains two 200-h.p. exciter turbines and four 2750-h.p. main turbines direct connected to 1920-kw., 2450-k.v.a. 80 per cent. power factor, 8000-volt, three-phase, 42-cycle generators with 2300-k.v.a., 8000, 45,000-volt, three-phase, oil-insulated, water-cooled transformers supplying power to the transmission lines.

These switching galleries are located at the end of the generator station and the operator at the desk faces toward the machines he is controlling. The mechanically operated field rheostat face-plates with their resistors are placed below the control desk. Above are the compartments containing two sets of field bus bars and two sets of switches are supplied for connecting the field circuits to either or both sets of field bus bars.

Three conductor cables from the generators end at pot heads under the alternating-current relay bus, and while normally each generator ties in with the low-tension side of its own transformer bank, a sufficient number of disconnecting switches are provided so that any generator or main transformer can be tied into this relay bus. The shunt transformers with their fuses in the generator circuit are located in this same structure, and the oil-immersed series transformers in the low-tension side of the step-up transformers are placed on top of the structure.

From the high-tension side of the 2300-k.v.a. transformers the leads pass through the floor to the 45,000-volt, motor-operated oil-breakers and thence through disconnecting switches to the high-tension bus on the floor above, which bus is sectioned by means of knife switches. From this bus the leads pass through disconnecting switches to the line-breaker and thence through disconnecting switches and series transformers to the protective devices and the outgoing lines.

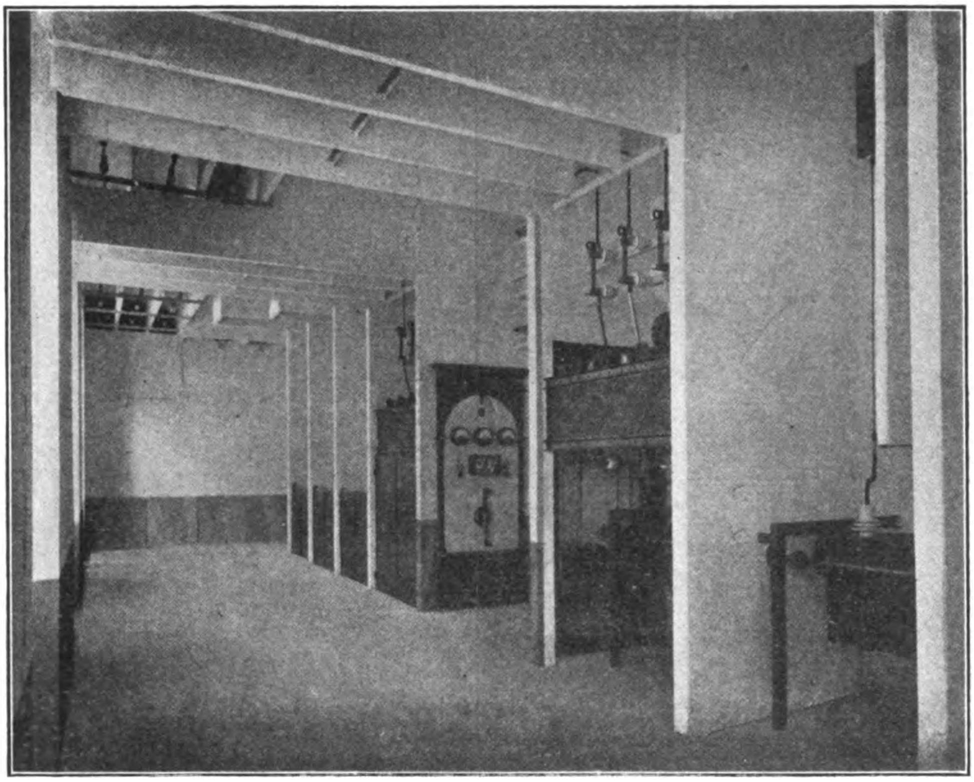


Fig. 23.—TRANSFORMER SWITCH-ROOM—PIATTAMALA STATION

In addition to the main 2300-k.v.a. transformers that step up to 45,000 volts, there is a 2300-k.v.a., three-phase transformer which connects to the 8000-volt relay bus and steps up the voltage to 27,000 volts for the line to Gravellona. Connected to the 27,000-volt bus are two 1000-k.v.a., three-phase transformers near the outside wall for the 12,000-volt circuit to Villa d'Ossola. The 27,000-volt and 12,000-volt circuit-breakers, bus bars, switches and similar apparatus are located above the 1000-k.v.a. transformers.

Fig. 19 shows two of the 45,000-volt, three-pole, automatic oil circuit-breakers used in the plant. Each breaker has its three poles in independent masonry compartments and is provided with six breaks in series per pole. The three poles are actuated by a common shaft driven by a motor with suitable clutch couplings and a spiral spring device. The concrete walls between the poles of the breaker are excellent examples of this kind of work. The porcelain in the top of the circuit-breaker tank and the porcelain studs of the swinging type disconnecting switches are typical of European practice.

The generating station at Haute Rive furnished by the Maschinenfabrik Alioth is used for light and power service in the Canton of Fribourg in Switzerland, and also supplies power in emergency to the Montreaux Oberland Bearnois Railways, running from Montreaux nearly to Interlaken through the mountains of Switzerland.

This station is arranged to contain 10 vertical shaft generators, each of 950-k.v.a. capacity, 50 cycles, 8600 volts, and each of these generators is provided with a control cabinet of the type shown in Fig. 9, Part I, these cabinets being placed along the wall of the station. Each pedestal is provided with a field ammeter, a main ammeter, operated by series transformer, a main volt meter, a synchronizing lamp, main circuit-breaker, field switch, field rheostat and similar devices.

The 8600-volt circuit-breakers for the outgoing feeders, as well as the feeder bus bars, are shown in Fig. 20. In this room there are two sets of three-phase bus bars arranged in the form of a ring, which is sectioned by knife switches in various places. The bus bars are made of bare copper strap attached to metal caps placed on porcelain insulators supported by metal pins and cast-iron brackets. The oil circuit-breakers are self-supporting and placed along the wall of the room in the manner indicated.

Recent Progress in Textile Mill Design and Operation —Electrification of the Industry

The Pacific Mills is one of the largest textile mills in the country, having a cotton department with 185,000 spinning spindles and 6717 looms, a worsted department of 53,064 worsted spinning spindles and 2650 looms, and a print works with 27 printing machines. With the natural increase in the size of the plant, the increase of speeds of machinery requiring additional power, and the constantly increasing demand for steam for manufacturing purposes it has become necessary to begin the reorganization of the entire power plant on a comprehensive basis. The present power plant consists of two sets of water wheels at the upper mill, one set at the lower mill, and several boiler plants and engines located in various departments.

The new power plant now being built is the beginning of the reorganization of the power system of the entire mill. It is located on Essex and Embankment Streets, about 800 ft. from the Merrimack River, from which an abundant supply of water for condensing and boiler feed is obtained, and beside the tracks of the Boston & Maine Railroad, over which coal is received.

The plant is intended to operate in connection with such portions of the present power system as will remain in commission temporarily or permanently. A portion of the existing power plant will remain probably for all time, with such renewals as are necessary. The mill owns the right to use a certain amount of water. This right was purchased many years ago, a cash payment for a portion of the price being made for it, the remainder being left at perpetual interest. It is reasonable to suppose, therefore, that the water will always be used to produce power and that the water power plants will be renewed as required, and that these plants will run in conjunction with the new power plant herein described.

WILL RETAIN PART OF OLD PLANT

Some of the engines now in use will be kept running as they now are until they are worn out, or until it becomes advantageous for other reasons to transfer the production of an equivalent amount of power to the new power station. There was so little available room in the lots with the rest of the plant that it was decided to build the new plant on an entirely separate lot and to make power as cheaply from it as possible. It would have led to considerable complication and special construction to get exhaust steam for manufacturing purposes. The station has therefore been designed along the same lines as would be adopted for a central station where power must be generated as cheaply as possible, without being able to use any of the waste products. It consists of a turbine room, a boiler room and a coal pocket.

In connection with the boiler plant there are two brick chimneys. The present machinery equipment is for 5500 kw., and the buildings are designed for liberal extensions to the south.

THE NEW SET OF BUILDINGS

The main building, consisting of the turbine room, 78 ft. 6 in. by 125 ft. 5 in., and a boiler room 86 ft. 8 in. by 142 ft., is built with brick walls with granite and terra cotta trimmings, and concrete floors and roof. The framing is of steel throughout. The boiler room floor is on the same level as that of the turbine room basement and the yard.

The turbine room floor is 14 ft. above the basement level, and this room is 25 ft. high under the roof trusses. Its floor is of reinforced stone concrete supported on steel beams. The turbine foundations and the floor are kept entirely separate in order to avoid any possibility of transmitting vibration from the machinery to the buildings. There are two rows of columns spaced 44 ft. centers on 17 ft. bays. In the space between these columns are locted the main units. Between the west columns and wall is the switchboard, and between the east columns and wall are the small engine units and exciters. The main generator space is covered by a 15-ton crane and the exciter space by a 5-ton crane. These cranes are hand operated.

At one end of the turbine room is a stair tower, the upper part of which is made into a fireproof storeroom. There are also two toilet rooms with showers, one being on the main floor and the other in the basement for the use of firemen.

The boiler room, which is one story high, has two rows of columns, the space between them being used as a firing floor, while the boilers are located between the columns and the walls. The space between the columns is covered by a metal frame skylight, the eaves of which are high enough above the main roof to admit of a row of metal louvres. These louvres have movable vanes, which can be operated from the boiler room floor. The roof for both the turbine and boiler room is composed of reinforced cinder concrete covered with plastic slate.

The chimneys are nine feet diameter, inside of core, and 200 ft. high above the boiler room floor. The core extends for the entire height, and both it and the shell are covered with a cast-iron cap made so that the core is free to expand. Both core and shell are of red brick.

COAL POCKET AND SIDING

The coal pocket is 209 ft. 6 in. by 52 ft., and is 20 ft. deep from the floor to the top of the rails on the trestle, from which the coal is dumped. The floor is 10 ft. below that of the boiler room and the yard level. The retaining walls are of reinforced concrete up to the level of the tracks. Above this they are of cement plaster on expanded metal and steel framing. The columns and roof trusses which span between wall columns are of steel, while the roof is of wood covered with slate. The building is lighted by skylights in the roof and ventilated by wooden louvres in the side walls and in the monitor on the roof. Inside the pocket the railroad is carried on steel bents. Outside the trestle is of wood throughout.

On account of the character of the ground it was necessary to carry all of the structures on piles. These piles are of concrete, 16 in. in diameter. The use of concrete piles made it possible to carry the depth of the footing course below the frost line, instead of down to the water line, as would have been necessary had wooden piles been used. All of the foundations are of concrete.

WATER SUPPLY FROM RIVER

The water is taken from the Merrimack River through a 48-in. steel penstock provided with sluice gate and screens, into a large concrete cistern located under the west side of the turbine room basement. The sides of this cistern form part of the building foundations and the bottom is low enough to insure an ample supply of water at all stages of the river. From this cistern the water is taken through the condensers and pumps and is then returned to the river through another 48-in. steel penstock, which discharges further down stream. Provision has been made so that later, if it is thought desirable, warm water from the condensers can be carried over to the print works for use in manufacturing processes.

METHOD OF COAL HANDLING

Coal is taken from the pocket by a single-track trolley with a grab bucket. There are two lines of track for this in the coal pocket, one on each side of the trestle, the track being supported from the roof trusses. These two lines unite between the pocket and the entrance to the boiler room, so that a single line of track is carried down over the center of the firing floor inside of the latter.

BOILER EQUIPMENT OF PLANT

The present installation consists of 24 horizontal return tubular boilers, built by the Bigelow Co., arranged in batteries of four each. Each boiler is 72 in. diameter and has 92 tubes 3½ in. diameter and 20 ft. long, and has an overhanging front. New England roller grates are used. The boilers are suspended by lugs and bolts from I-beams carried on columns independently of the settings. The settings are of red brick lined throughout with fire-brick. A steel flue with damper regulator conveys the gases to the chimney. Mounted in the rear of each boiler setting is a Foster superheater. The steam pressure is 150 lb. per sq. in., and the steam is to be superheated about 125° F.

TURBINE AND ENGINE EQUIPMENT

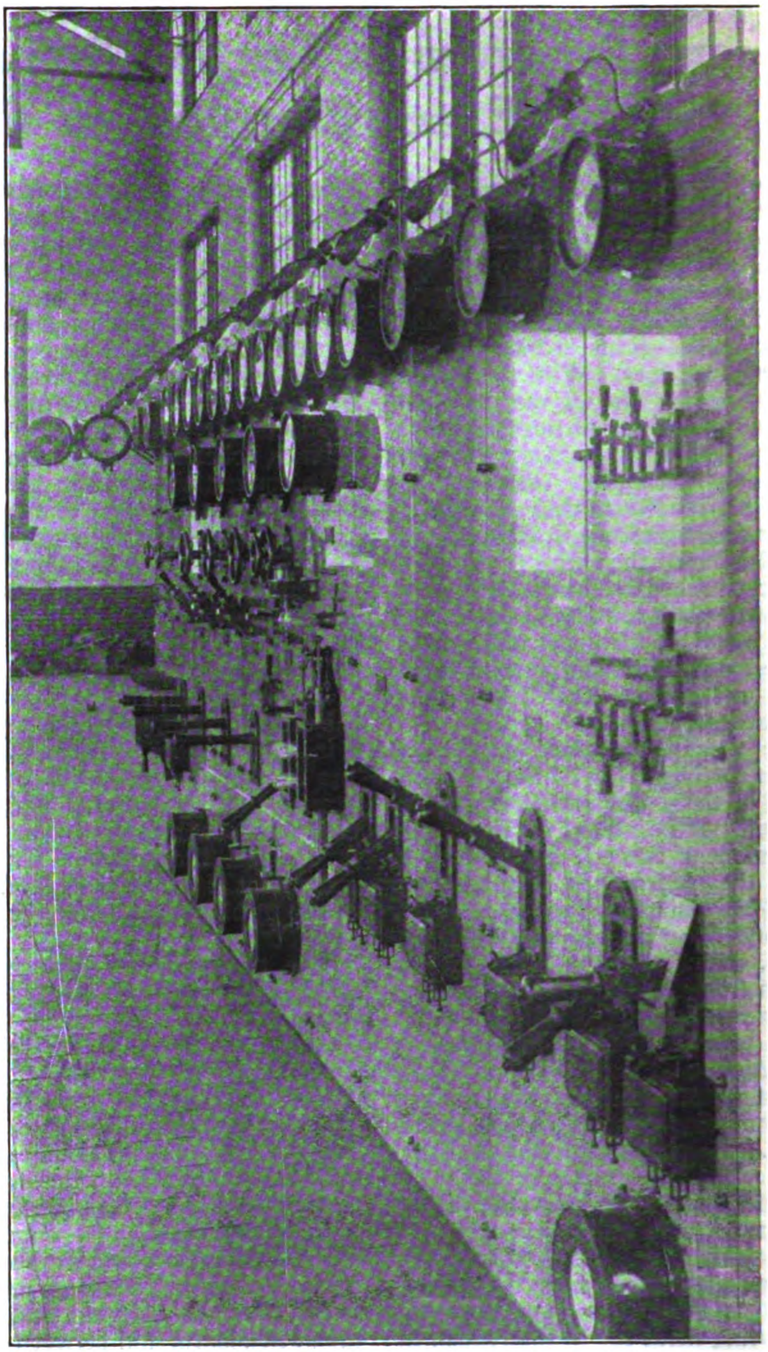
On the main turbine room floor are located three 750-kw. and one 3250-kw. Allis-Chalmers Parsons turbine units, generating 60-cycle current at 2300 volts; a 75-kw. engine-driven alternator capable of running in parallel with the above or separately on an auxiliary set of busses, a 50-kw. steam-driven and 55-kw. and a 100-kw. motor-driven exciters, and a 15-panel switchboard.

The turbines are designed to run at 1800 rev. per min. Each is equipped with a centrifugal governor and automatic load and safety stop valves. The generators are of the revolving field enclosed type with forced ventilation. The air for this is sucked in by the rotating field through a duct leading to an airshaft. The opening for this shaft is up near the roof, thus insuring a supply of clean, cool air. Each unit is supplied with oil by an oil pump mounted on its frame and direct driven through gears. An auxiliary steam-driven oil pump supplies oil at starting. The frontispiece on page 902 shows view of turbine room.

AUXILIARY APPARATUS

In the basement are located the condensers, three 12 and 8 by 14 in. feed pumps, two 1000-gal. underwriter fire pumps and a 3000-h.p. closed feed water heater. Two of the 750-kw. turbines are equipped with Warren jet condensers having twin double-acting steam-driven air pumps. The third 750-kw. unit has a turbo-jet condenser set, built by the Allis-Chalmers Co. This consists of a jet condenser mounted directly beneath the exhaust nozzle of the turbine. To this is connected a three-lobe cycloidal pump driven by a small steam engine.

The 3250-kw. turbine unit is equipped with two (2) turbo-jet condensers. These are so arranged that they can be operated separately in case of an accident. They are similar to the one on the 750-kw. unit, but larger. One is mounted on each side of the generator foundation. All the condenser heads have adjustable spray cones. Openings are left in the floor above the condensing apparatus so that it can be reached by the large crane.



FRONT VIEW OF STEAM PLANT SWITCHBOARD. PACIFIC MILLS, LAWRENCE, MASS.

ARRANGEMENT OF STEAM PIPING

After leaving the superheater the steam passes through a four-inch nozzle with two valves and a bleeder into a 10-in. steel header, located in the boiler room and below the level of the turbine room floor. Two long bends between the superheater and this header, one vertical and one horizontal, provide for expansion. The header is divided into sections by bypass valves, and is supported by balanced levers hung from the roof beams so as to make it as flexible as possible. Six-inch pipes feed the 750-kw. turbines, and a nine-inch pipe feeds the 3250-kw. turbine. Each turbine is provided with two valves, one at the steam chest and one at the header. The auxiliaries are fed from the header at two points. All piping is laid out to give the greatest possible allowance for expansion.

FEED WATER PIPING

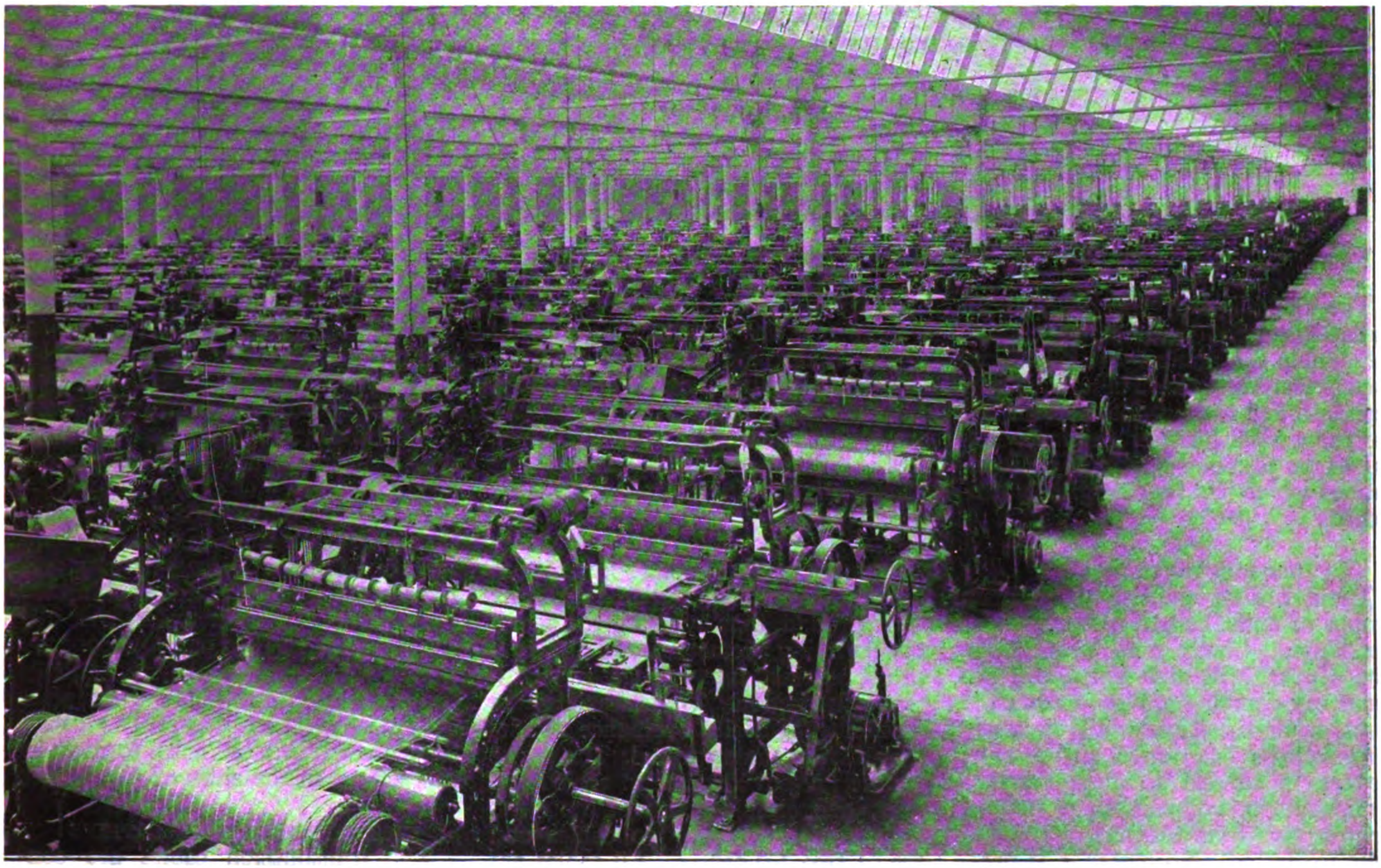
The feed pumps normally take water from the overflow pipe from the condensers, but they may also use water from either the cistern or the city supply. These pumps ordinarily discharge through the heater to the seven-inch brass feed main in front of the boilers, from which the boilers are fed. They may also be made to discharge into a cold-water feed main of iron, which is to be used in case of an accident to the main feed pipe, or for testing purposes. By operating the necessary valves, one battery or part of a battery may be fed in either manner. A Hancock inspirator has also been installed for night use, when the load will be extremely light.

The high-pressure steam piping is dripped by means of No. 40 Holly drip system, and the low-pressure piping by means of traps.

LAYOUT OF SWITCHBOARD

The present board consists of three panels for the direct-current side of the exciters and two for the auto-starter for the motor side of one exciter; five panels for the alternating-current generators, each with an ammeter, one voltmeter and one indicating and a recording wattmeter, a three-pole single-throw non-automatic, hand-operated oil switch, and necessary accessories; a total load panel with polyphase indicating wattmeter, Chapman voltage regulator, a power factor meter and a three-phase ground detector; and four feeder panels each with an automatic, hand-operated remote control three-pole single-throw oil switch, and a wattmeter for each feeder circuit. The synchroscope and voltmeters are located on a swinging bracket at the exciter end of the board.

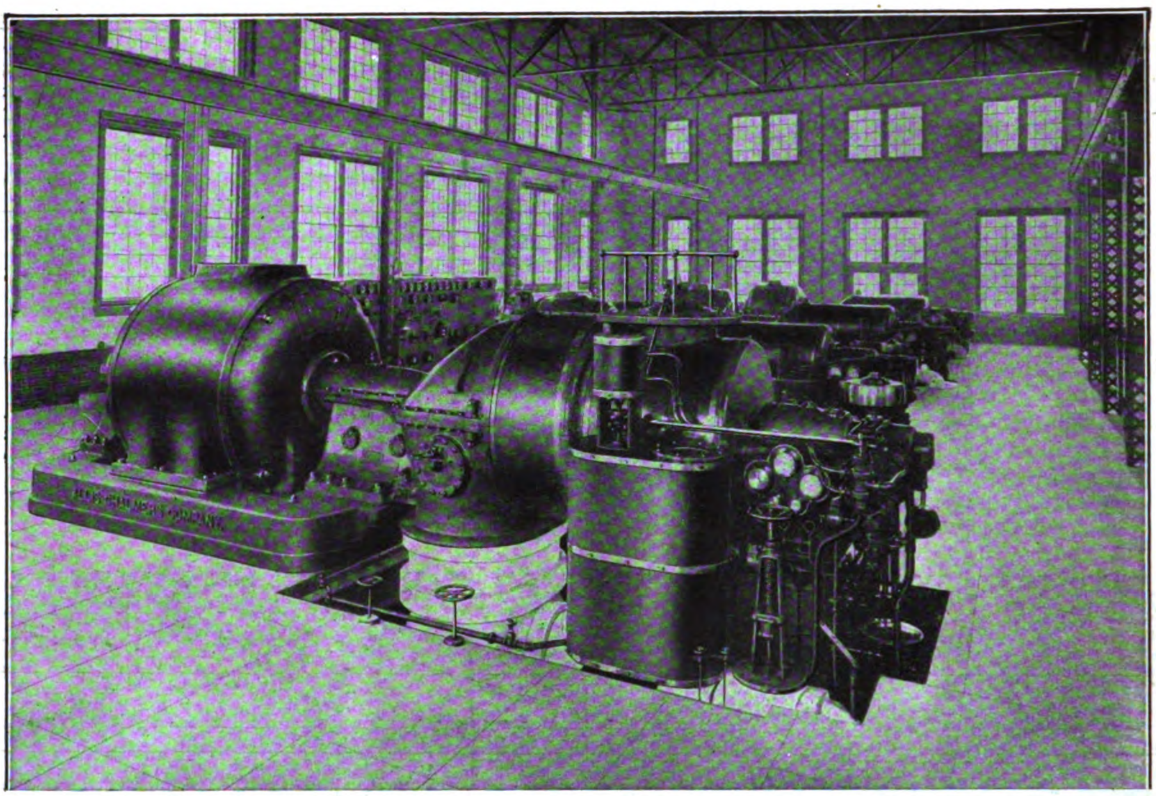
In laying out the feeder circuits from this board, the scheme was adopted of carrying one large circuit to each mill yard, so that a center of distribution was made inside the mill yard. This was done so that it would be possible to operate any generators about the yard in parallel with the station, the line to the station in that case acting somewhat as a tie line under some conditions. One panel with an indicating and an integrating wattmeter, and an automatic hand-operated oil switch, is provided for each main feeder. All oil switches are mounted on the wall back of the board, the operating levers being under the floor. The rheostats are on the basement floor. Machine and feeder leads are located on the basement ceiling. The feeder leads are taken to the north end of the turbine basement, where they are connected to the transmission cables by disconnecting switches.



INTERIOR OF WEAVE ROOM AT THE ROYAL WEAVING CO.'S PLANT, SHOWING ELECTRICALLY DRIVEN LOOMS

INSTALLATIONS MADE

This plant at present comprises two installations. At first, the three (3) 750-kw. units and 12 boilers were installed. At that time these gave ample power, but before this plant was thoroughly in operation the mill commenced a complete reorganization of the upper mill plant, which greatly increased the load at this plant. At the same time construction was started on other buildings for the lower mill, so that it became necessary to at once install more machinery in the new plant.



INTERIOR VIEW OF PACIFIC MILLS POWER HOUSE SHOWING ONE 3250 K. W.

The buildings of the original installations were made large enough for double the number of boilers and for another turbine. These have now been installed and put into service. At the same time another chimney similar to the first one was built on foundations which had been originally provided.

DISTRIBUTION SYSTEM

There are at present three main groups of mills, known respectively as the Upper, Lower and Yarn Mills. The Upper Mill and Yarn Mill are about one-fourth (¼) mile from the plant, while the Lower Mill is nearly three-fourths (¾) mile away. The current is carried to these various groups at 2300 volts and there stepped down to 550 volts for motors and 115 volts for lights. No power is at present carried to the Yarn Mill, as its mechanical drive is still good. The lights, however, are carried by the station.

At the upper mill there are three (3) main transformers for power, each 2300 to 575 volts and 800 k.v.a.; six main lighting transformers arranged in two banks, each transformer being 100 k.v.a. 2300 to 115 volts; and three auxiliary power and three auxiliary lighting transformers. These latter are principally for night use and each 15 k.v.a.

At the lower mill are three main transformers for power, each 2300 to 575 volts and 625 k.v.a.; three lighting transformers 2300 to 115 volts, 110 k.v.a. each, and one 25-k.v.a. transformer for auxiliary lighting at night. There are also three 30-k.v.a. transformers for Yarn Mill lighting, and three 55-k.v.a. lighting transformers for a weave shed near the lower mill. All transformers are single phase, all 100 k.v.a. and larger are water-cooled.

CONDUITS AND TRANSMISSION LINES

The transmission system is entirely underground, thus avoiding the use of any lightning protection, and also providing against interference from future construction. There was also the possibility of a city ordinance requiring all wires underground. The cables for the present installation are of two sizes, one circuit being of four 4-0 cables, one of three 3-0 cables and one of two 3-0 cables. All cables are three conductor, stranded copper, insulated with varnished cambric and protected by a lead sheath. The cables are insulated for a working pressure of 5000 volts, but will operate, of course, at 2300 volts.

The conduit system is made of multiple duct vitrified tile laid in concrete, with joints wrapped with burlap soaked in cement. This conduit is only two ducts wide throughout its length, so that each duct has at least one surface exposed to the surrounding earth, thus avoiding a reduction in the carrying capacity of any cable, due to poor radiation.

The manholes are generally about 300-ft. centers, with a maximum of 410-ft. centers. Racks are formed in the sides of these manholes by projecting courses of brick from the inside of the walls. They are built with concrete bottoms, eight-inch brick sides and concrete tops, carried on old rails. Circular cast-iron covers are used.

The route of this conduit is such that it was necessary to cross the Boston & Maine Railroad tracks and Broadway, a public street at about the same point. In order to facilitate any future work at this point, a concrete tunnel was constructed here, with its top about three feet below the surface of the street and road. The cables here are carried in racks formed by projections in the sides of the tunnel.

SWITCHBOARD INSTALLATIONS

The transmission cables are connected through disconnecting switches mounted on marble tablets in the transformer houses to the terminals of the step-down transformers. The secondaries of these transformers are controlled by a marble switchboard at the upper and lower yards. From these boards the current is carried to the motors and lights in ordinary open wiring, run generally on the ceilings of the various rooms. These same switchboards also control the generators at the upper mill, as will be explained later. The wiring for this plant has been kept as simple as possible, all connections which might lead to complications in switching, etc., being avoided.

MOTORS FOR 6300 HORSE POWER

About 6300 h.p. of motors have been installed about the mills, the average size being 45 h.p. Most of them are suspended from steel framing on the ceilings, but some are arranged for floor and some for wall mounting. The group system of driving has been adopted in all cases, except in the picker room of the upper mill, where individual motors are installed on each machine. The motors, which are in sizes of 50 h.p. or larger, are of the internal resistance type. The smaller sizes are squirrel cage. Each is equipped with an ammeter and an automatic oil switch with overload and low voltage release coils.

LIGHTING FROM NEW PLANT

Practically all of the electric lights in the mills are now carried by the new plant. In a few cases this work has not yet been completed. The three-phase four-wire connection of the secondaries of transformers has been used whenever possible, so as to save copper. The yards of the various groups of mills are large, and this was an important item.

An auxiliary set of lights, which can be run from the small set of transformers connected at will to the 75-kw. engine set in the plant, has been installed for lighting the help into and out of the mill after hours. These lights are spaced about every 50 ft. in each room. They can also be connected to the main lighting busses when desired, by means of double-throw switches. The yard is also lighted all night from this same source of power. Most of the lighting is done by incandescent and arc lamps. One weave room, where lights are required all day, is being equipped with Cooper-Hewitt mercury vapor lamps.

HYDRO-ELECTRIC INSTALLATION

The two old water-wheel plants at the upper mill were about worn out when the new steam plant was built, so that the first thing that was done with the current from the new plant was to relieve one of these plants of duty so that it could be remodeled. As soon as this one had been completed the other one was shut down and remodeled.

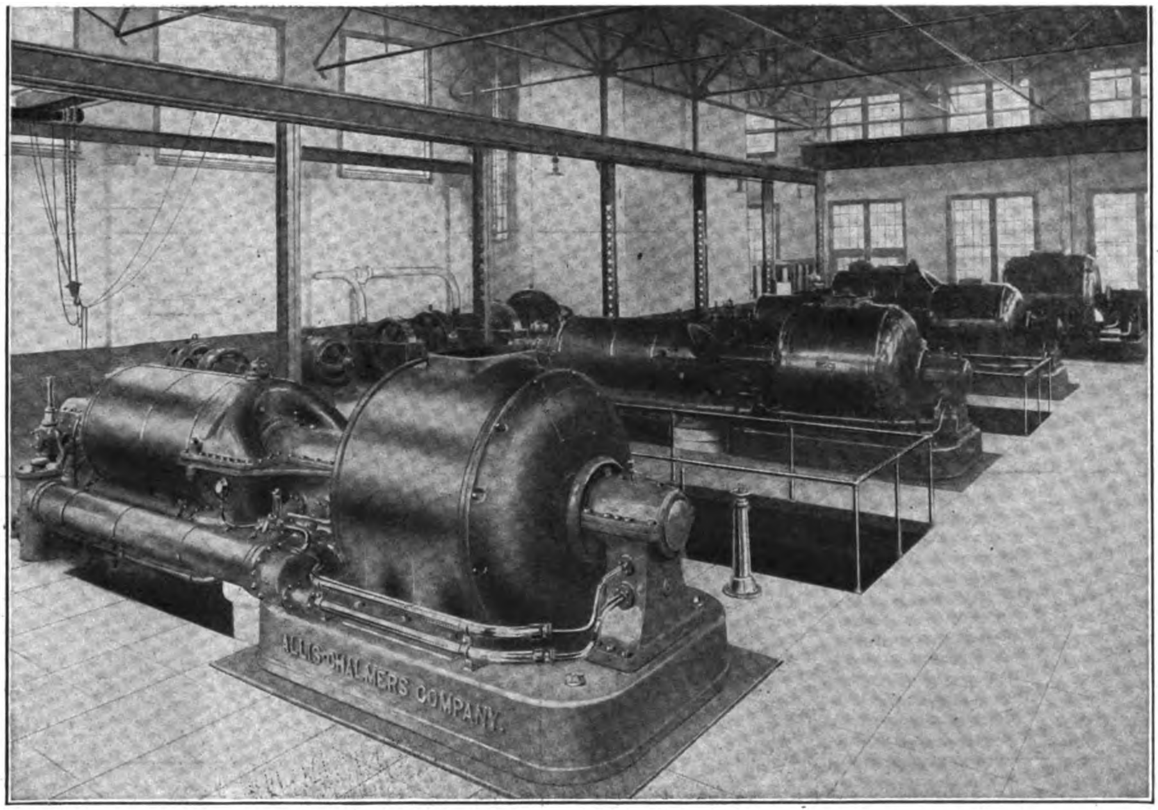
After looking the ground over carefully, it was decided to equip both of these plants electrically so as to secure the benefit of more complete flexibility of operation. The water power sometimes falls to a very low value, due to back-water, and in extreme cases entirely gives out, so that to leave this plant on mechanical drive would mean that either engines must be installed as relays, which was inconvenient, or that part of the mill would be shut down during high water. Another valuable feature of the electric drive was that this water power could be used for driving any part of the electric load at night, thus saving steam for this work.

DETAILS OF HYDRO-ELECTRIC PLANT

Both hydraulic plants are similar, except that the one locally known as "East Pit" has an 800-kw. generator, and the other a 600-kw. generator. Both are three-phase, 60-cycle, and 600-volt at 180 rev. per min. They operate in parallel with the steam station, being connected to the bus bars on the low-tension side of the 1000-k.v.a. transformers. From these same busbars all of the power is distributed to the upper mill yard. These generators were furnished by the General Electric Co.

Each installation of water wheels consists of a pair of 39-in. and a pair of 36-in. Type C Hercules wheels, built by the Holyoke Machine Co. These are installed in steel cases and have steel draft tubes. The original steel penstocks are still used for bringing the water from the canal to the wheels. As the depth of water under the draft tubes could not be made very much it was thought best to provide conical diffusers under each tube.

The normal head is about 28 ft., but during high water this falls considerably. Under the higher heads the two 39-in. wheels will use the full amount of water that the mill is entitled to at that plant, but under the lower heads the two 36-in. wheels also have to be put on, and being smaller in diameter, they can run to better advantage under these lower heads than



INTERIOR VIEW OF PACIFIC MILLS POWER HOUSE SHOWING THREE 750 K. W. ALLIS-CHALMERS TURBO-GENERATORS the larger wheels, thus keeping up the efficiency.

Each wheel unit is controlled by a suitable governor, also furnished by the Holyoke Machine Co. These governors have electrical control from the switchboard and can be adjusted to be non-operative for speed changes of less than five per cent. The gates can will remain there under all ordinary conditions of operation.

SWITCHBOARDS AND CONTROLS

The generator panels for these units are similar in every respect to those on the steam plant board, except that the oil switches are automatic with time-limit relays. Both generators are controlled from the "West Pit," so that the operator does not see the 800-kw. unit at all, as it is in another room, but by a suitable indicator for the gate opening and the electrically controlled governor, the operation is as simple as for the 600-kw. machine, which is very near the board.

This same board, as before explained, controls the feeder circuits for the upper mill. The feeders for each main department have a graphic recording Westinghouse meter, so connected as to show their total load. Thus the amount of power chargeable to any department can be obtained. This same scheme of metering has been used throughout the plant, thus giving very satisfactory power records.

The first installation of the new steam plant was put into service about July, 1908; the water-wheel units in the spring of 1909, and the 3250-kw. turbine in the summer of 1909. The power factor of this system is about 80 per cent. for the power load, and somewhat better when the lighting load is on. The generators are all designed for this 80 per cent. power factor. They will also stand liberal overload. This entire installation has been designed by and installed under the supervision of Charles T. Main, engineer, 45 Milk Street, Boston.

ROYAL WEAVING CO.'S NEW PLANT

The Royal Weaving Co.'s Darlington Mill is a modern plant. There are about 600 looms, all of which are driven individually by one-half horse power 220-volt, three-phase, 60-cycle motors.

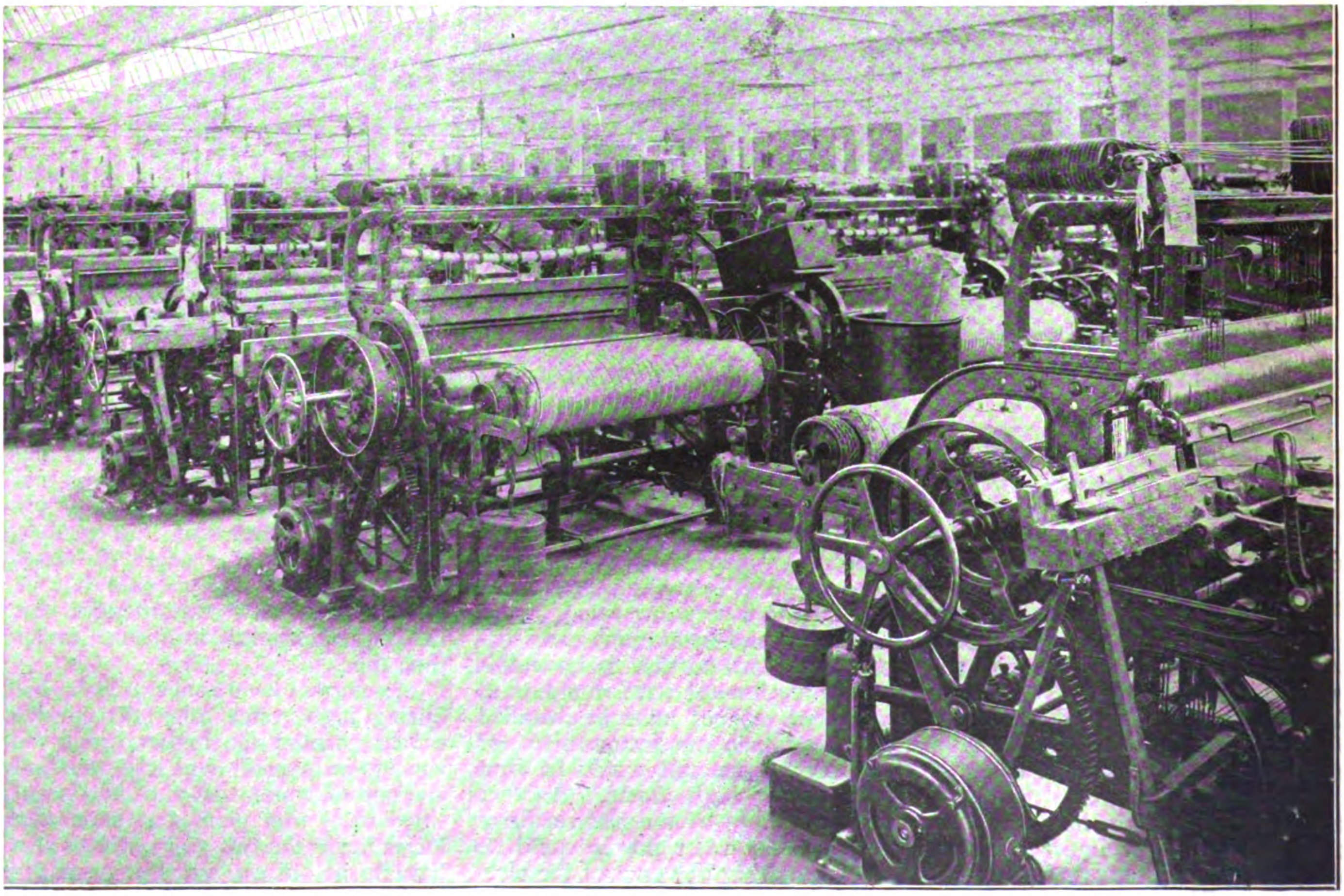
In the cotton spinning mill all machinery is electrically driven by means of 550-volt, three-phase, 60-cycle motors, arranged on the group system. This plant is being increased by the addition of more than 1000 looms and a small dyehouse, thus requiring new buildings. On account of the necessity of maintaining a boiler plant for heating and dyeing, and the lower cost at which current could be produced at the plant over current purchased, it was decided to build a power plant at the mill. It is with the description of the power plant that this article has chiefly to do.

POWER HOUSE

The power house for this plant consists of a steam turbine and generator house, about 64 by 98 ft., with basement; in the rear and adjoining which is the boiler house, 47 by 93 ft. The boiler house floor and turbine room basement floor are at the same level, with the main floor or turbine house 14 ft. above.

The buildings are of red brick with granite trimmings. The chimney for the plant has a height of 175 ft. above the boiler room floor, with eight feet diameter flue, and is built of red brick. The walls of the turbine room are faced with white enamel brick to a height of six feet six inches, with red brick in white mortar above. The floor of the turbine room is of steel frame with reinforced concrete slabs, on top of which are bedded red vitrified tiles; the basement or turbine room has a granolithic concrete floor and the boiler room floor is of vitrified brick bedded on a concrete base.

Roof of power house is of rein-



ANOTHER WEAVE ROOM AT THE ROYAL WEAVING CO.'S PLANT, SHOWING ELECTRICALLY DRIVEN LOOMS forced cinder concrete resting on steel trusses and girders, and covered with tar and gravel. A toilet room, with all modern conveniences, including shower bath, is provided. A 15-ton hand-operated traveling crane is provided in the turbine room.

EQUIPMENT

The equipment of the plant consists of four (4) 350-h.p. Babcock & Wilcox water tube boilers equipped with Foster superheaters, supplying steam to three 500-kw. horizontal type turbine alternators, with their necessary condensing apparatus and other auxiliaries.

On the main turbine room floor are placed the three 500-kw. turbine alternators, with their exciters and switchboard; also a turbine-driven and a motor-driven pump for hot-water circulation system heating the mills of the plant. In the basement below is placed the condensing apparatus, including engines and pumps for cooling towers, boiler feed pumps, domestic service pump and feed-water heater. An exhaust steam and a live steam heater is placed in the boiler room in an elevated position for heating water used in the hot-water heating system in the mills.

All water for use of this plant is taken from the city supply or pumped from artesian wells. In order to run condensing, four double-fan cooling towers are provided for cooling the condensing water; they were built by the Wheeler Condenser & Engineering Co., and are proportioned to lower the temperature of 1700 gal. of water per minute from 105° F. to 85° F. when the temperature of the atmosphere does not exceed 70° F. and the relative humidity is not greater than 70 per cent. In the machinery arrangement of the power house space is reserved for an additional unit of the same or greater size and two additional boilers. The steam pressure carried is 175 lb. gauge with 125° F. superheat at the turbine throttle.

On account of the large number of small motors in the mill the power factor is about 70 per cent. In order to take care of this low power factor the turbine generators have 500-kw. steam ends and 750-kw. electric ends. These generators are wound for 550 volts and are three-phase, 60-cycle, and run at 3600 rev. per min.

The three condensers for the plant are Allis-Chalmers standard turbo-jet condensers, each direct driven by means of 10 by 12-in. "Lycoming" engine, built by the Valley Iron Works, Williamsport, Pa. Two water-tight concrete trenches extend longitudinally through the basement of the power house, in one of which flows the condensing water from base of cooling towers, in the other the condensers discharge water to hot well, over which are located two 10-in. double-suction horizontal shaft centrifugal pumps. The pumps were built by the Allis-Chalmers Co., and are each direct connected to an eight-inch by nine-inch Shepard engine, running at 350 rev. per min. The discharge from these pumps goes to the top of cooling towers.

The exciters consist of one 50-kw. steam turbine, direct connected to one 50-kw. 120-volt direct-current generator and one 55-kw., 60-cycle, three-phase, 2300-volt induction motor, mounted on the same base and direct coupled to a 55-kw. 120-volt direct-current generator.

The mills are heated by hot water. The turbine-driven and motor-driven pumps on the heating system, also the heater for same, were furnished by the contractor for heating system, and not as part of the power-house equipment. The two boiler feed pumps are the Warren Steam Pump Co. duplex outside end packed plunger pumps, pot valve pattern, size 12 in. by 7 in. by 12 in. The domestic service pump is of the same make and is a duplex horizontal piston pump, size 10 in. by 6 in. by 12 in. All pumps are fitted to work under a steam pressure of 175 lb. and 125 degrees superheat.

The feed-water heater is the Webster open type feed-water heater, capable of raising the temperature of 60,000 lb. of water per hour from a temperature of 40° F. to within 5° F. of the temperature of exhaust steam entering the heater.

SWITCHBOARD

The switchboard for this station consists of 15 panels of blue Vermont marble. The first three panels from the right of the board when facing it are for the exciters and voltage regulator; the next is for a future alternator; then comes the three panels for the present alternators; next is a panel for station lights and frequency and power factor meters and ground detector; the rest of the panels are for lighting and power feeders. The last panel is for a future feeder circuit and is blank at present.

Each alternator panel is equipped with three ammeters, an indicating and an integrating wattmeter, and the necessary switches, rheostat mounting, etc., and a non-automatic oil switch. Each feeder panel is equipped with an ammeter, indicating wattmeter and an automatic oil switch with time limit relay. Two alternating-current voltmeters and the synchroscope are mounted on a swinging bracket at the exciter end of the board. One of the voltmeters is connected permanently to the bus bars and the other can be plugged onto any machine. A clock in an ornamental grillwork is mounted over the center of the board.

All oil switches are mounted on the wall back of the board and no voltage higher than 110 reaches the board proper at all. The bus bars are on the framework above the switches, and the instrument transformers are on a framework in the basement. Those for the alternator, however, are mounted inside of the generator foundation so as to be easily accessible, and at the same time, out of the way.

The lead-sheathed cables start at the instrument transformers and pass immediately into the conduit system below the basement floor. This switchboard was furnished and erected by the Allis-Chalmers Co.

METHOD OF OPERATION AND ARRANGEMENT

The main turbines run with a steam pressure of 175 lb. and 125° F. superheat. The turbines exhaust to condenser or through atmospheric relief valve to atmosphere. All pumps, condenser engines, fan engines and other auxiliaries also run with 125 lb. steam pressure and 125° F. superheat, and exhaust into a common system of piping. This common system is connected to feed water heater and exhaust heater on hot water mill heating system, also to atmosphere. The high pressure heater on the mill heating system is supplied through a thermostatic controlled valve, with boiler steam in case the low pressure heater shall not have sufficient exhaust steam to raise the water to the required temperature.

The domestic service pump which is installed for supplying water for general uses has its suction connected to pipe from artesian wells, the discharge from this pump is piped to heater, hot water heating system, make-up in condensing water system, hand hose, toilet supply and other fixtures. This discharge also has a connection through a meter and check valve with city water supply.

The boiler feed pump piping is so arranged as to pump from heater, city water supply, or from artesian wells, also so that either pump can pump from heater at same time the other pumps from well. The discharge piping has double connections arranged similar to the suction piping, *i. e.*, so that both pumps can discharge hot or cold water to boilers; also so that either pump can discharge hot water to either boiler or boilers at same time as other pump discharges cold water to the others.

GUARANTEED EFFICIENCY OF PLANT

The plant at the time of writing is

not quite ready for operation. The contractors have guaranteed a plant efficiency of 46,000 B.t.u. per kw-hr. output, measured at the switchboard terminals, when the plant is operating at its rated capacity of 1500 kw. with a load factor and a power factor of 100 per cent., which will be obtained by means of a water rheostat. The British thermal units used are to be obtained by multiplying the number of pounds of coal fired per hour by the number of British thermal units contained in an average sample of coal used, as determined by analysis. The mill heating apparatus is not to be considered in the test.

WHITMAN MILLS NEW WEAVE SHED

The new weave shed of the Whitman Mill, New Bedford, Mass., now in process of construction, when completed in the spring, will be one of the largest in the world. This shed is of brick construction, one story high, and the dimension are 369 by 550 ft. It has a saw-tooth roof, supported by hard pine columns, and a double floor of hard pine and maple supported on steel beams. The interesting feature of the equipment of this new shed is the electric power equipment. Power is furnished by a 2000-kw. Allis-Chalmers generator driven by a steam turbine with six 150-h.p. Allis-Chalmers motors. The generator and steam turbine will be located in the old powerhouse.

Motors in the weave shed are arranged for group drive, with all the shafting underneath the floor. The Cramer moistening system has been selected for this shed. It will have overhead steam heat, and the Grinell sprinkling system for fire protection. When equipped this shed will have 3400 looms, and the product will be fine specialties in silk and cotton.

THE MODEL NASHAWENA MILL

The Nashawena Mill, which is being built at New Bedford, Mass., by a new company of this title organized by William Whitman, is the fifth big cotton mill that Mr. Whitman has given to New Bedford, and is one of three large mills that have been built under his direction this last year, these enterprises representing an investment of something over $6,000,000. The other two mills are the Nonquit No. 2, at New Bedford, and a big worsted spinning mill at the Arlington Mills, Lawrence, Mass.; to the latter plant is also being added a yarn-finishing and mercerizing mill of large size.

The Nashawena plant is unique in many ways, but particularly because of the fact that it is the largest cotton mill built anywhere in the world, so far as known, at one time, and has the largest weave shed in the world. In its constructive features it shows some radical departures from old standards, especially in the substitution of steel girders for hard pine beams, and in the superior lighting of the mill, 80 per cent. of the sides of the spinning mill being glass. The sanitary equipment is unapproached in its completeness, and no expense has been spared to make every detail of construction and equipment perfect, yet the cost of the plant per spindle is no larger than that of many inferior mills.

GENERAL ARRANGEMENT

The plant consists of five separate brick buildings ranged on both sides of Bellville Avenue, near the site of the Nonquit No. 1 mill. The weave shed, with the main building just behind it, extends north and south on the opposite side of the avenue from the Nonquit. Both buildings are 800 ft. long and the main mill is four stories high and 135 ft. broad, while the weave shed is 285 ft. broad and has one story and a basement 14 ft. deep and 80 ft. wide, running the full length of the building. The storehouse, occupying a position in the rear of the main mill, is 100 by 300 ft. and two tall stories in height. The boiler-house and engine-room and the offices are housed in two separate buildings on the east side of the avenue, near the Acushnet River, from which a plentiful supply of salt water is easily obtainable.

FEATURES OF CONSTRUCTION

As a whole, the plant is of standard slow-burning mill construction, except in some particulars where the nature of the work to be done, or where the vast size of the mill have caused original methods to be employed. The structure is supported on concrete foundations, going down 6 to 12 ft. below high-tide level. The main mill has steel I-beams because of the excessive cost of good hard pine, but the columns are mostly of wood. The bays are 12 ft. wide, with a transverse spacing of 26 ft.

In order to obtain the greatest volume of light possible, on account of the fine character of the goods manufactured, the window pilasters are only 25 in. wide, making the wall 80 per cent. glass. Maze glass is used in the transoms and in all the lower sash, excepting a narrow strip of clear glass at the bottom of each window. The floors are of three layers, the first being 5-in. hard pine nailed to a 4 by 8-in. nailing-strip, which is secured to the I-beams by means of ¾-in. screws put through specially prepared holes in the flanges. The first layer is laid longitudinally to carry the floor load to the joist, the intermediate floor of cheap 1-in. spruce laid at right angles to it is used for the purpose of tying the planking together, and a surface layer of 1-in. maple is put on parallel to the heavy planking, the object being that the floor may be renewed without interfering with the operations in more than one bay at a time—a difficulty that is always attendant on the use of transverse flooring. The roof is of 4-in. hard pine planks, with a pitch of 1-in. to the foot, and is covered with a tar and gravel roofing.

THE WEAVE SHED

In the weave shed the floor is similar to that of the main mill, with the exception that the bays are 24 ft. wide and that in the cloth-room there is an extra series of floor beams supported by columns, making the bays here 12½ ft. wide. The roof is saw-toothed construction, facing the north. However, the whole surface is not roofed in this manner, there being a 10-ft. platform extending along the edge on each side for the purpose of allowing workmen to have access to the roof without climbing over the glass. The side walls, however, have a very few small windows, because it was considered desirable to avoid the shadows side windows are likely to produce.

THE SANITARY PROVISIONS

With regard to the sanitary conditions, the Nashawena is an unusually good example of the theory that provision for the welfare of the employe is profitable. Salt water is used for cleansing the toilet rooms, because it has been observed that salt water removes the odors often prevalent in such rooms of old mills. This system, however, necessitates the use of a large amount of brass piping, which is rather expensive. The toilet rooms are further improved by the use of glazed brick for the walls and concrete floors covered with a terazzo wearing surface, so that these places may be washed down with a hose. In addition to placing them in all parts of the plant, the builders have built water fountains at close intervals. The method used here is notable. The fountains are of the "no-cup" type, from which one may drink without inconvenience and without using the unsanitary drinking cup.

On account of the immense size of the building the vacuum system of heating with overhead steam pipes is used. The temperature is further controlled by the Cramer moistening system, which can be so regulated as to warm or cool the air as well as to control the humidity.

THE LARGE POWER PLANT

The power plant is on the east side of Bellville Avenue and is connected with the mill by means of a tunnel through which are carried all of the water piping, electric wires and steam piping. The power house is composed of three rooms—a boiler room, a pump room and an engine room. The boiler room is supplied with 16 Manning boilers built by the Bigelow Co., of New Haven, Conn., which are fired by hand. The gases are carried away by a chimney 250 ft. high, built of reinforced concrete by the Alphonse Custodis Chimney Construction Co. The engine room is equipped with two 3000-kw. Allis-Chalmers turbo-generator sets, each equipped with the necessary condensers and ten electrically-driven vacuum pumps. There is also a 500-kw. turbo-generator for the lighting and for driving the machine shop and auxiliary machinery.

The drive of the mill is entirely by electricity in small group drives. They are of the induction type and operate on a three-phase illuminating circuit of 600 volts. The lighting circuits use 220 volts direct current.

The fire protection of the plant is most thorough; it is connected with the system of the other mills of the Whitman group, so that the Nashawena can be served by seven pumps, each with a capacity of 1500 gal. per min.

The capacity of the Nashawena is 150,000 spindles and 5000 looms, devoted to the manufacture of high-grade novelties in silk and cotton.

Buying Alternating-Current Motors

By H. M. PHILLIPS

The purchaser of an alternating-current motor may be guided in his selection by much the same line of reasoning that he would apply in the selection of a direct-current motor, or other piece of machinery. The intention is to get apparatus best suited to the purpose at minimum cost.

PHASE

Is a single-phase, two-phase or three-phase motor to be chosen? The answer is generally determined by the available source of power; where there is a possibility of selection the single phase should be avoided, except possibly for railway work. The first cost will be found to be comparatively high, the efficiency and power factor are apt to be a little low and in the opinion of the majority of engineers the motor is more apt than the other types to give trouble when subjected to very hard service. There should be little difference in cost between two- and three-phase motors, their efficiency, operating characteristics and reliability are practically the same. The two-phase motor requires four wires brought from the source of supply against three for the three-phase, which may slightly increase the cost of installation. When lights and motors are to be operated on the same system the two-phase arrangement has certain advantages in regard to uniformity of lighting.

VOLTAGE

The voltage also is generally determined by the source of supply, although if transformers are to be used any desired voltage may be obtained to operate the motor. If the supply is 2200, or even 4400, volts a large motor is best that is wound for that voltage and connected directly to the supply. A shock from this current is very apt to be fatal, and great care should therefore be exercised in the installation of the motor and wires leading to same. No one but an experienced electrician should be allowed to touch the motor while current is on. The insulation of this motor may be somewhat more likely to fail than would be the case if it were wound for a lower voltage; and especial care should be taken to protect it from moisture. If this installation is considered too dangerous transformers may be installed and a 220- or 550-volt motor purchased. These will have practically the same efficiency and operating characteristics as the high voltage motor and may be slightly lower in first cost; the price of transformers, however, will make the total cost of installation decidedly greater.

With motors of comparatively small size the difficulty of providing proper insulation, both in manufacturing and in installing, makes the use of a 220- or 550-volt motor almost imperative.

FREQUENCY

The motor must be wound for the same frequency as the supply. Twenty-five cycles is a desirable frequency for motor work, especially on long transmission lines, but the cost for transformers is considerably greater than for 60 cycles, which is perhaps the best for general factory purposes. Incandescent lamps may be operated on either frequency, but arc lamps are more successful on 60 cycles.

INDUCTION MOTORS

For the great majority of cases a "squirrel cage" induction motor will be chosen; the motor is almost invariably of the open type, which compares closely with the semi-enclosed direct-current motor as far as mechanical protection is concerned; the motor is so little affected by dust and the moving parts are of such rugged construction that it will operate successfully in most of the locations where an enclosed direct-current motor is required. As a rule, there is no standard enclosed induction motor, but when one is to be used in a very damp location, or if for other reasons it appears desirable, tight covers may be provided for the openings in the motor frame. This will decrease the rated capacity of the motor very largely, except when used on very intermittent duty, and correspondingly increase the cost for a given horse power. As is the case with a direct-current motor, a saving may sometimes be effected by ordering for intermittent duty. The opportunity is not so frequently offered; the direct-current motor of medium size requires from five to eight hours at full load to attain constant temperature, the corresponding induction motor may require from two to four. The two-hour intermittent rating commonly given the direct-current motor is therefore of little benefit with the present type. When the full-load period does not exceed 30 minutes an intermittent duty motor may effect considerable saving in cost. When the rating of a motor is increased in this manner there is no increase in the momentary load that it can carry or in the load that it is able to start, which may offset the advantage of the higher rating.

SPEED

A high-speed motor should always be cheaper for a given horse power than a low speed, but the available speeds are somewhat limited with alternating-current motors; the no-load speed must always be a factor of the frequency of the supply. When the frequency is 60 cycles per sec., or 3600 per min., speeds of 3600, 1800, 1200, 900, 720, 600 and 514 rev. per min. may be obtained; the full-load speed is seldom more than 10 per cent. below the no-load. With a 25-cycle circuit the speeds are correspondingly reduced.

ALTERNATING CURRENT

The motor is perfect in regard to reversal of rotation, it runs equally well in either direction without any adjustment or increase in cost; the external controlling apparatus required for reversing is simple and inexpensive. It is, however, essentially a constant-speed motor, and with a few exceptions, mentioned below, speed regulation is unattainable.

GUARANTEES

In selling an induction motor the maker will generally guarantee certain values for "efficiency," "power factor," "slip," "starting torque" and "pull-out torque," the last two being expressed in terms of "full-load torque." The clearance may also be given in some cases. Temperature rise is guaranteed in the same manner as for direct-current motors.

The importance of variations in efficiency depends entirely upon the amount of power that will be saved and its value. If a motor is to operate 10 or 24 hr. per day and power is expensive a small difference in efficiency is worth considering. If the motor is to operate but half an hour per day, or if power is very cheap, the efficiency is of little importance.

The power factor is generally of less importance than the efficiency. A motor of low power factor may have the same efficiency as one of higher, in which case the former will draw the larger current from the line, although it consumes no more power than the latter. This will have the effect of slightly increasing the losses in the line and in the generator, but as these are normally but a small percentage of the total load they are in most cases negligible. The load on the engine will be the same in either case and there is little choice between the two. In the case of a large motor or of a group of small ones on a long transmission line the power factor may become of considerable importance. In this case the loss on the line may be quite large, and the addition caused by a low power factor be worth considering; or the higher current to be carried might require heavier conductors for the line, which would very materially increase the cost. It should also be remembered that an alternating-current generator is rated at an output of a given number of amperes, consequently the generator can deliver more power, with a correspondingly greater load on the engine, at a high power factor than at a low; the same generator would be capable of delivering 80 h.p. at 80 per cent. power factor, 90 h.p. at 90 per cent. power factor or 100 h.p. at 100 per cent. power factor. The regulation of the generator is also better when operating on high power factor than on low. In ordinary practice the power factor of a single motor will have but little effect on that of the generator, which may be considered as an average of that of each unit of its load.

As the power factor of induction motors decreases quite rapidly as the load diminishes and as few motors run continuously on full load, the power factor at one-half load is of considerable importance.

The starting torque is of comparatively small importance when the motor starts under light load, which is usually the case; there are, however, numerous exceptions, elevating and conveying machinery, long lines of shafting, machinery with heavy fly wheels and all other cases where a heavy pull is required to start the load. The torque is the pull in pounds exerted at the face of a pulley two feet in diameter, but it is usually more convenient to express its value as a multiple of the pull required on a pulley of any size when the motor is carrying its full load at normal speed. One and one-half times full-load torque is a figure frequently given for starting torque and proves very satisfactory in most instances, although a very heavy current will be required for starting when the actual load approaches that figure. If the load is above the specified figure the motor may refuse to start; if the load has great inertia and so requires a considerable time to be brought up to speed with the specified starting torque the motor may become very hot before full speed is attained. This difficulty may be overcome by the use of a special motor, one method being to wind the rotating part with wire of comparatively high resistance. This will increase the slip and decrease the efficiency of the motor, but as it adds but little to the expense it is quite likely to prove the best method when only a moderate increase of starting torque is desired. If this method is not sufficient, or if the increased losses are too great a drawback, a different type of winding, described below, should be employed.

The pull-out torque, expressed as a multiple of full-load torque, is the maximum that the motor can exert while running; on account of reduced speed it is slightly more than the momentary over-load that the motor can carry. When the pull-out torque is exceeded the motor will stop quite suddenly and cannot start again until the load is reduced to the value of the starting torque, which is considerably lower than the pull-out. Although the motor will heat very rapidly under a load approaching the value of pull-out torque, it is well to have this value as high as possible in order that the motor may not be brought to a standstill by the momentary application of a heavy load, such as might be occasioned by the throwing of a clutch, shifting a belt, or the momentary overloading of a machine tool. From two to three times the full-load torque is commonly specified for pull-out torque.

The heating of an induction motor is its only limitation as to load-carrying capacity up to the time that the pull-out value is reached; it can operate on such a load for a very brief period, depending upon the size of the motor, when the odor and smoke of overheated insulating material gives warning that a burn-out is to be expected. Lower loads can be carried for a longer period, and the motor should be able to carry 25 per cent. overload from 30 min. to one hour without excessive heating. Such an overload capacity is frequently included in specifications. When operated continuously on full load no part of the motor should reach a temperature of more than 50° C. above the surrounding air, although 55 degrees is sometimes allowed for the revolving part of a squirrel cage motor. If the motor is to operate in an abnormally warm location the limiting rise should be correspondingly reduced. Lower values than those mentioned are desirable, as they will generally indicate a greater overload capacity.

The "slip," usually expressed as a percentage, is the amount of reduction from no-load speed that is found when the motor is operating under full load. Like the slip of a belt, it is a direct loss of power. A motor may run at 85 per cent. efficiency on full load while the slip is 5 per cent.; if by a change in the winding the slip is increased to 10 per cent. the full-load efficiency will be reduced to 80 per cent.; as the slip is approximately proportional to the load the loss will not be so marked on lighter loads. In ordinary practice the slip varies between three and ten per cent.; for ordinary service the motor may therefore be considered to run at constant speed.

In spite of the loss in efficiency a motor with comparatively high slip is desirable for driving certain classes of machinery; those provided with heavy fly-wheels or having a reciprocating motion. The variation of speed with load will allow the fly-wheel to fulfil its function or the motion of the machine to be reversed without subjecting the motor to a heavy overload and causing violent fluctuations in the line current and voltage. In some cases it may even prevent the pull-out torque being exceeded. An increase in slip is obtained by providing the rotating part of the motor with a winding of higher resistance than would otherwise be used; which, as previously stated, also increases the starting torque. A resemblance may be noted between the induction motor with high slip and the compound wound direct-current motor; the latter, however, does not suffer the loss in efficiency mentioned above.

When an exceedingly heavy starting torque is desired, when the motor is frequently started and stopped under a moderate torque and the heavy fluctuations of current caused thereby are annoying, when a comparatively slow rate of acceleration is desired or speed regulation is to be obtained by an operator in constant attendance, the squirrel cage winding on the rotating part of the motor is replaced by an open winding, the ends of which are led to collector rings on the shaft. These rings are connected by brushes and suitable leads to a controller, the operation of which introduces a variable amount of resistance into the circuit formed between the collector rings. In the cases previously described the slip and starting torque were increased by permanently increasing the resistance of the rotating element. In the present case the resistance can be varied at the will of the operator, and may therefore be carried to a far higher value in starting than would be permissible if it were to be left permanently in circuit. Although the speed of the motor may in this way be reduced to any desired extent the operation at low speeds will be very inefficient, the slip, as previously stated, being a direct loss of power; at half speed and full-load torque the motor would have less than 50 per cent. efficiency. Also, as the slip is nearly proportional to the load or torque, a motor that is running under load at very slow speed will quickly run up to very nearly the rated speed when the load is thrown off unless the operator throws additional resistance into the circuit; conversely, a motor operating under light load at slow speed will be brought to a standstill when the load is increased unless resistance is cut out.

The clearance between the stationary and rotating parts is exceedingly small on all induction motors; a very rigid construction of shaft and bearings is therefore desirable. To increase the clearance will mean a loss of other valuable characteristics, but, other things being equal, the motor with the larger clearance is evidently to be desired. The "total air gap" is sometimes specified in place of clearance. Its value is twice that of the clearance.

SYNCHRONOUS MOTORS

The synchronous motor is seldom used except for large units. It may be constructed to operate equally well on single-phase, two-phase or three-phase circuits, the proper winding being provided in each case, but its general use is limited by the facts that there must be a supply of direct current to excite its field magnets and that in its simpler forms it is not self-starting even under no load. When its fields are properly excited and it has been brought up to its rated speed, which may be done by a small induction or direct-current motor mounted on the same shaft or in some instances by a special winding on the main motor, current may be thrown on from the main supply at the instant that synchronism is indicated by lamps or by a suitable instrument on the starting panel. If we assume that the frequency, or, in other words, the speed of the main generator remains constant, this motor will run at absolutely constant speed from no load up to a very heavy overload; when the overload becomes too great the motor will stop suddenly.

Although the above distinguishing characteristics may be valuable in some instances, a more important factor is its ability to run at almost any desired power factor. Varying the strength of the direct current exciting the field magnets, which may readily be done by an attendant while the machine is running, will cause a variation in the power factor. In this manner it can not only be raised to 100 per cent. but can be made to neutralize the effect of other apparatus having a lower power factor. Its own value can never exceed 100 per cent., but it can run on a lower power factor which may be said to act in an opposite direction from that of the ordinary induction motor and so bring the value in the main transmission line and on the generator up to 100 per cent., even when other apparatus is running at a comparatively low power factor.

In order to insure reliability, continuous service under severe working conditions, one must be guided by much the same considerations as in buying direct-current motors or any kind of electrical or mechanical apparatus. Secure a machine that is heavy enough for the work; do not try to make a 10-h.p. motor carry a 20 horse load. Although mere weight is not a criterion of excellence, from a merely mechanical standpoint one should be sure that the manufacturer has not gone too far in his efforts to save material; special attention being given to the bearings. Most important of all, buy of a firm with an established reputation, or of one in whose engineering ability, skilled workmanship and conscientiousness in the use of high-class material and turning out a first-class product one is thoroughly assured. There are possibilities of defective material and workmanship that can hardly be detected by inspection or test of the finished motor.

Cutout For Protecting Street Series Lighting Systems

Open circuits in street-lighting systems are more or less frequent and not only result in interrupted service, but are also a source of grave danger to the public. Another serious commercial feature incidental to open circuits is that where outages are penalized by the municipality such interruptions entail a loss of revenue to the central station. To meet the conditions imposed by commercial requirements, the device illustrated herewith has been developed and presents a satisfactory solution of what has been a very troublesome problem to central-station managers desiring to give the best possible street-lighting service.

CONSTRUCTION

Fig. 1 illustrates the general construction and assembly, the weather-proof cover having been removed to permit a clear view of the various elements. A control magnet provided with a movable core is so arranged as to actuate a pair of laminated-copper brushes normally held by gravity against two stationary contacts, to which the loop of lamps to be protected is connected. By means of heavy porcelain insulators the movable brushes are thoroughly insulated from each other, and in turn the stationary contacts are insulated from each other and ground.

CARBON SPARK GAP

A pair of adjustable carbons mounted on insulators form a spark gap in series with the control magnet and in shunt across the main lamp circuit. Direct connection is made between the line and one of the spark-gap carbons. The opposite carbon, in addition to its line connections, is also

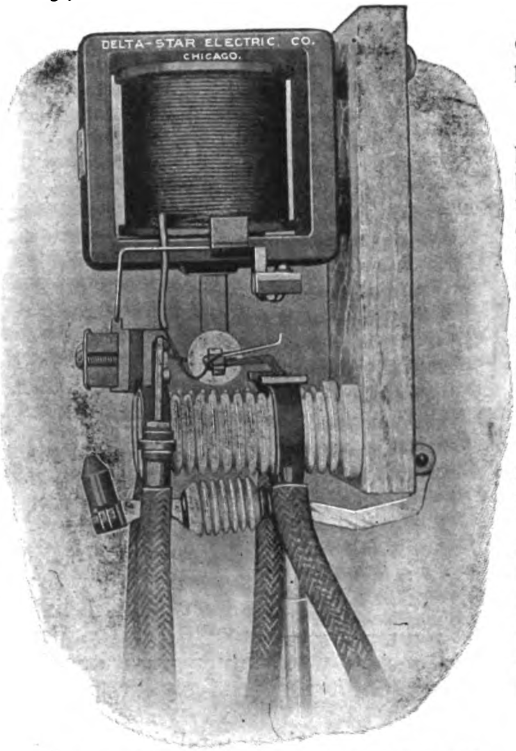


Fig. 1.—CUTOUT WITH WEATHER-PROOF CASING REMOVED

connected to an auxiliary fixed contact and a movable contact actuated by an insulated handle.

OPERATION OF CUTOUT

When a break occurs in the protected section of a circuit the full-line potential will exist between the adjacent points of the gap, the spacing of which is such that the potential will immediately break across. An instantaneous current will then flow from the generator or transformer terminal across the gap and through the control magnet. The conditions outlined above will continue but a fraction of a second, as the current flowing through the control magnet energizes a movable core, causing it to be immediately drawn up and the lamp circuit opened. The circuit is continued through the control magnet and a signal lamp, which remains lighted as long as the magnet is energized, thus giving visual indication of trouble in the protected loop.

REPAIRING BREAK

After a break in the line has been repaired, the protected lamp circuit is still dead and can only be restored by pushing up the movable carbon contact which then bridges the air gap, thus short-circuiting the control magnet. Demagnetization of the core is thus effected and the plunger falls by gravity, re-establishing the circuit.

IMPROPER REPAIRS OR SECOND BREAK

If, however, the circuit has not been properly repaired, or a second break has occurred, the arc will be re-established across the gap, the control magnet will be re-energized and the defective line again cutout. This procedure will continue until the defective circuit is properly closed, as it is impossible for other conditions to exist.

APPLICATIONS

Fig. 2 shows one of the simplest applications of the cutout which, being placed at A, protects the loop beyond it. If a break occurs as at O, the cutout will operate, disconnecting this loop entirely from the balance of the circuit, and short-circuiting the line at A, keeping the remainder of the circuit in operation. The defective loop now being dead, can be repaired and reconnected into the circuit.

Fig. 3 represents the condition which usually exists in the lighting of a long avenue or boulevard where the two legs of the circuit run parallel without loops. Let B, C and D be cutouts placed in multiple across the line. Suppose a break occurs beyond B, B will operate, disconnecting the defective portion, while maintaining the entire line up to B. If this break had occurred between C and B, C

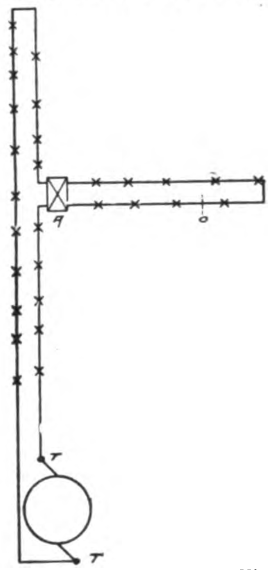


Fig. 2.—PROTECTING LOOP

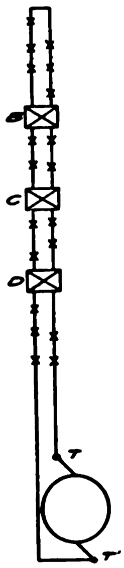


Fig. 3.—BOULEVARD LIGHTING

would have operated, cutting off everything beyond C and maintaining the circuit up to C; in the same manner had the break occurred between C and D, D would have operated. In order to obtain this action it is only necessary to adjust the spark gap of each cutout so that the gap increases in length as the cutouts approach the station. It is then evident that when a break occurs, say, beyond B, the full-line potential difference will momentarily exist across the three spark gaps; but, spark gap B being the shortest, will be broken down first, thus operating the cutout B. In the same manner should the break occur between B and C, C will operate. In this manner all parts of the circuit up to the cutout nearest the trouble will be always maintained.

Fig. 4 represents three circuits being operated from a single machine or transformer. It is the usual practice to keep the terminals of these various circuits in the station as AA¹, BB¹ and CC¹, so that, should trouble occur on any one of the lines, the defective line can be disconnected and the other two circuits kept in service, thus locating the trouble on one-third of the line and preventing the entire system from being out of service. This is frequently done at the expense of long lengths of wire, which could be dispensed with were it not for this desire to localize the trouble.

By introducing cutouts on the system, the same results may be obtained and the unnecessary wire removed, this being illustrated by Fig. 5, which shows the same three circuits equipped with cutouts D, E and F, which allow the removal of the portion of the lines A¹, B, B¹ and C from their station terminals to the points as shown, leaving at the station only the terminals A and C¹. This results in a considerable saving in wire with its line loss, station apparatus, maintenance, the eliminating of possible trouble on the portion of the line removed, the making of room on the poles for other wires, and at the same time having better protection than when these lines were running to the station, plus the protection afforded by other cutouts which might be placed upon the system.

COMMERCIAL ADVANTAGES

A few of the commercial advantages of the new method of protecting high-tension lighting circuits may be summarized as follows: Prevention

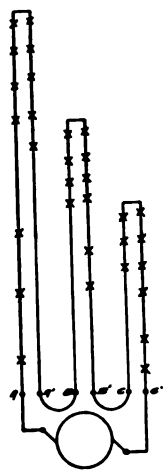


Fig. 4.—USUAL DROP METHOD

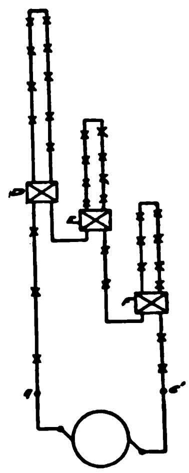
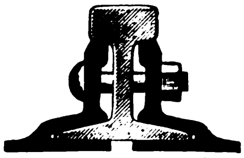
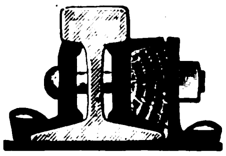


Fig. 5.—WIRE-SAVING METHOD

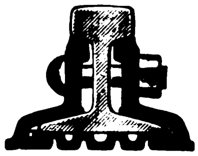
of outages and accidents, automatic location of faults, automatic disconnection of ruptured circuits facilitates quick and safe repairs to line, does not interrupt working parts of circuit, reduces number of circuits, effects considerable saving in wire, reduces number of station regulators and switchboards, enables use of longer lamp circuits, reduces legal claims. The apparatus described above is manufactured and designed by the Delta-Star Electric Co., Chicago, Ill.



CONTINUOUS JOINT

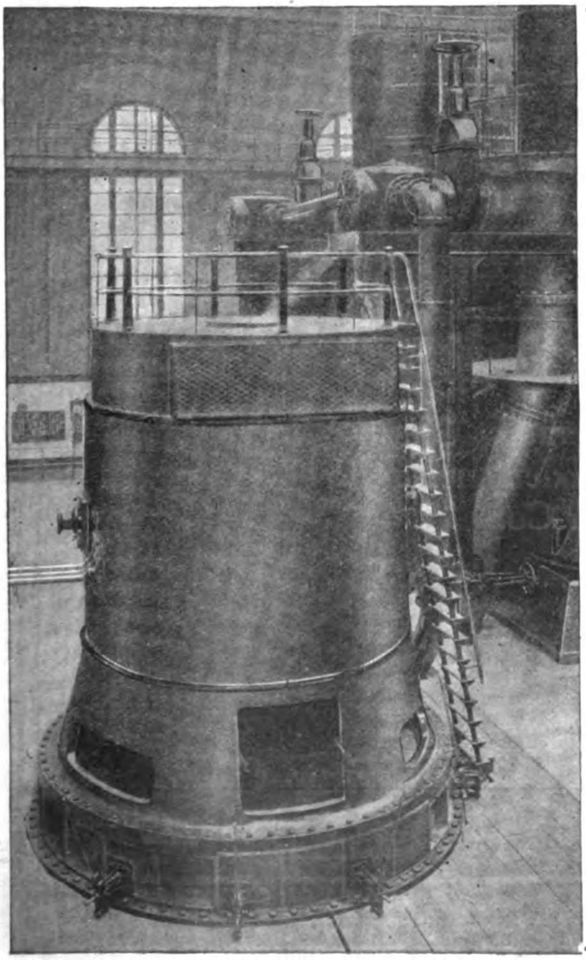


WEBER JOINT



WOLHAUPTER JOINT

CONTINUOUS GIRDER



Classified Directory of Manufacturers

ADJUSTERS
Morse, Frank W., Boston, Mass.

AIR AND GAS COMPRESSORS
Allis-Chalmers Co., Milwaukee.
American Air Compressor Works, N. Y.
Blake Mfg. Co., Geo. F., New York.
Chicago Pneumatic Tool Co., Chicago.
Clayton Air Compressor Works, N. Y.
Curtis & Co., Mfg. Co., St. Louis.
Dean Bros. Steam Pump Wks., Indianapolis.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Hall Steam Pump Co., Pittsburg.
Ingersoll-Rand Co., New York.
Knowles Steam Pump Works, New York
Laidlaw-Dunn-Gordon Co., New York.
McGowan Co., John H., Cincinnati.
National Brake & Elec. Co., Milwaukee
Norwalk Iron Works, Norwalk, Conn
Platt Iron Works Co., Dayton
Providence Engine Works, Providence
Snow Steam Pump Works, New York
Sullivan Machinery Co., Chicago.
Worthington, Henry R., New York.

ALTERNATORS
Allis-Chalmers Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Elec. Works, Indianapolis.
General Electric Co., Schenectady, N. Y
National Brake & Elec. Co., Milwaukee
Wesco Supply Co., St. Louis
Western Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg

ANCHORS (GUY)
Holden Anchor Co., Des Moines, Ia.
Matthews & Bro., W. N., St. Louis, Mo

ANNUNCIATORS
Central Electric Co., Chicago, Ill.
Doubleday-Hill Electric Co., Pittsburg
Electric Appliance Co., Chicago.
Haines, J. Allen, Inc., Chicago.
Manhattan Elec. Supply Co., New York
Ostrander & Co., W. R., Chicago.
Van Dorn-Elliott Elec. Co., Cleveland.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.

ATTACHMENT PLUGS
Hubbell, Harvey, Bridgeport, Conn.

BATTERIES—PRIMARY
Bunnell & Co., J. H., New York.
Burnley Battery & Mfg. Co., Painesville Ohio.
Central Electric Co., Chicago
Doubleday-Hill Elec. Co., Pittsburg.
Eastern Carbon Works, Jersey City, N. J.
Edison Mfg. Co., New York.
Elec. Motor & Equipment Co., Newark N. J
French Battery Co., Madison, Wis.
Gordon Battery Co. New York.
Lawrence Elec. Co., F. D., Cincinnati, O.
Leclanche Battery Co., New York.
Manhattan Electrical Supply Co., Chicago.
Waterbury Battery Co., Waterbury, Conn.
Wesco Supply Co., St. Louis, Mo
Western Electric Co., Chicago.

BATTERIES—STORAGE
American Battery Co., Chicago.
Doubleday-Hill Electric Co., Pittsburg.
Electric Storage Battery Co. Philadelphia.
General Storage Battery Co., New York.
Gould Storage Battery Co., New York
National Battery Co., Buffalo, N. Y.
Railway Safety Service Co., Springfield, Mass.
Universal Electric Storage Battery Co., Chicago.
Willard Storage Battery Co., Cleveland.

Classified Directory of Manufacturers—*Cont'd*

ELLS
- Central Electric Co., Chicago.
- Manhattan Electrical Supply Co., New York and Chicago.
- Ostrander & Co., W. R., New York
- Wesco Supply Co., St. Louis.
- Western Electric Co., Chicago.

BELT DRESSING
- Cling Surface Mfg. Co., Buffalo
- Dixon Crucible Co., Jos., Jersey City, N. J.

BELTING
- Boston Belting Co., Boston.
- Eureka Fire Hose Co., New York
- Jeffrey Mfg. Co., Columbus, O.
- Link-Belt Engineering Co., Philadelphia.
- Pittsburg Gage & Supply Co., Pittsburg.
- Robins Conveying Belt Co. New York

BLOWERS
- Allis-Chalmers Co., Milwaukee.
- American Blower Co., Detroit.
- American Gas Furnace Co., New York.
- Buffalo Forge Co., Buffalo.
- Chicago Flexible Shaft Co., Chicago.
- Crocker-Wheeler Co., Ampere, N. J.
- Dean Bros. Steam Pump Works, Indianapolis.
- Green Fuel Economizer Co., Matteawan, N. Y.
- Platt Iron Works, Dayton, O.
- Smith, J D., Fdy. Supply Co., Cleveland.
- Sprague Electric Co., New York.
- Sturtevant Co., B. F., Hyde Park, Mass.

BLUE PRINT MACHINERY
- Buckeye Engine Co., Salem, O.
- Keuffel & Esser Co., New York.
- Kolesch & Co., New York
- Resolute Machine Co., New York
- Wagenhorst & Co., J. H., Pittsburg.

BOILERS
- Atlantic Works, East Boston, Mass.
- Babcock & Wilcox Co., New York.
- Harrison Safety Boiler Works, Phila
- Heine Safety Boiler Co., St. Louis.
- Platt Iron Works, Dayton, O.
- Riter-Conley Mfg. Co., Pittsburg
- Robb-Mumford Boiler Co., South Framingham, Mass.
- Struthers-Wells Co., Warren, Pa.
- Walsh's Holyoke Steam Boiler Co., Holyoke, Mass.
- Wetherill & Co., Robt., Chester, Pa.

BOXES—JUNCTION
- Bossert Electric Construction Co., Utica.
- D. & W. Fuse Co., Providence. R. I.
- Steel City Electric Co., Pittsburgh

BOXES—OUTLET
- Bossert Electric Const. Co., Utica, N. Y.
- Steel City Electric Co., Pittsburgh

BRUSHES—CARBON
- Central Electric Co., Chicago.
- Eastern Carbon Works, Jersey City, N. J.
- Holmes Fibre-Graphite Mfg. Co., Germantown, Pa.
- Le Valley Carbon Brush Co., New York.
- National Carbon Co., Cleveland.
- Speer Carbon Co., St. Mary's, Pa.
- Western Electric Co., Chicago.

BUSHINGS-OUTLET
- Steel City Electric Co., Pittsburgh

CABLE HANGERS
- Barron & Co., Jas. S., New York.
- Bissell Co., F., Toledo, O.
- Standard Underground Cable Co., Pittsburg.
- Steel City Electric Co., Pittsburg.
- Wesco Supply Co., St. Louis, Mo
- Western Electric Co., Chicago.

CABLE JOINTS
- Dossert & Co., Inc., New York

CARBONS
- Central Electric Co., Chicago.
- Eastern Carbon Works, Jersey City, N. J.
- National Carbon Co., Cleveland.
- Reisinger, Hugo, New York.
- Speer Carbon Co., St. Marys, Pa.
- Wesco Supply Co., St. Louis.

CASTINGS
- American Steel Foundries, Chicago.
- Alton Machine Co., New York.

Classified Directory of Manufacturers—*Cont'd*

- Lunkenheimer Co. Cincinnati.
- New England Butt Co., Providence, R. I.
- Phosphor-Bronze Smelting Co., Ltd., Philadelphia.

CHAINS FOR ARC LAMPS
- Oneida Community, Ltd., Oneida, N. Y

CIRCUIT BREAKERS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Cutter Electrical Mfg. Co., Philadelphia.
- Doubleday-Hill Electric Co., Pittsburg.
- Fort Wayne Electric Works, Fort Wayne, Indiana
- General Electric Co., Schenectady, N. Y.
- Hartman Circuit Breaker Co., Mansfield, Ohio.
- La Roche Co., F. A., New York.
- Sundh Electric Co., New York.
- Switchboard Equip. Co., Bethlehem, Pa.
- Ward Leonard Electric Co., Bronxville, N. Y.
- Wesco Supply Co., St. Louis
- Western Electric Co., Chicago.
- Westinghouse Electric & Mfg. Co. Pittsburg.

CLAMPS—CABLE
- Matthews, W. N., & Bros., St. Louis.

CLEATS
- Blake Signal & Mfg. Co., Boston, Mass.
- Imperial Porcelain Works, Trenton, N. J
- Pass & Seymour, Inc., Solvay, N. Y.
- Sears, Henry D., Boston.

CLIMBERS
- Klein & Co., Mathias, Chicago.

CLUSTERS
- Benjamin Elec. Mfg. Co., Chicago
- Hubbel, Harvey, Bridgeport, Conn.

COAL AND ASH-HANDLING MACHINERY
- Brown Hoisting Machinery Co. land
- Case Mfg. Co., Columbus, O.
- Hunt Co., C. W., New York.
- Jeffrey Mfg. Co., Columbus, O.
- Link Belt Co., Philadelphia.
- Mead-Morrison Mfg. Co., Boston.
- Northern Engineering Works, Detroit
- Robins Conveying Belt Co., New York.

COILS—INDUCTION
- Ostrander, W. R., & Co., New York.
- Splitdorf, C. F., New York.

COMMUTATOR LUBRICANT
- Allen & Co., L. B., Chicago.
- Dixon Crucible Co., Jos., Jersey City.

COMMUTATORS
- Homer Commutator Co., Cleveland, O.

CONDENSERS—ELECTRIC
- Marshall, William, New York.

CONDUIT RODS
- Barron & Co., Jas. S., New York.
- Cope, T. J., Philadelphia.
- Doubleday-Hill Electric Co., Pittsburg

CONDUITS
- American Circular Loom Co., Chelsea, Mass.
- The Gillette-Vibber Co., New London, Conn.
- American Conduit Co., Chicago.
- American Vitrified Conduit Co., N. Y.
- Camp Co., H. B., New York.
- Doubleday-Hill Electric Co., Pittsburg.
- Gest, G. M., New York.
- National Conduit & Cable Co., N. Y.
- National Metal Molding Co., Pittsburg
- Orangeburg Fibre Conduit Co., Orangeburg, N. Y
- Sprague Electric Co., New York.

CONDUIT FITTINGS
- Steel City Electric Co., Pittsburgh

CONDUIT REAMERS
- Steel City Electric Co., Pittsburg.

CONDUIT TOOLS
- Cope, T. J., Philadelphia.
- Steel City Electric Co., Pittsburg.

CONTROLLERS
- Allis-Chalmers Co., Milwaukee.
- Case Mfg. Co., Columbus, O.
- Crocker-Wheeler Co., Ampere, N. J.
- Cutler-Hammer Mfg. Co., Milwaukee.
- Elec. Controller & Supply Co., Cleveland

Classified Directory of Manufacturers—Cont'd

N. Y. Electric Controller Co., New York.
Simplex Electric Heating Co., Cambridge, Mass.

COPPER CASTINGS
Anderson Mfg. Co., A. & J. M., Boston.
Ward-Leonard Co., Bronxville, N. Y.

CRANES
Northern Engineering Works, Detroit.

CROSS ARMS
Locke Insulator Mfg. Co., Victor, N. Y.

CUT-OUTS AND SWITCHES
Bissell Co., The F., Toledo, O.
Bossert Electric Const. Co., Utica, N. Y.
Central Electric Co., Chicago.
Crouse-Hinds Co., Syracuse, N. Y.
Cutter Elec. & Mfg. Co., Philadelphia.
Ft. Wayne Elec. Wks., Inc., Fort Wayne.
General Electric Co., Schenectady, N. Y.
Hart Mfg. Co., Hartford, Conn.
Manhattan Elec. Supply Co., New York.
Sorenson, P., Brooklyn.
Switchboard Equip. Co., Bethlehem, Pa.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

DIRECT MOTOR DRIVE FOR PLANERS
The Electric Controller & Supply Co., Cleveland.

DRILLS
Morse Twist Drill & Machine Co., New Bedford, Mass

DRYING MACHINERY
Aiton Machine Co., New York.
Buffalo Foundry & Machine Co., Buffalo.
Devine Co., J. P., Buffalo.
Sturtevant Co., B. F., Boston

DYNAMOS AND MOTORS
Allis-Chalmers Co., Milwaukee.
American Engine Co., Bound Brook, N J.
Bogue Electric Co., C. J., New York.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Central Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Electric Co., Pittsburg.
Eck Dynamo & Motor Wks., Belleville, N. J.
Electro-Dynamic Co., Bayonne, N. J.
Elwell-Parker Electric Co., Cleveland.
Emerson Electric Mfg. Co., St. Louis.
Fort Wayne Electric Works, Fort Wayne.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
National Brake & Elec. Co., Milwaukee
New England Motor Co., Lowell, Mass.
Ridgway Dynamo & Motor Co., Ridgway, Pa.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Boston.
Triumph Electric Co., Cincinnati.
Wagner Electric Mfg. Co., St. Louis.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

ELECTRIC RAILWAY SUPPLIES
Railway Safety Service Co., Springfield, Mass.

ELECTROMAGNETS
Acme Wire Co., New Haven, Conn
Schureman, J. L., Co., Chicago.
Splitdorf, C. F., New York.

ELEVATORS
American Tool & Machine Co., Boston
Caldwell & Son Co., H. W., Chicago.
Jeffrey Mfg. Co., Columbus.
Link Belt Eng'g Co., Philadelphia.
Obermayer Co., S., Cincinnati.
Otis Elevator Co., N. Y.
Poole Eng'g Mch. Co., Baltimore.

ENGINEERING CONSTRUCTION
Elm City Engineering Co., New Haven, Conn.

The Institute of Operating Engineers

At a meeting held in New York City on March 10th, the organization of The Institute of Operating Engineers was decided upon. A temporary executive committee was chosen to arrange for a far-reaching and vigorous campaign in behalf of the principles and purposes of the Institute, which are, briefly:

To unite in one vocational organization all those who are vitally interested in operating engineering.

To make possible practical co-operation between the engine-room and the school-room to the extent that ultimately the Institute may become a model vocational college.

Mr. W. Rice is secretary and the headquarters of the new society are in the Engineering Societies' Building, New York.

Westinghouse Turbine Sales

Taking advantage of the opportunity offered by the low-pressure steam turbine when used in connection with the exhaust of other prime movers for increasing plant output without requiring additional boiler capacity, the Baldwin Locomotive Company is installing three 500-kw. low-pressure units at its Philadelphia works.

At Missouri Valley, Iowa, the Missouri Valley Electric Light Company has just installed a 500-kw. Westinghouse turbine generator set for furnishing local light and power.

The first 1000-kw. high-pressure turbine generator unit in the new 5000-kw. power plant of the Pillsbury Flour Mills Company, Minneapolis, Minn., has been contracted for with the Westinghouse Machine Company, East Pittsburg, Pa.

The Edison Storage Battery Company, of Orange, N. J., is having a rush of orders for their new battery, and large volumes of business are reported by the Electric Storage Battery Company, of Philadelphia.

The Arkansas Association of Public Utility Operators held its third annual convention at Pine Bluff, Ark., April 27-29. About fifty members were present.

Classified Directory of Manufacturers—Cont'd

ENGINES—GAS AND GASOLINE
- Allis-Chalmers Co., Milwaukee.
- Buckeye Engine Co., Salem, O.
- Carlisle & Finch Co., Cincinnati, O.
- De La Vergne Machine Co., New York.
- Elbridge Engine Co., Rochester, N. Y.
- Marine Engine & Machine Co., N. Y.
- Mietz, A., N. Y.
- Otto Gas Engine Works, Philadelphia.
- Power & Mining Machinery Co., Cudahy, Wis.
- Westinghouse Machine Co., Pittsburg.
- Wood & Co., R. D., Philadelphia.

ENGINES—STEAM
- Allis-Chalmers Co., Milwaukee.
- American Blower Co, Detroit.
- Am. Engine Co., Bound Brook, N. J.
- Ball Engine Co. Erie, Pa.
- Blake Mfg. Co., Geo F., New York.
- Buckeye Engine Co., Salem, O.
- Buffalo Forge Co., Buffalo.
- Frick Co., Waynesboro, Pa.
- Hooven, Owens, Rentschler Co., Hamilton, Ohio.
- Mecklenburg Iron Wks., Charlotte, N. C.
- Providence Eng'g Works, Providence.
- Shepherd Eng'g Co., Franklin, Pa.
- Southwark Fdy. & Mch. Co., Philadelphia.
- Struthers-Wells Co., Warren, Pa.
- Sturtevant Co., B. F., Hyde Park, Mass
- Watertown Eng. Co., Watertown, N. Y
- Westinghouse Machine Co., Pittsburg.
- Wetherill, Robert & Co., Chester, Pa.

EXHAUST HEADS
- American Spiral Pipe Works, Chicago.
- Direct Separator Co., Syracuse.
- Hoppes Mfg. Co., Springfield, O.
- Pittsburg Gage & Supply Co., Pittsburg
- Sturtevant Co., B. F., Hyde Park, Mass
- Watson & McDaniel Co., Philadelphia.
- Wright Mfg. Co. Detroit.

FANS AND MOTORS
- Century Electric Co., St. Louis.
- Diehl Mfg. Co., Elizabethport, N. J.
- Doubleday-Hill Elec. Co., Pittsburg.
- Eck Dynamo & Motor Wks, Belleville, N. J.
- Elec. Motor & Equip. Co., Newark, N. J
- Emerson Electric Mfg. Co., St. Louis.
- Ft. Wayne Elec. Works, Ft. Wayne, Ind
- General Electric Co., Schenectady, N. Y
- Robbins & Myers Co., Springfield, O.
- Sprague Electric Co., New York.
- Wesco Supply Co., St. Louis.
- Western Electric Co. Chicago
- Westinghouse Elec. & Mfg. Co., Pittsburg.

FANS—EXHAUST AND VENTILATING
- Allen Electric Co., Chicago.
- Century Electric Co., St. Louis.
- Crocker-Wheeler Co., Ampere, N. J.
- Diehl Mfg. Co., Elizabethport, N. J.
- Emerson Elec. Mfg. Co., St. Louis.
- Green Fuel Economizer Co., Matteawan
- Sprague Electric Co., New York.
- Sturtevant Co., B. F., Boston.
- Western Electric Co., Chicago.

FIXTURES—GAS AND ELECTRIC
- Benjamin Elec. Mfg. Co., Chicago.
- Cleveland Gas & Fixture Co., Cleveland
- Gail-Webb Mfg. Co., Buffalo
- Goodwin & Kintz, Winsted, Conn
- Wells Light Mfg. Co., New York

FLASHERS
- Advertising Mirrograph Co., Brooklyn
- Campbell Electric Co., Lynn, Mass.
- Elec. Motor & Equip. Co., Newark, N. J
- Haller Machine Co., Chicago.
- Reynolds Elec. Flasher Mfg. Co., Chicago

FLEXIBLE SHAFTS
- Chicago Flexible Shaft Co., Chicago.
- Stow Flexible Shaft Co., Philadelphia
- Stow Mfg. Co., Binghamton, N. Y

FRICTION TAPE AND CLOTHS
- Massachusetts Chemical Co.

FUSES
- Arknot Co., Hartford, Conn.
- Chase-Shawmut Co.
- Chicago Fuse Wire & Mfg. Co.
- D. & W. Fuse, Providence, R. I.
- Johns-Manville Co., H. W., New York

Classified Directory of Manufacturers—*Cont'd*

GAS ENGINE SPECIALTIES
Lunkenheimer Co.

GAUGES—PRESSURE, STEAM, WATER
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston.
Bristol Co., Waterbury, Co., Conn.
Hohmann & Maurer Mfg. Co., Rochester.
Manning, Maxwell & Moore, New York.
Pittsburg, Gauge & Supply Co., Pittsburg.
Star Brass Mfg. Co., Boston.
Walworth Mfg. Co., Boston.

GEARS
New Process., Rawhide. Co.
Nuttal Co., R. D. Pittsburg

GERMAN SILVER
Seymour Mfg. Co Seymour, Conn

GLASS
Phoenix Glass Co., New York.

GLOBES, SHADES, ETC.
Holophane Glass Co., New York.
Phoenix Glass Co., New York.

GRAPHITE
Dixon Cruc. Co., Jos., Jersey City, N. J.

GUARDS—INC. LAMPS
Gail-Webb Mfg. Co., Buffalo.
Hubbell, Harvey, Bridgeport
Matthews & Bro., W. N., St. Louis.

HANGER BOARDS
Ft. Wayne Elec. Works, Ft. Wayne, Ind.

HANGERS—CABLE
Chase-Shawmut Co., Newburyport, Mass.
Standard Underground Cable Co., Pittsburg.

HEATING DEVICES, ELECTRIC
American Elec'l Heater Co., Detroit.
Barr Elec. Mfg. Co., W. J., Cleveland.
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Electric Heating Co., Chicago.

HEATING—EXHAUST STEAM
Am. District Steam Co., Lockport, N. Y
Diamond State Fibre Co., Elsemere, Del.
Mica Insulator Co New York.

HOISTS AND CONVEYORS
Hunt, C. W., Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Northern Engineering Works, Detroit.

HYDRAULIC MACHINERY
Dayton Globe Iron Works Co., Dayton.
Dean Bros. Steam Pump Wks., Indianapolis.
Leffel & Co., James, Springfield, O.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co., Dayton, O.
Risdon-Alcott Turbine Co., Mount Holly, N. J.
Smith Co., S. Morgan, York, Pa.

IMPREGNATING APPARATUS
Buffalo Foundry & Machine Co., Buffalo
Devine Co., J. P., Buffalo.
Hubbard's Sons, Norman, Brooklyn.

INDICATORS
American Steam Gauge & Valve Mfg Co.

INSTRUMENTS—ELECTRICAL
American Instrument Co., Philadelphia
Atwater Kent Mfg. Co., Philadelphia.
Baillard, E. V., New York.
Biddle, James G., Philadelphia.
Bristol Co., Waterbury, Conn.
Clark Electric Meter Co., Chicago.
Connecticut Telephone & Electric Co., Meriden, Conn.
Cutter Elec. & Mfg. Co., Philadelphia.
Dongan Instrument Co., Albany, N. Y.
Duncan Elec. Mfg. Co., Lafayette, Ind.
Eldredge Elec. Mfg. Co., Springfield, Mass.
Foote-Pierson & Co., New York.
Fort Wayne Electric Works, Ft. Wayne Ind.
General Electric Co., Schenectady.
Keystone Elec. Instrument Co., Phila
Leeds & Northrup, Philadelphia.
Machado & Roller, New York.
Pignolet, Louis M., New York.
Queen & Co., Philadelphia.
Robert Instrument Co., Detroit.
Sangamo Electric Co., Springfield, Ill.

Convention of Inventors

The International Congress of Inventors, the first great association of inventors, which was founded in 1906, will hold its first National Convention, accompanied by an exhibition at Rochester, N. Y., June 13th, to 18th.

The objects of this organization, as stated in its constitution, are as follows:

"To endeavor to establish a standing for a United States patent independent of any court action.

To procure legislation or action by the Federal or State governments when needed.

To reform abuses and secure freedom from unlawful and unjust exactions.

To promote intercourse among the members of this association for their mutual interests.

To maintain headquarters under the personal charge of the secretary who shall attend to the correspondence, procure data for use of the members, build up a library, direct members to sources of advice on all matters pertaining to patents, collect statistics generally and specifically for the use of the members; keep on file the records of the patent office, bulletins and periodicals relating to patents.

To present the solid front of a strong international organization whenever necessary to assert the rights of members collectively or individually.

To acquaint the members with what is going on throughout the world in the great fields of industry, all of which are dependent on the brain of the inventor.

To give advice to an inventor who is a member of the congress, who may be in need of it as to the procedure which could be most advantageous to him, and to employ able legal talent whenever it may be necessary to defend the interests of the association.

To keep always in mind the mutual advantages of organization and break down the barriers which have too long kept inventors apart and at the mercy of those corporations and others who, for but a small consideration, would take from an inventor that which is often of great value, and that simply because the inventor lacked the protection which organization would give; always remembering that in this association there shall ever be the fullest freedom for individual action on the part of a member with regard to his own invention and patent business entirely independent of his connection with this association and that the secrecy surrounding his invention shall in no way be affected."

Book Review

"Hydroelectric Developments and Engineering," by F. Koester. D. Van Nostrand Company, New York. Cloth; 454 pages; illustrated; 7½ by 10¼ in. Price $5.00.

This work may be termed a full-length portrait of the hydroelectric industry at the present time. It is mainly historical and descriptive, and its information has been drawn from a bewildering number of sources, both domestic and foreign. Divided into three parts, treating respectively of the transformation of water-power into electrical energy, the transmis-

[*Continued on page* 22.]

Classified Directory of Manufacturers—*Cont'd*
Schaeffer & Budenberg, New York
Simplex Co., Newark, N. J.
Wagner Electric Mfg. Co., St. Louis.
Westinghouse Elec. & Mfg. Co., Pittsburg
Weston Elec. Instr. Co., Newark, N. J.
Whitney Elec'l Instr. Co., New York.

INSULATING MACHINERY
Aiton Machine Co., New York.
New England Butt Co., Providence, R. I

INSULATING MATERIAL COMPOUNDS—CLOTH AND PAPER
Anderson Mfg. Co., A. & J. M., Boston.
Johns-Manville Co. H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—COMPOUNDS PAINTS AND VARNISHES
Macon-Evans Varnish Co., Pittsburg.
Massachusetts Chem. Co., Walpole, Mass.
Standard Paint Co., New York.
Sterling Varnish Co., Pittsburg.

INSULATING MATERIAL—FIBRE
Am. Vulcanized Fibre Co., Wilmington.
Diamond State Fibre Co., Elsmere, Del
Kartavert Mfg. Co., Wilmington, Del.
Morris Elec. Co., Wilmington, Del.
United Indurated Fibre Spec. Co., Lockport, N. Y
Wilmington Fibre Spec. Co., Wilmington.

INSULATING MATERIAL—LAVA
American Lava Co., Chattanooga. Tenn
Kruesi, P. J., Chattanooga.
Steward Mfg. Co., D. M., Chattanooga

INSULATING MATERIAL—MICA
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago

INSULATING MATERIAL—PORCELAIN
Imperial Porcelain Works, Trenton, N. J
Locke Insulator Mfg. Co., Victor, N. Y
National Porcelain Co., Trenton, N. J.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATING MATERIAL—TAPE
Amer. Electrical Wks., Philipsdale, R. I
Massachusetts Chem. Co., Walpole, Mass
Morgan & Wright, Detroit
New York Insulated Wire Co., N. Y.
Okonite Co., Ltd., New York
Schott, W. H., Chicago.
Standard Underground Cable Co., Pittsburg.

INSULATORS—GLASS
Hemingway Glass Co., Louisville
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.

INSULATORS—PORCELAIN AND COMPOSITION
Anderson Mfg. Co., A. & J. M., Boston
Imperial Porcelain Works, Trenton, N. J
Johns-Manville Co., H. W., New York
Locke Insulator Mfg. Co., Victor, N. Y
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O

INSULATOR SUPPORTS
Steel City Electric Co., Pittsburgh

JACKS
Watson-Stillman Co., New York.
Henderer's Sons, A. L., Wilmington, Del.

JUNCTION BOXES
Standard Underground Cable Co., Pittsburg, Pa.
Bossert Elec. Const. Co., Utica, N. Y

KNIFE SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

LAMPS—ARC
Adams-Bagnall Elec. Co., Cleveland.
Am. Arc Lamp Co., Kalamazoo, Mich.
Anderson Mfg. Co., A. & J. M., Boston.
Beck Flaming Lamp Co., New York.
Excello Arc Lamp Co., New York.
Ft. Wayne Electric Works, Ft. Wayne.
General Electric Co., Schenectady.
Hamburger, Felix, New York.
Helios Mfg. Co., Philadelphia.
Marquette Elec. Mfg. Co., Chicago.
Tearing Co., C. J., Philadelphia.
Warner Arc Lamp Co., Muncie, Ind

Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LAMPS—INCANDESCENT
American Electric Lamp Co., Phila., Pa.
Banner Electric Co., Youngstown, O.
Bay State Lamp Co., Danvers, Mass
Boston Incandescent Lamp Co., Danvers, Mass.
Brilliant Electric Lamp Co., Cleveland.
Bryan-Marsh Co., New York.
Buckeye Electric Co., Cleveland.
Columbia Inc. Lamp Co., St. Louis.
Economy Electric Co., Warren.
Edison Dec. & Min. Lamp Co., Harrison, N. J
General Electric Co., Harrison, N. J.
New York & Ohio Co., Warren.
Novelty Incandescent Lamp Co., Emporium, Pa.
Rooney Elec. Lamp Co., New York.
Shelby Electric Co., Shelby, O.
Stuart Howland Co., Boston.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LIGHTNING ARRESTERS
Anderson Mfg. Co., A. & J. M., Boston.
D. & W. Fuse Co., Providence, R. I.
Electric Service Supplies Co., Phila
Lord Electric Co., New York.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LINE MATERIAL
Anderson Mfg Co A. & J. M., Boston.

LOCKERS
Edward Darby & Sons Co., Philadelphia
Merritt & Co., Philadelphia.

LOCOMOTIVES—INDUSTRIAL
Goodman & Co., Chicago

sion of electrical energy, and modern European and American hydroelectric developments, it takes up each feature in a brief but clear manner, presenting the fundamental principles, and then giving illustrations in practice. This is done throughout the first two parts of the work, after which the third part is devoted to descriptions of representative plants in the United States, Mexico and Europe. The volume is attractively gotten up and splendidly illustrated with more than 500 maps, charts and tables of all parts of a water-power plant and transmission and complete plants. The book should be a great convenience to all who are interested in the subject to which it pertains.

The Electric Service Supplies Company, Philadelphia, has issued a booklet outlining the merits of Garton-Daniels lightning arresters, with particular reference to their use in alternating-current service.

Classified Directory of Manufacturers—Cont'd.

Jeffrey Mfg. Co., Columbus, O
Porter Co., H. K., Pittsburg.
Vulcan Iron Works, Wilkesbarre, Pa

LUBRICANTS
Dixon Cruc. Co., Jos., Jersey City, N J

MAGNET WIRE
Acme Wire Co., New Haven, Conn.
Griffin, Frank B., Oshkosh, Wis.
Roebling & Sons, Trenton, N. J.
Seymons Mfg. Co., Seymons, Conn

MALLEABLE CASTINGS
Jeffrey Mfg. Co., Columbus, O.

METAL POLISH
Hoffman, George W., Indianapolis, Ind.

METALS
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

MICA—(See Insulating Material.)

MINING MACHINERY
Allis-Chalmers Co., Milwaukee
Dean Bros. Steam Pump Wks., Indianapolis.
General Electric Co., Schenectady, N. Y
Jeffrey Mfg. Co., Columbus, O.
Power & Mining Machinery Co., Cudahy.

PINS—STEEL
Locke Insulator Mfg. Co., Victor, N. Y

PLATINUM
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

PLUGS
Dickinson Mfg. Co., Springfield, Mass.
Freeman Elec. Co., E. H., Trenton, N. J
General Mfg. & Sup. Co., Trenton, N J
Paiste Co., H. T., Philadelphia.

PLUGS—ATTACHMENT
Hubbell Harvey, Bridgeport, Conn.

POLES—ARC LAMP
Mott Iron Works, J. L., New York

POLES, BRACKETS, PINS, ETC.
Bissell Co., F., Toledo, O.
Cresap Co., The, Bristol, Tenn.
Humbird Lumber Co., Sandpoint, Ida.
Kellogg Switchboard & Sup. Co. Chicago.
Sand Point Cedar Co., Sandpoint, Ida.
Southern Exchange Co., New York.
Worcester Co., C. H., Chicago

PORCELAIN—(See Insulating Machinery).

POWER TRANSMISSION MACHINERY
Case Mfg. Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Phila., Pa
Mead-Morrison Mfg. Co., Boston, Mass
Robins Conveying Belt Co., New York.

DRESSES, DIES AND SPECIAL MACHINERY
Watson-Stillman Co., New York.

PULLEYS
Rockwood Mfg. Co., Indianapolis, Ind.

PUMPS—ELECTRIC
Allen Electric Co., Chicago, Ill.
Allis-Chalmers Co., Milwaukee, Wis.
Conover Condenser Co., Paterson, N. J.
Dean Bros Steam Pump Wks., Indianapolis.

PUMPS—STEAM
Dean Bros. Steam Pump Wks., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Platt Iron Works Co., Dayton, O.
Quimby, Wm. E., New York.
Watson Machine Co., Paterson, N. J.
Worthington, H. R., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Deming Co., Salem, O.
Morris Company, I. P., Philadelphia, Pa
Platt Iron Works Co., Dayton, O.

PUMPS—VACUUM
Alberger Condenser Co., New York.
Dean Bros. Steam Pump Wks., Indianapolis.
Hubbard's Sons, Norman, Bklyn., N. Y.
Platt Iron Works Co., Dayton, O.

Classified Directory of Manufacturers—Cont'd

PUSH BUTTONS
Dunbar Bros., Bristol, Conn.
Sarco Company, New York.

RAIL-BONDS
Chase-Shawmut Co., Newburyport, Mass
Lord Electric Co., New York.
Roebling's Sons Co., J. A., Trenton, N. J

RECEPTACLES
Benjamin Electric Mfg. Co., Chicago, Ill.
Freeman Elec. Co., E. H., Trenton, N. J
Paiste Co., H. T., Philadelphia, Pa.

RECORDING INSTRUMENTS
Bristol Co., Waterbury, Conn
Bristol, Wm. H., New York.

REFLECTORS
Frink, I. P., New York.
Goodwin & Kintz, Winsted, Conn.
National X Ray Reflector Co., Chicago. Ill.
Phoenix Glass Co., New York.

REPAIRING
Gregory Electric Co., Chicago, Ill.
Heck, Louis, Newark, N. J.
Van Dorn-Elliott Electric Co., Cleveland, Ohio.
Ward, Leonard Electric Co., Bronxville, N. Y.

RESISTANCE UNITS
Cutler-Hammer Mfg. Co., Milwaukee.
Simplex Electric Heating Co., Cambridge, Mass.

RHEOSTATS
Automatic Electric Co., Chicago, Ill
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman & Co., J. L., Chicago, Ill.
Sundh Electric Co., New York.
Ward Leonard Electric Co., Bronxville, N. Y.

ROSETTES
General Mfg. & Supply Co., Trenton
Hart Mfg. Co., Hartford, Conn.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Inc., Solvay, N. Y
Sears, Henry D., Boston, Mass
Trumbull Elec. Mfg. Co., Plainville, Conn.

RUBBER MACHINERY
Aiton Machine Co., New York.

SEARCHLIGHTS
Bogue Elec. Co., C. J., New York.
Carlisle & Finch Co., Cincinnati, O.

SECOND-HAND APPARATUS
Bender, George, New York.
Chicago House Wrecking Co., Chicago.
Dustin Co., Chas. E., New York.
Gas & Electric Development Co., N. Y.
Gregory Electric Co., Chicago, Ill.
Linder, H. J., New York.
Richter, Eugene, Philadelphia, Pa.
Station Equipment Co., Chicago, Ill.
Thompson, Joseph H., Jr., New York.
Toomey, Frank, Philadelphia, Pa.
Yearsley & Levene, Philadelphia, Pa.

SHADE HOLDERS
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SHADES
Holophane Co., New York.
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.

SIGNS—ELECTRIC
A. & W. Sign Co., Cleveland, O.
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C., Parkersburg. W. Va.
Metropolitan Engineering Co., N. Y.
Reynolds Elec. Flasher Mfg. Co., Chicago, Ill.

SIGN LETTERS
Day & Night Sign Co., Easton. Pa.
Elec. Motor & Equip. Co., Newark, N. J
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C, Parkersburg, W. Va.
Matthews & Bro., N. W., St. Louis, Mo.

Mine Inspectors' Convention

The annual convention of the Mine Inspectors of the United States will be held in Chicago, Ill., June 9 to 15. In view of the action being taken to prevent repetitions of recent mine disasters, it is expected that the subject of electricity will receive a great deal of attention.

James Taylor, of Peoria, Ill., is chairman of the arrangement committee.

Classified Directory of Manufacturers —Cont'd

SLEEVING
Belden Mfg. Co., Chicago, Ill.
Benjamin Electric Mfg. Co., Chicago, Ill.
Bryant Electric Co., Bridgeport, Conn.
Connecticut Electric Mfg. Co., Bantam, Conn.
Crescent Electrical Mfg. Co., Rochester.
Crouse-Hinds Co., Syracuse, N. Y.
Dunton & Co., M. W., Providence, R. I.
Federal Electric Co., Chicago, Ill.
Freeman Electric Co., E. H., Trenton.
General Mfg. & Supply Co., Trenton.
Johns-Manville Co., H. W., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Pass & Seymour, Solvay, N. Y.
Peru Electric Mfg. Co., Peru, Ind.
Porcelain Electrical Mfg. Co., Trenton.
Stanley & Patterson, New York.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Weber Electric Co. (Henry D. Sears, General Sales Agent, Boston, Mass.).
Yost Electric Mfg. Co., Toledo, O.

SOLDER
Belden Mfg. Co., Chicago, Ill.
Walworth Mfg. Co., Boston, Mass.
Western Electric Co., Chicago, Ill.

SOLDERING FLUX
Allen Co., L. B., New York.
Dunton & Co., M. W., Providence
Uebelmesser, Chas. R., Bayside, N. Y.

SOLDERING IRONS
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Elec. Heating Co., Chicago, Ill

SOLENOIDS
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman, J. L., Co., Chicago, Ill.

SPEED INDICATORS
Schaeffer & Budenberg, New York.

SPRINGS
Barnes Co., Wallace, Bristol, Conn.
Dunbar Bros. Co., Bristol, Conn.
Manross, F. N., Forestville, Conn.

SUPPLIES—ELECTRICAL
Am. Elec'l Supply Co., Chicago, Ill.
Central Electric Co., Chicago, Ill.
Central Electric Supply Co., New York.
Cobb, H. E., Chicago, Ill.
Commercial Electrical Supply Co., St. Louis, Mo.
Dearborn, Electric Co., Chicago, Ill.
Doubleday-Hill Elec. Co., Pittsburg, Pa.
Electric Appliance Co., Chicago, Ill.
Electrical Material Co., Baltimore, Md.
Erner & Hopkins Co., Columbus, O.
Ewing-Merkle Elec. Co., St. Louis, Mo.

Classified Directory of Manufacturers—Cont'd
Garton Co., W. R., Chicago, Ill.
Hudson Electric Supply Co., New York.
Latham & Co., E. B. New York.
Machado & Roller, New York.
Manhattan Elec'l Supply Co., New York.
Metropolitan Elec'l Supply Co., Chicago.
Nagel Electric Co., W. G., Toledo, O.
Novelty Electric Co., Philadelphia, Pa.
Ostrander & Co., W. R., New York.
Patrick, Carter & Wilkins Co., Phila., Pa.
Pettingell-Andrews Co., Boston, Mass.
Robertson Electric Co., Buffalo, N. Y.
Sherman-Brown-Clements Co., N. Y.
Stuart-Howland Co., Boston, Mass.
Union Electric Co., Pittsburg.
United Electric & Apparatus Co., Boston
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.

SUPPLIES—TELEPHONE
Am. Elec. Telephone Co.
International Teleph. Mfg. Co.
Kellogg Switchboard & Supply Co., Chicago.
Western Electric Co., Chicago.

SWITCHBOARDS
Adam Electric Co., Frank, St. Louis, Mo
Anderson Mfg. Co., A. & J. M., Boston, Mass.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Chase-Shawmut Co., Newburyport, Mass.
Cleveland Switchboard & Electric Co., Cleveland, O.
Condit Elec'l Mfg. Co., Boston, Mass.
Crescent Elec'l Mfg. Co., Rochester, N.Y.
Crocker-Wheeler Co., Ampere, N. J.
Crouse-Hinds Co., Syracuse, N. Y.
D'Olier, Jr., Co., Henry, Philadelphia
Ft. Wayne Elec. Wks., Ft. Wayne, Ind
General Electric Co., Schenectady, N. Y.
Grady Co., S. S., Cambridge, Mass.
Hill Electric Co., W. S., New Bedford, Mass.
Ideal Elec. & Mfg. Co., Mansfield, O.
Jones Electrical Co., New York
La Roche Co., F. A., New York.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Westinghouse Elec. & Mfg. Co., Pittsburg

SWITCHES
Anderson Mfg. Co., A. & J. M., Boston
Dickinson Mfg. Co.

ARC LIGHTS
Sarco Co., New York.

CANOPY
Sarco Co., New York.

CEILING
Jones Electrical Co., New York.
Krantz Mfg. Co., H., Brooklyn, N. Y.
Sorensen, P., Brooklyn, N. Y.

CLOCK
A. & W. Electric Sign Co., Cleveland, O
Campbell Electric Co., Lynn, Mass.
Elec. Motor & Equip. Co., Newark, N. J
General Electric Co., Schenectady, N. Y
Hartford Time Switch Co., Hartford.
Manhattan Elec'l Supply Co., New York.
Prentiss Clock Improvement Co., N. Y.
Specialty Mfg. Co., Youngstown, O.
Sorensen, P., Brooklyn, N. Y.
Trumbull Elec. Mfg. Co.. Trumbull, Conn.

SWITCHES—
KNIFE
Adam Electric Co., Frank, St. Louis, Mo.
Anderson Mfg. Co., A. & J. M., Boston, Mass.
Chase-Shawmut Co., Newburyport, Mass.
Cleveland Switchboard & Electric Mfg. Co., Cleveland, O.
Condit Elec'l Mfg. Co., Boston, Mass.
Connecticut Electric Mfg. Co., Bantam, Conn.
Crescent Elec'l Mfg. Co., Rochester, N. Y.
Crouse-Hinds Co., Syracuse, N. Y.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Hill Electric Co., W. S., New Bedford, Mass.

Classified Directory of Manufacturers—*Cont'd*

Ideal Elec. & Mfg. Co., Mansfield, O.
La Roche Co., F. A., New York.
Lang Electric Co., J., Chicago, Ill
Lundin Electric & Machine Co., Boston.
Manhattan Elec'l Supply Co., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Mutual Electric & Machine Co., Wheeling, W. Va.
Ohio Brass Co., Mansfield, O.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Solvay, N. Y.
Trumbull Elec. Mfg. Co., Plainville Conn.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

OIL

Adam Electric Co., Frank, St. Louis, Mo
Condit Elec'l Mfg. Co., Boston, Mass.
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
Helios Mfg. Co., Philadelphia, Pa.
Hill Electric Co W. S., New Bedford, Mass.
Pettingell-Andrews Co., Boston, Mass.
Trumbull Elec. Mfg. Co. Plainville, Conn.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

SNAP

Bissell Co., F., Toledo, O.
General Electric Co., Schenectady, N. Y.
Hart Mfg. Co., Hartford, Conn
Sarco Company, New York.

PENDANT

Sarco Company, New York.

TACHOMETERS

Schaeffer & Budenberg, New York.

TAPE

American Elec'l Wks., Philipsdale, R. I.
Boston Woven Hose & Rubber Co. Cambridge, Mass.
Brixey, W. R., New York.
Diamond Rubber Co., Akron, O.
Dunton & Co., M. W., Providence.
Electric Appliance Co., Chicago.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goodrich Co., B. F., Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
Hartford Rubber Works, Co., Hartford, Conn.
Johns-Manville Co., H. W., New York
Knowles, C. S., Boston, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
Massachusetts Chem. Co., Walpole, Mass.
Mica Insulator Co., New York.
Morgan & Wright, Chicago, Ill.
National Insulator Co., Boston, Mass.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Pennsylvania Rubber Co., Jeannette, Pa.
Republic Rubber Co., Youngstown, O.
Revere Rubber Co., Boston, Mass.
Standard Paint Co.. New York.

TELEPHONES

American Bell Telephone Co., Boston.
Connecticut Telephone & Electric Co., Meriden, Conn.
Couch Co., S. H., Boston, Mass.
Electric Goods Mfg. Co., Boston, Mass.
Gail-Webb Mfg. Co., Buffalo, N. Y.
Manhattan Elec'l Supply Co., New York.
Novelty Electric Co., Philadelphia, Pa.
Russell Electric Co., Danbury, Conn.
Schmidt-Wilckes Elec. Co., Weehawken, N. J.
Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
Vote-Berger Co., La Crosse, Wis.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co.

THEATER DIMMER

Campbell Electric Co., Lynn, Mass.
Cutler-Hammer Mfg. Co., Milwaukee

New Publication on Electricity

"Electricity," by H. M. Hobart, B. S. D. Van Nostrand Company, New York. Cloth; 207 pages; illustrated; 5½ by 7½ in. Price $2.00.

This is a text-book written primarily for British engineering students. In a concise and somewhat homely fashion it presents the fundamental elements of electrical engineering, using the metric system throughout. Simple algebra is the only mathematics used, and the work is well reinforced with diagrams and tables throughout. The method of treatment is to present, wherever possible, a physical conception of the phenomena under discussion, and work out completely to the point where a few arithmetical examples will suffice to clinch the matter in the student's mind. The subject is thus presented in a thoroughly modern way, and the book may also be useful as a book of reference.

The Missouri Electric, Gas, Street Railway and Motor Works Association held its convention April 14th, 15th and 16th, at Jefferson City, Mo.

Classified Directory of Manufacturers—Cont'd

Simplex Electric Heating Co., Cambridgeport, Mass.
Union Elec. Mfg. Co., Milwaukee, Wis.
Universal Electric Stage Lighting Co. New York.
Ward Leonard Electric Co., Bronxville N. Y.
Wirt Electric Co., Philadelphia, Pa.

TIME SWITCHES

Anderson Mfg. Co., A. & J. M., Boston

TRANSFORMERS

Am. Transformer Co., Newark, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y
Irwin & Co., O. C., Crawfordsville, Ind.
Kuhlman Electric Co., Elkhart, Ind.
Lafayette Electrical Mfg. Co., Lafayette. Ind.
Moloney Electric Co., St. Louis, Mo.
Packard Electric Co., Warren, O.
Peerless Transformer Co., Warren, O
Pittsburg Transformer Co., Allegheny Pa
Wagner Elec. Mfg. Co., St. Louis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

TROLLEY WHEELS

Anderson Mfg. Co., A. & J. M., Boston.

TURBINES—STEAM

Allis-Chalmers Co., Milwaukee, Wis.
Am. Turbine Eng. Co., Washington, D. C
Ball & Wood Co., New York.
De Laval Steam Turbine Co., Trenton
General Electric Co., Schenectady, N. Y.
Hooven, Owens, Rentschler Co., Hamilton, O.
Morris Co., I P., Philadelphia, Pa.
Westinghouse Mach. Co., Pittsburg, Pa

VALVES

Am. District Steam Co., Lockport. N. Y
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston, Mass.
Crane Co., Chicago, Ill.
Crosby Steam Gauge & Valve Co., Boston.
Fairbanks Co., New York.
Homestead Valve Mfg. Co., Homestead, Pa
Jarecki Mfg. Co., Erie, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Valve and Fitting Co. Pittsburg, Pa.
Powell Co., W. M., Cincinnati, O.
Schutte & Koerting Co., Philadelphia.
Walworth Mfg. Co., Boston, Mass.

VARNISH—ARMATURE AND COIL

Calman & Co., Emil, New York.
Eagle Paint & Varnish Co., Pittsburg
Growthwell, A., New York.
Macon-Evans Varnish Co., Pittsburg. Pa
Massachusetts Chem. Co., Walpole, Mass
Sherwin-Williams Co., Cleveland.
Standard Paint Co., New York.
Standard Varnish Works New York
Sterling Varnish Co., Pittsburg, Pa.

WATER WHEELS

Allis-Chambers Co., Milwaukee, Wis.
Dayton Globe Iron Works, Dayton, O.
Doble & Co., Abner, San Francisco, Cal.
Leffel & Co., James, Springfield, O.
Lombard Governor Co., Ashland, Mass.
Morris Co., I. P., Philadelphia, Pa.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co. Dayton, O.
Risdon-Alcott Turbine Co. Mt. Holly, N. J.
Smith Co., S. Morgan, York, Pa.
Trump Mfg. Co., Springfield, O.

WATTMETERS

Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.
Diamond Meter Co., Peoria, Ill.
Duncan Electric Mfg. Co., Lafayette, Ind.
Ft. Wayne Elec. Wks., Ft. Wayne, Ind
General Electric Co., Schenectady, N. Y
Helios Mfg. Co., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
Keystone Electrical Inst. Co., Phila., Pa
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Classified Directory of Manufacturers—*Cont'd*

Weston Elec'l Inst. Co., Newark, N. J.
Whitney Electrical Inst., Co., New York.

WIRE—

COPPER

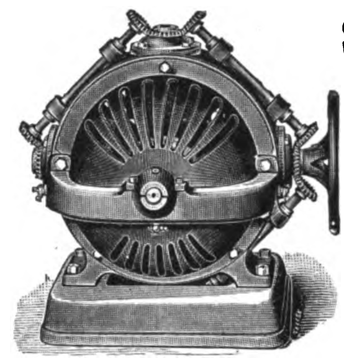
Am. Electrical Heater Co., Detroit, Mich.
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill
Ansonia Brass & Copper Co., New York
Bishop Gutta Percha Co., New York.
Chicago Insulated Wire Co., Chicago.
Crescent Insulated Wire & Cable Co., Trenton, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Monarch Electric & Wire Co., Chicago.
Moore, Alfred F., Philadelphia, Pa.
National Conduit & Cable Co., New York
Phillips Insulated Wire Co., Pawtucket R I.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg. Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg, Pa
Western Electric Co., Chicago.
Wire & Telephone Co. of America, Rome, N. Y.

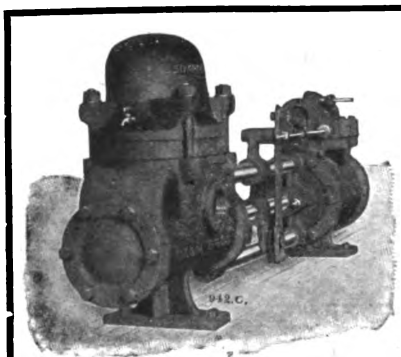
MAGNET

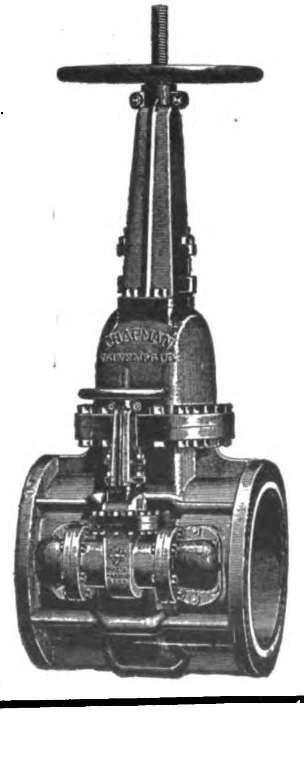
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill.
Ansonia Brass & Copper Co., New York.
Belden Mfg. Co., Chicago, Ill.
Chicago Insulated Wire Co., Chicago.
D. & W Fuse Co., Providence, R. I.
Driver-Harris Wire Co., Harrison, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago. Ill.
Moore Alfred F., Philadelphia, Pa.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg. Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg. Pa
Stuart-Howland Co., Boston. Mass
Washburn Mfg. Co., Phillipsdale, R. I.
Waterbury Brass Co., Waterbury, Conn.
Western Electric Co., Chicago, Ill.
Wire & Telephone Co. of America, Rome.

RUBBER COVERED

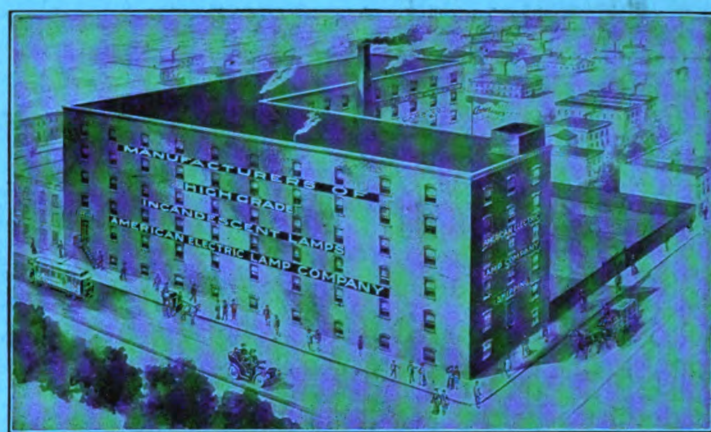
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago.
Atlantic Ins. Wire & Cable Co., New York.
Bishop Gutta Percha Co., New York.
Boston Insulated Wire & Cable Co., Boston, Mass.
Brixey, W. R., New York
Crescent Insulated Wire & Cable Co., Trenton, N. J.
General Electric Co., Schenectady, N. Y.
Hazard Mfg. Co., Wilkesbarre, Pa.
India Rubber & Gutta Percha Insulating Co., New York.
Indiana Rubber & Insulated Wire Co., Jonesboro, Ind
Lowell Insulated Wire Co., Lowell, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
National India Rubber Co., Bristol, R. I.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Phillips Insulated Wire Co. Pawtucket, R. I.
Reed Electrical Cordage Co., Syracuse, N. Y.
Roebling's Sons Co., John A., Trenton.
Safety Ins. Wire & Cable Co., New York.
Simplex Electrical Co., Boston, Mass.
Standard Underground Cable Co., Pittsburg.
Waterbury Co., New York.
Wire & Telephone Co. of America, Rome







American Electric Lamp Co.



Manufacturers of all Types of Incandescent Lamps

HAVE ON HAND, READY FOR IMMEDIATE DELIVERY, A LARGE STOCK OF

AMERICAN MAZDA LAMPS

AMERICAN TANTALUM LAMPS

AMERICAN METALLIZED FILAMENT LAMPS

AMERICAN CARBON FILAMENT LAMPS

AMERICAN MINIATURE LAMPS

[illegible] Quoted on Application

FACTORY AND GENER[illegible] 153-159 JEFFERSON STREET, PHILADELPHIA, PA.

NEW YORK OFFICE: [illegible] BOSTON OFFICE: 38 KILBY STREET

ELECTRICAL AGE

Established 1883

THE ELECTRICAL AGE COMPANY, 45 E. 42d Street, NEW YORK

Vol. 41
No. 5

JUNE, 1910

$1.00 per Year
15 Cents per Copy

Index to Advertisers, page 5.

Classified Index, page 15.

18 Million Readers Have Learned the Advantage of Electric Lighting.

Every month since last September millions of readers of the most widely read magazines have learned that electric lighting, with its many advantages, is now well within the means of all who live within the borders of a lighting circuit.

Thousands of these readers have written for further information, proving that a widespread interest has been created. Many of these inquirers stated that they were using other methods of lighting; the arguments were reaching not only the non-user of electric service, but also those who feel the need of more light.

From coast to coast lighting companies have written favorably of this campaign because they have found it helpful in extending the use of electric lighting on their circuits.

This extensive advertising in the popular magazines is but one part of the widespread campaign to popularize electric lighting with MAZDA lamps.

General Electric Company

2523A

These Trade Papers Help You to Sell More Current

In addition to the widespread advertising in the popular magazines, the campaign for more *electric* light is also carried on through the columns of a long list of representative trade papers.

Bankers, building managers, hotel owners, manufacturers, shoe dealers, hatters, haberdashers, clothiers, furnishers, dry goods men, furniture dealers, house furnishers, jewelers, druggists, hardware dealers, and others have learned that an electrically lighted store is a business asset—that brilliancy brings business.

One of the quickest and best ways to reach the influential members of a particular trade is through the columns of the journal published in the interest of that trade. These trade papers contain information vital to the trade, and are read with keen interest.

In these papers the same arguments are used by the General Electric Company that you would use to induce business men to use your service.

This broad campaign makes it easy for you to extend the use of electric lighting on all parts of your circuit.

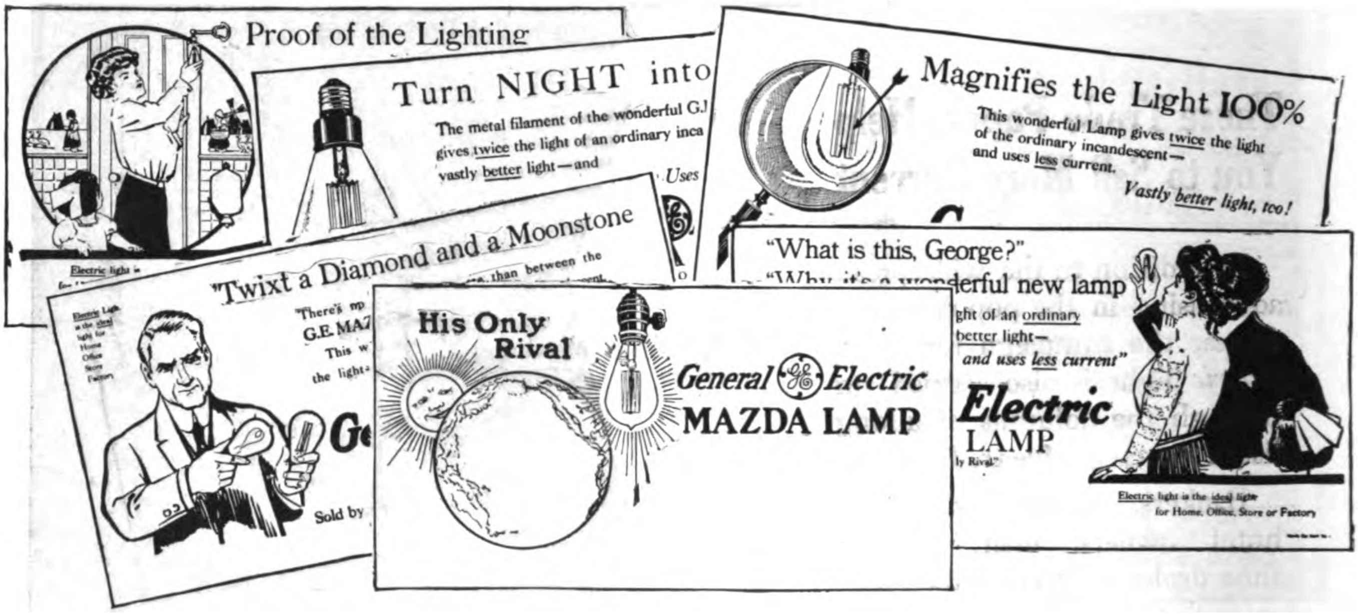
Main Lamp Sales Office
Harrison, N. J.

Principal Office
Schenectady, N. Y.

LIST OF SALES OFFICES:

Atlanta, Ga.	Denver, Col.	Philadelphia, Pa.
Baltimore, Md.	Detroit, Mich.	Pittsburg, Pa.
Boston, Mass.	(Office of Sol'g Agt)	Portland, Ore.
Buffalo, N. Y.	Indianapolis, Ind.	Richmond, Va.
Butte, Mont.	Kansas City, Mo.	Salt Lake City, Utah
Charleston, W. Va.	Los Angeles, Cal.	San Francisco, Cal.
Charlotte, N. C.	Minneapolis, Minn.	St. Louis, Mo.
Chicago, Ill.	Nashville, Tenn.	Seattle, Wash.
Cincinnati, O.	New Haven, Conn.	Spokane, Wash.
Cleveland, O.	New Orleans, La.	Syracuse, N. Y.
Columbus, O.	New York, N. Y.	

2523B



Take Advantage of this Newly Aroused Interest in Electric Lighting

To reap the full benefit of the universal interest in electric lighting created by our general advertising, start a local campaign of your own. You can crystallize general interest into a particular local interest—the inevitable result of which will be the sale of more current to more customers.

A series of out-of-the-ordinary street-car cards and newspaper advertisements, brimful of result-getting arguments, brings the kind of results that keep a new business department hustling from daylight to dark.

You can do that kind of advertising without having to employ a staff of artists and advertising experts because the entire advertising department of the General Electric Company is at your service. Advertising experts have prepared a series of car cards and newspaper advertisements that will build up the volume of your business by adding to your customers' list the present non-user of your service and by increasing the amount of current used by present customers.

These newspaper advertisements, electrotyped and all ready for your local printer, will be furnished free of charge to progressive lighting companies, together with a full series of street-car cards, imprinted with your firm name.

It is decidedly to your advantage to write at once for complete particulars. Address

General Electric Company
Advertising Department
Schenectady, N. Y.

2523C


His Only Rival
Get cheaper electric light from the Sun's Only Rival
General GE Electric
MAZDA LAMP
Order from your electric light company or dealer, or write to
General Electric Co.-Schenectady, N. Y.
© 1910 GENERAL ELECTRIC CO. SCHENECTADY, N.Y.

INDEX TO ADVERTISERS

ELECTRICAL AGE

Volume XLI. Number 5.
$1.00 a year; 15 cents a copy.

June, 1910

The Electrical Age Co.
New York.

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JOHN HAYS SMITH, Pres.
C. A. HOPE, Sec. J. H. COOK, Treas.

Telephone No. 6498 Murray Hill
Cable Address—Revolvable, New York

JOHN HAYS SMITH, Editor

SUBSCRIPTION RATES

United States and Mexico, $1.00.
Canada, $1.50. To Other Countries, $2.50

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

Entered as second class matter at Post Office New York, New York

CONTENTS

The Convention Program

Criticism is such an easy art, and so often springs from disagreeable qualities of the mind, that he who essays to pass a contrary opinion is in danger of getting rapped for his pains. We therefore understand the risk involved in making comment upon the splendidly large, complex and variegated St. Louis program of the National Electric Light Association.

Three addresses, 16 committee reports, mostly voluminous, and 44 articles, each purporting to deal directly with some important central station problem, is a *pot pourri* of the grandest proportions ever served to a convention of electrical men. In our opinion, 1911 cannot surpass it—and should not. The folly of passing the literary pie ought to stop. No man should write unless he has something to say. And no member should be permitted to engross the attention of a thousand or more men unless he has a substantial paper to present.

Two-thirds of the papers presented before this convention would, in our opinion, have been thrown out by such an editing committee as the A. I. E. E. provides to protect itself against the extreme tenuousness of the amateur investigator.

Several years ago the press of papers forced the association to adopt parallel sessions as a mere expedient to compass the literary mass within the week. This year we have had a three-ring continuous performance!

Would it not be proper to appoint an editing committee to determine subjects of most general interest; to regulate the mass of manufacturer's data, so often followed in its presentation by the ominous absence of discussion, and to guide the analysis of the cumbersome data of the committee reports.

An effort should be made to direct the lines of thought along channels of greatest interest and there should be an attempt to vary the program so that an all-around central station man could get the things of most interest to him. For example, he would fare better if the mornings of each successive day were given over to the technical program, including the newly created power transmission section, and two afternoons to the commercial program, two afternoons to the accounting work, and a final afternoon to the company and section work. Briefly, half of the day to technical work and *half of the day* to commercial work. Not necessarily that this apportionment of time is correct, or would remain constant with the rapid development of the industry, but the program should be arranged so that anybody could get it all!

This is more particularly desirable since the bulk of the membership is largely from small central stations, where the manager must be somewhat familiar with all of its activity. He is, or should be, the single creative mind of his enterprise.

We hope that something will be done to make the association work of the greatest benefit to the new membership and we hope there will be a careful effort to get an efficient program of the widest possible interest next year.

RELATIONS WITH THE PUBLIC

The increasing attention to the commercial side of the central station industry is a good omen. This year there were two addresses that deserve careful thought and study, and might well be read with as much thoroughness as is required of the pupil in learning his catechism. We refer to the paper of Arthur S. Huey on Commercialism in the Central Station, and the evening address of Samuel A. Insull.

In strong, crisp sentences Mr. Huey sweeps rapidly over the fundamentals of the relationship of the central station to the public. Boldly he proclaims what public utility operators are now beginning to see:

"State utility commissions have proven mighty, educative forces."

"Not a single state commission has yet failed to be impressed with the chief claims of operating companies and to base its decisions upon broad recognition of many principles which *companies vainly have tried to have the people understand.*" Mr. Insull also expressed himself as not viewing with alarm the proper regulation of central-station business, but as feeling that the best results will be obtained by regulated monopoly, that securities will stand in higher credit, and financing for our rapid growth will be the easier.

Mr. Insull also declared that "no little damage had been done to the corporate interests of the country by the action of officials who seem to have concern only for the profit of the moment, and little or no concern for the permanency of their investment."

In no uncertain words Mr. Huey on the morning before said:

"No words are strong enough to denounce the central-station management which regards the community it serves as a mere field for exploitation—as a mere machine for the coining of electric service into dollars. An attitude like this will wreck any utility organization."

Here is another important point in Mr. Huey's paper which has not hitherto been presented forcibly:

"The central station is a part of the economic scheme of the modern city." There is much to be done before the average central station gets to this point of view, and when it does "it should profit in proportion to the co-operative value it returns to the community." This larger view of our relations with the public is bound to simplify our municipal problem and make our position secure against the attack of petty politicians.

CENTRAL STATION RATES

The reduction in current effected by tungsten lamps and the consequent lessening of revenue which follows its introduction has alarmed central stations who are under a franchise to furnish current at a fixed rate. Looking ahead toward further reductions in current consumption of the new lamp, Mr. Doane, under the head of "High Efficiency Lamps," proposes an amplification of the Doherty ready-to-serve system. Mr. Doane advocates higher readiness-to-serve and consumer's charges with a lower price per kilowatt-hour. Such a plan would undoubtedly preserve the income from lighting from the effect of high efficiency lamps under present rates. We are inclined to agree with Mr. Dow that it would increase the bills of large numbers of small consumers and affect public sentiment adversely. Theoretically the proposal is just, but we are afraid that it would lead to "minimum bills," and rob the consumer of the security which he feels in having a meter to register his demand. Many companies have with wisdom discontinued the unpopular "minimum bill." The association has done well to refer this paper to a committee.

PROBLEMS IN POWER TRANSMISSION

If Mr. Buck's paper will stimulate engineers to look more closely into the engineering of materials for line constructions it will have well served a most useful purpose. The building of an enduring line is a mechanical engineering problem, and only in the simplest way do electrical considerations now enter. Hitherto the petticoated pin insulator has been a serious electrical problem in line work, but with the introduction of the suspended type of insulator, we are relieved of the trouble in getting a sufficient leakage surface in one porcelain structure.

With old-fashioned, closely-set wooden poles, the questions of sag and strength of conductor did not enter seriously. The introduction of the more costly tower has much lengthened the span, and since its cost varies roughly with the square of its height, it is now necessary to draw wires under minimum sag and therefore maximum tension.

Mr. Buck declares that the 100,000-volt suspended lines are not giving any more trouble than the early 20,000-volt lines. He indicates also that the difficulty in raising the line voltage has now shifted from the line to the apparatus itself in which the line ends.

He boldly suggests also that regulation of the line voltage can best be secured by placing shunt inductances at intervals on the line and so adjusted as to neutralize the line-charging current.

"Resumption of service should never wait upon repairs," says Mr. Buck, and in the present state of the art we shall always have to look forward to interruptions. Adequate switching arrangements and spare circuits are advocated as the proper way of minimizing line outages. We would like to suggest that if bridge-engineers and tool builders worked with as small a factor of safety as the engineers of our long-distance transmission lines there would be serious and disastrous disturbances in the world's economies. It is up to designers to build more rugged lines.

The suggestion that the largest field for future evolution in line transmission is toward direct current has been pronounced fatuous by many competent engineers. Nevertheless, Mr. Buck proposes such a development.

The nonchalance of the manufacturers and the heavy investment in alternating-current apparatus would certainly weigh heavily against its introduction, even assuming the system were perfected. Commercial power transmission is possible only to-day because of the voltage flexibility of the transformer. And when such a device has been worked out for changing the voltage of direct current without loss of energy, we shall doubtless see a beginning of direct-current transmission.

RESIDENCE LIGHTING

The rather liberal estimate of $160,000,000 per year is the value which Mr. H. J. Gille puts on a fully developed residence lighting of the country. The author says the proportion of this business which is already developed is small. He assumes a diversity factor of 1:4, which is fairly high, a city population of 40,000,000, and an average of 15 50-watt lamps, which is wrong. The people are going to use 25-watt lamps at no distant day and some 5,000,000 of them are now in various uses. But be Mr. Gille's figures as they may, the problem of how to get all the houses on the line is highly important.

Mr. Gille points out that only 50 per cent. of the residence lighting peak overlaps the commercial lighting and power, and that therefore residence lighting offers an opportunity of improving the station load-factor. He estimates the revenue per kilowatt of station demand at $80 per year.

Growth and Magnitude of the Central Station Industry

The magnitude of the central electric station industry in the United States in the census year 1907 as compared with the census year 1902, and the growth during the intervening five-year period, are shown in the Census Bureau's special report, on the second United States census of the Central Electric Light and Power Stations for the year 1907.

The central electric stations are defined in the report as those which, exclusive of isolated electric plants, furnish electrical energy for lighting and heating; and power for manufacturing and mining purposes, for street railways and elevators, for charging batteries, etc.

In 1902 the annual output of all electric stations and electric railways amounted to 4,768,535,512 kw-hr. In 1907 the output of the two classes of stations was 10,621,406,837 kw-hr., the increase in that year as compared with 1902 being 122.7 per cent. In 1902 the output by electric railways formed 47.4 per cent. of the total, but by 1907 the proportion for such railways had fallen to 44.9 per cent.

GREAT INCREASE IN PLANTS

The number of commercial and municipal plants increased from 3620 in 1902 to 4714 in 1907, the increase amounting to 30.2 per cent.

There were, in 1907, according to the report, upward of 30,000 individuals, companies, corporations, and municipalities, exclusive of isolated electric plants, which reported the generation or utilization of electric current in what may be termed "commercial enterprises."

These industries represent an outstanding capitalization of $6,209,746,753, of which amount, $1,367,338,836 is credited to central electric stations $3,774,722,096 to electric railways, $814,616,004 to commercial or mutual telephone companies, and $253,019,817 to telegraph companies, the latter item including $32,726,242, the capital stock of wireless telegraph companies. The capitalization of the 17,702 independent farmer or rural telephone lines and of the 1157 electric police-patrol and fire-alarm systems could not be ascertained.

THE MUNICIPAL STATIONS

The report states that the municipal stations are practically exempt from the consolidations that so frequently occur among commercial companies, and this fact no doubt accounts in large part for the proportionately greater increase discovered in the former class of stations. Not only was there a large increase in the number of municipal stations, but an analysis of the report shows that, although 33 municipal stations which reported in 1902 had become commercial stations in 1907, 113 stations which were reported as commercial in 1902 had become municipal in 1907.

Census Report of Street-Railway Development

The remarkable development since 1902 of the industrial activities of the street and electric railways of the United States is clearly seen in the statistics compiled by the Census Bureau from the census of such companies, taken in 1907, in which it is stated that in 1907 it was found that car mileage had increased 41.4 per cent.; there was a gain of 63.3 per cent. in the total number of passengers; a rise of 55.9 per cent. in the number of fare passengers; the number of companies increased 25.2 per cent.; the trackage lengthened by 52.4 per cent.; the gross income of the railways jumped 71.6 per cent.; the amount of salaries and wages kept upward pace with the rest; and electricity practically superseded all other kinds of motive power.

An interesting feature of the report is the comparative summary for 1907 and 1902, in which it is shown that the total number of operating and lessor companies in the United States in 1907 was 1236 and in 1902, 987, the per cent. of increase being 25.2 The operating companies in 1907 numbered 945 and in 1902, 817, an increase of 15.7 per cent. The lessor companies in 1907 numbered 291 and in 1902, 170, the per cent. of increase being 71.2.

In 1907 the total number of miles of line, by which is meant length of first main track or roadbed, was 25.547.19, as compared with 16,645.34 in 1902, the per cent. of increase being 53.5. The total number of miles of track, meaning the total length of all trackage, including sidings, was 34,403.56 in 1907, as against 22,576.99 in 1902, the per cent. of increase amounting to 52.4. Of the total number of miles of track, those operated by electricity in 1907 numbered 34,059.69 and in 1902, 21,907.59. The per cent. of increase was 55.5. The trackage operated by animal power in 1907 was 136.11 and in 1902, 259.10. The per cent of decrease amounted to 47.5. The trackage operated by cable in 1907 was 61.71 and in 1902, 240.69, the per cent. of decrease being 74.4. The trackage operated by steam in 1907 was 146.05 and in 1902, 169.61, a decrease of 13.9 per cent.

GREAT INCREASE IN COST.

The cost of construction and equipment in 1907 was $3,637,668,708; as compared with $2,167,634,077 in 1902, the per cent. of increase amounting to 67.8.

The number of employees in 1907 was 221,449, and in 1902 it was 140,769, the per cent. of increase being 57.3.

The total number of cars in use in 1907 was 83,641, as against 66,784 in 1902, an increase of 25.2 per cent. The number of passenger cars in 1907 was 70,016, as compared with 60,290 in 1902. The per cent. of increase was 16.1. The number of all other cars in 1907 was 13,625, and in 1902 it was 6494, the per cent. of increase being 109.8.

The total number of passengers in 1907 was 9,533,080,766, as against 5,836,615,296 in 1902, an increase of 63.3 per cent. The number of fare passengers in 1907 was 7,441,114,508, as compared with 4,774,211,904 in 1902, the per cent. of increase being 55.9. The number of transfer passengers in 1907 was 1,995,658,101, and in 1902 it was 1,062,403,392, the increase amounting to 87.8 per cent. The number of "free" passengers in 1907 was 96,308,157. The statistics of 1902 furnish no figures of this kind. The number of fare passengers per mile of track in 1907 was 216,522, and in 1902 it was 212,217, the per cent. of increase being 2.

The car mileage, including passenger, express, freight, mail, etc., in 1907 was 1,617,731,300, as compared with 1,144,430,466 in 1907, an increase of 41.4 per cent.

In 1907 the number of power houses was 829, as against 805 in 1902, the increase representing 3 per cent.

The steam and gas engines and water wheels used in generating the electricity were reported as having 2,476,479 h.p. in 1907 as compared with 1,349,211 in 1902, an increase of 1,127,268 h.p., or 83.6 per cent.

The kilowatt capacity of dynamos in 1907 was 1,723,416, and in 1902, 898,362, an increase of 91.8 per cent.

The gross income of the operating companies in 1907 was $429,744,254 and in 1902 it was $250,504,627, an increase of 71.6 per cent. The operating earnings in 1907 were $418,187,858 as compared with $247,553,999 in 1902, the increase being 68.9 per cent. The income from other sources in 1907 was $11,556,396, and in 1902 it was $2,950,628, an increase of 291.7 per cent.

The per cent. ratio of operating expenses to operating earnings in 1907 was 60.1, and in 1902 it was 57.5.

The total capitalization outstanding of the operating and lessor companies in 1907 was $3,774,772,096, while in 1902 it was $2,308,282,099, an increase of 63.5 per cent.

NEW DEVELOPMENT WORK IN 1907

There were 101 companies reported at the census of 1907 as having properties under construction, but not in operation during any portion of the census year. This indicates, approximately, the amount of new development work in progress in 1907. These companies reported 675.85 miles of track as completed by December 31, 1907, and an estimated total of 3,101.30 miles of track for the roads when completed. Their total outstanding capitalization had a par value of $232,298,844.

THE REASON FOR LARGER CARS

The use of electricity has made it possible to increase the size of the passenger cars, which accounts for the fact that there was, from 1902 to 1907, an increase in the total number of only 16.1 per cent. The truth of this is evidenced by the fact that the increase in the number of fare passengers, 55.9 per cent. from 1902 to 1907, was much greater than the corresponding increase in the number of cars.

The amount reported in 1907 as cost of construction and equipment is more than nine times as great as in 1890 and over one and two-thirds as great as the total for 1902.

PASSENGER-SERVICE INCOME PROPORTION.

The income from passenger service formed 99 per cent. of the total income from operation in 1890, but this proportion decreased to 94.5 per cent. in 1902 and to 91.4 per cent. in 1907. The percentage that the income from sources other than operation formed of the gross income was 1.2 per cent. for both 1902 and 1890, and by 1907 it increased to 2.7 per cent.

Some Problems in Power Transmission

H. W. BUCK

TOWERS

The rise in the price of wood and the reduction in the cost of fabricated structural steel has naturally led to the substitution of steel towers for the old wooden poles on many lines. Such steel construction enables higher supports to be used and consequently longer spans with the resulting economies. Steel supports also eliminate the fire risk, which is one advantage. The question of depreciation in a steel tower, due to corrosion, even if galvanized, has, however, not yet been definitely determined, for most tower lines have been in service for only a few years. If the steel legs of the tower are installed directly in the ground it is questionable whether the life of this part of the tower will be any longer than that of a wooden pole. The strength of a tower with its legs in the ground is also uncertain, since the quality of the soil varies to such an extent. If the legs of the towers are concreted in the ground the tower is greatly strengthened and corrosion is practically eliminated, but the cost per tower installed is thereby in some cases as much as doubled. Unless, therefore, the amount of power transmitted is very large, so that the cost per horse power of the line is reduced, steel tower construction is almost prohibitive in cost.*

In order to reduce this cost it is common practice to make the smaller members of the tower not more than one-eighth inch in thickness. The life of steel members of this small section, even if galvanized, has yet to be determined, although the results on windmill towers are encouraging.

SPANS

The lengthening of the span on transmission lines has been an obvious result of the introduction of steel towers. It reduces the number of insulators and consequently the opportunity for break-downs, and has other advantages, but the lengthening of the span has introduced other difficulties.

With the old-fashioned short-span construction common on wooden pole lines the question of sag and strength of conductor was of very little importance. Lines could be installed slack, using soft-drawn conductors and strains on insulators, and supports could be reduced to a minimum. Conductors on this account seldom broke. The sag was small in any case, and a foot or so more or less made very little difference. With long spans, however, there is a radical difference in requirements. In order to reduce the height of towers, since their cost increases almost as the square of the height, the conductor must be drawn up to the maximum possible tension. This has eliminated the use of soft-drawn metal for conductors and has necessitated the development of commercial hard-drawn copper and aluminum of very high elastic limit. The long span also requires the stringing of the wire with the greatest care with accurate observations as to temperature and tension.

The high-working stress in conductors necessary in modern long-span lines has introduced new mechanical problems in insulator, joint crossarm designs. Furthermore, the conductor is stressed so near to its elastic limit at times of low temperature and high wind that a short-circuit on the line is almost certain to burn it enough to cause it to part from reduction in cross section. When a conductor does part under these conditions, the high initial tension is likely to cause considerable damage to adjacent insulators, cross-arms, etc., from recoil.

A further difficulty in the case of very long spans has resulted from vibration of the conductor and its crystallization and ultimate breakage at the point of attachment. In such cases it has been found necessary to make the attachment more or less flexible. The suspension type of insulator is specially favorable for this reason.

The economical span length for steel construction under present conditions ranges from about 300 ft. as a minimum to 750 ft. maximum, depending upon a large variety of conditions peculiar to each line. It is impossible to give any formula expressing the proper economical span length for a given line, since so many variables enter into the equation.

INSULATORS.

Up to about 60,000 volts the standard type of pin insulator construction gives very satisfactory results. With the rise in transmission voltage above this figure, however, mechanical difficulties are encountered due to the large size of pin insulator required. The cost of this type of insulator increases nearly as the cube of increase in voltage, above 60,000 volts, and the necessary height of the pin imposes tensional strains on the crossarm which are objectionable.

Probably the most important and radical improvement which has taken place in recent years in power transmission has been the development and introduction as a commercial success of the so-called suspension insulator construction. It superseded the pin type almost immediately for the very high voltage lines and now is standard for voltages above about 80,000. Its advantages and its successful performance have been definitely established on a number of important transmission systems already in operation.

The suspension insulator requires a higher tower than the equivalent pin insulator. This is a disadvantage, but it is offset by the simplification of the crossarm possible with the suspension insulator and the elimination of torsion on the arms and head of the tower.

The hardware used in connection with the suspension insulators of various forms is not altogether satisfactory, and there is a field for development and improvement here.

INSTALLATION OF CONDUCTORS.

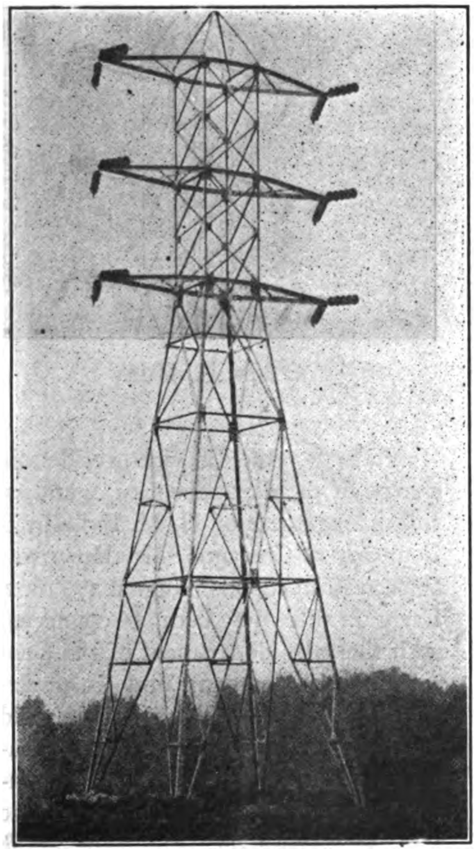
Where pin insulators are used the usual method of construction consists in drawing the conductor up to tension over the top of the crossarms or through the groove in the top of the insulator. Since each pin insulator is a fixed point on the line the conductor when up to tension can be tied in at any insulator and fixed until the next few spans are drawn up, and so on. With suspension insulators the method is not so simple. Usually the wire is slung in snatch-blocks, one hung from each crossarm and a mile or so of conductors drawn up to tension. The cable is then fixed to some tower with an auxiliary clamp. After this operation it is necessary to transfer the cable from each snatch-block to the suspension clamp on each insulator, and ultimately the auxiliary clamp must be removed. This extra labor involved puts the suspension insulator at a disadvantage in cost of construction. There are possibilities for improvement here, especially in training linemen to this special work, which is new to most of them. Experience is specially necessary for the tying-in conductors at dead-end insulators where the operation is quite complicated.

There has been considerable discussion as to the best method of securing conductors on suspension insulator lines. Probably the most satisfactory is to place at regular intervals along

* N. E. L. A., 1910.

the line, one mile or so apart, extra strong towers where dead-end insulators can be installed and the line fixed at these points. These towers should be strong enough to withstand any strain likely to occur on the line. The intermediate towers should be equipped with suspension insulators, but with the conductor clamped thereto so that it can slip through in case of breakage. The intermediate towers need then be only just strong enough to carry the actual weight of the conductors and to resist the overturning moment, across the line, due to wind. At angles dead-end insulators should, of course, be used with extra strong towers.

Italian engineers carried this principle to an extreme several years ago by using flexible towers as intermediate supports. The arrangement has special merit in connection with suspension insulators, and has recently been taken up actively in this country. It gives promise of economy, especially from the viewpoint of cost of tower assembly and erection.



VOLTAGE.

The success with suspension insulators on the recent 100,000-volt lines in this country has been remarkable, and such lines have actually given less insulator trouble than the early 20,000-volt lines when they were first installed. Since the degree of insulation with suspension insulators can be increased to almost any desired extent without involving prohibitive difficulties, there seems to be no reason in the insulator itself why much higher voltages should not give satisfactory results. There are, however, other considerations which will probably limit line voltage to approximately 100,000 volts for some time to come. The insulation of the line itself is a much easier problem than that of transformers, lightning arresters and substation equipment, and these devices cannot be considered entirely satisfactory even at 100,000 volts in the present state of the art.

Oil switches become of enormous proportion at this voltage and involve the use of large quantities of oil under conditions where the fire risk is considerable. Furthermore, the spacing necessary between phases at 100,000 volts is so great that substation buildings are necessarily very large and expensive. It is questionable whether the economy in conductor cost in a voltage raise from 100,000 volts to 150,000 volts would not be more than offset by the increased cost of insulator towers, substations and operating equipment. There are other problems incident to the very high line voltages which have not yet been solved. The line-charging current is a serious element on long lines even at 100,000 volts, and the atmospheric discharge loss increases rapidly above this voltage. The spacing between conductors for the latter reason will have to be largely increased as the voltage goes up, and it will probably be necessary to artificially increase the diameter of conductor to reduce the discharge loss. This will increase the wind strains on towers and increase their cost.

It is probable that 100,000 to 110,000 volts is as high a voltage as is justified on a large commercial scale under the state of the art as it is at the moment. It would be well for electrical engineers to be conservative in this regard in the best interests of permanent advancement, since a too rapid rise in line voltage applied commercially is certain to result in unforeseen difficulties and unsatisfactory service which can only retard legitimate development.

REGULATION

Voltage regulation under the variable load on very long high voltage lines cannot be considered satisfactory under present conditions. This is due principally to the great inductive drop and the excessive charging current, both of which are exaggerated at 60 cycles. For instance, the wattless leading current in a 100,000-volt, 60-cycle, single-circuit line 150 miles in length is approximately 50 amperes or 8650 kilovolt-amperes. This requires a very considerable generator capacity to operate the line even at no load. This charging current magnetizes the generator field so that the voltage will automatically build itself up until a condition of high saturation in the generators is reached. In order, therefore, to maintain normal voltage under these conditions the generator direct-current field must be cut out almost entirely. The combination is highly unstable. As the load comes on, if it is inductive, such as induction motors, the line-charging current may be neutralized or the power-factor may actually show lagging current as a resultant. The generator fields must then be strengthened to a point which on the no-load saturation curve of the machines would correspond to a voltage much above normal. Assume then that some circuit breaker on the system opens up, cutting off a large block of energy load and also part of the compensating lagging current; the resultant current at the generators immediately changes from lag to lead, the line-charging current again predominating, and the generator voltage may rise as much as 50 per cent. This serious rise in voltage is caused by momentary speed rise due to reduction in load, armature reaction due to change from lag to lead, and in addition there is the boost of voltage over the line inductance due to the leading current. Other power users on the system which remain connected to the lines under these conditions will suffer from the disturbance.

This problem in regulation can be solved only by the installation of shunt inductance placed at intervals along the line permanently connected thereto, and so adjusted as to neutralize the line-charging current regardless of conditions in the various receiver circuits. If it becomes necessary to neutralize the lagging currents of the receiver circuits, rotary condensers should be installed, which operate very satisfactorily. It is not feasible, however, to neutralize the lagging currents in the received circuits with the line-charging current if good line regulation is required, since one is a constant and the other is a variable.

FREQUENCY

While 60 cycles does not compare favorably with 25 cycles for line conditions alone, on account of the increased charging current and inductive drop at the higher frequency, 60 cycles is coming into more general use on the large transmission systems. This is due somewhat to the necessity of operating in conjunction with existing plants; but there is justification for it in the reduced cost and size of the transformers, which are large and expensive in any case at high voltages. One of the strong arguments formerly used in favor of 25 cycles for transmission is its benefit in rotary converter operation. On account of poor voltage regulation, however, it is no longer usual practice to install converters on long lines, since the independent voltage control of the motor-generator set is required. Furthermore, the general adoption of 25 cycles for single-phase railway operation does not look as probable as it did a few years ago; so that greater advantages for overhead work seem to be in the 60-cycle system. Where extensive underground cable networks are involved 25 cycles is desirable in order to reduce the cable eddy current and dielectric losses and to lessen the charging current.

LIGHTNING ARRESTERS

Good progress has been made in lightning arresters through the development of the electrolytic type. If a disturbance takes place on a line causing a wave of high voltage the electrolytic arrester allows the surge to pass through it satisfactorily and absorb its energy. Under these conditions the dynamic current does not follow and the arrester is not overheated. If, however, the actual voltage on the line rises for reasons previously discussed, the arrester breaks down and the current which passes is actually dynamic current flowing at the higher voltage, and here the heat generated in the electrolyte is apt to cause an explosion with consequent ejection of liquid, oil, etc., and permanent damage to the disk units.

It is not likely that lightning itself will be as troublesome at 100,000 volts and over as it is on the lower voltage systems. The insulation of the entire transmission system is so high that the potentials due to lightning are not so likely to cause a puncture, and a point should ultimately be reached where all the apparatus will have sufficient insulation to be practically lightning-proof. Arresters are really more for protection from so-called surges than from lightning. Even these should be reduced as line voltages go up, since the reaction due to any sudden change in line current is proportional to the square of the line current. The higher the voltage, of course, the less the current for a given power, so that the tendency should be to lessen disturbances.

GUARD WIRE

The steel guard wire installed along the top of many recent transmission lines has given promising results, and the general opinion is that it is a benefit as a protection from lightning. It has an additional mechanical advantage in tying all the towers together and an added electrical use in connecting all the towers so that all must be at the same potential. If it is then necessary to work on a conductor on the line, this conductor can be grounded to any tower and brought thereby to the same potential with every tower, so that work can be safely carried on without danger from shock.

RELIABILITY OF SERVICE

As long as overhead transmission lines exist, as they are under the present state of the art, occasional interruptions to service will necessarily occur. It is better to recognize this and make provision to reduce the duration of interruption. An interruption once or twice a year, lasting a few minutes, will cause very little inconvenience even to the most exacting public utility. The real problem in satisfactory service is to design switching arrangements and provide spare circuits and apparatus so that when trouble does occur it can be located rapidly, cut out and service resumed at once. Resumption of service should never wait upon repairs.

One of the most important elements in case of trouble is effective telephonic communication between the various parts of the transmission system. The practice lately has been to remove telephone wires entirely from transmission towers, so that they will not be subject to trouble from the high-tension conductors. This is especially necessary on the very high voltage lines because of static induction. The latter is more difficult to satisfactorily eliminate than magnetic induction, which can usually be overcome by transposition.

The largest field for future evolution in power transmission is toward high-voltage direct current. Its advantages over alternating current from the standpoint of the line itself would be very great. The effective voltage would coincide with the maximum, and the insulator problem would be reduced 30 per cent. The number of conductors would be reduced to at most two, and possibly one with grounded return would be satisfactory. Line changing current and self-induction would cease to exist and the question of power-factor would be eliminated. The whole problem of power transmission would be vastly simplified and costs would be reduced for construction. Such a development would undoubtedly double the practicable transmission distance. This, however, is not a problem in power transmission, but one in electro-magnetic machinery, and it would involve radical developments and probably some new discoveries. The complications now necessary for the generation and utilization of high-voltage direct current are such that its general adoption would not be commercially practicable.

ARTHUR S. HUEY

Arthur S. Huey is vice-president in charge of the department of operation and management of H. M. Byllesby & Company at Chicago. Mr. Huey was born in Minneapolis, August 17, 1862. Early in life he became connected with the sales department of the Geneal Electric Company and its predecessors in the northwest. He sold much of the first heavy electrical machinery used in Minnesota and adjoining States. In 1902 Mr. Huey became associated with H. M. Byllesby & Company, and both he and that organization have achieved remarkable success. In addition to the engineering business, Byllesby & Company now operate and manage gas, electric and street railway properties in 45 American cities and towns. Mr. Huey is president of the Ottumwa Railway & Light Co., El Reno Gas & Electric Co., Consumers Power Company of Minnesota, Fort Smith Light & Traction Co., and vice-president of the Muskogee Gas & Electric Co., Oklahoma Gas & Electric Co., San Diego Cons. Gas & Elec. Co., Mobile Electric Company, Enid Electric & Gas Co.

Commercialism in the Central Station

By ARTHUR S. HUEY
Vice-President H. M. Byllesby & Co., Chicago, Ill.

The central station industry has suffered too long from lack of the genuine commercial spirit.

The real commercial spirit is to supply the needs of the public as perfectly as possible.

It is along these lines that central station management has shown its greatest weakness.

There has been no lack of invention and improvement in the electrical art. Thousands of men have labored successfully to cheapen, popularize and multiply the uses of electrical energy.*

In many instances operating companies have failed lamentably in carrying out their part of the task—in educating the consumer to the proper and wide-spread employment of the products of the inventor and manufacturer.

Instead of the judicious cultivation of the use of electrical energy by the public, too many operating companies have contented themselves with simply offering service and letting it go at that.

MUST STUDY PEOPLE'S NEEDS.

The endeavor to-day should not be to search for excuses for wrong conditions, but to probe into the demands and needs of the consumer and to anticipate constantly what he wants and can buy advantageously; also to let him know about it.

This commercialism in the central station is the force which will do as much as anything else to make popular the central station corporation.

The hostility and prejudice against utility companies throughout the country is largely undeserved. It is caused by a great deal of misunderstanding and a percentage of truth.

The percentage of truth runs from zero to proportions in rare instances, which I hesitate to estimate.

It is absurd to blame the agitators and the disgruntled and avaricious for everything. Some of our ills originate in ourselves, and the apex of folly is to ignore our own shortcomings.

I venture the assertion that at least 75 per cent. of public ill-feeling against utility organizations has been caused by the failure of operating companies to take pains to please their customers.

I am quite sure that numerous pioneers in the central station industry launched their enterprises with the idea that all they had to do was to install some machinery, string wires on poles, connect up stores and dwellings—and take in money.

Aspirations so devised either have been blasted or reformed so thoroughly that their authors could not recognize them.

We used to think that the conditions which make the central station company naturally and essentially a monopoly were bulwarks of protection.

Most of us are now convinced, I believe, that these conditions are in the nature of a two-edged sword. They are every bit as much an element of danger as they are an element of security.

Your live manufacturer or merchant succeeds because he contrives to please the public a trifle better than his competitors. So does the prosperous theatrical manager; the winning politician. They exist in their respective callings because they make a business of satisfying the consumer and constituent.

PUBLIC OPINION AND STATE COMMISSIONS.

I do not mean to say that all companies have gone to sleep on their arms and remained comatose until the storm of adverse public sentiment breaks like a thunderclap.

Hundreds of operating companies are now straining every nerve to do everything which can reasonably be expected of them. They are searching the highways and byways for means to satisfy the public. And these efforts are meeting with public recognition, although complete appreciation is a plant of slow growth.

In communities where companies have exerted themselves to render full value to consumers and have made some shift toward educating the public to the facts underlying the central station business, the public is awakening to a new sense of justice toward utility corporations.

People are realizing more than ever before that there are two sides to these questions; that the public owes as many obligations to a progressive public service organization as the corporation owes to the public.

I regret any opposition to the growing tendency toward the creation of state commissions empowered with regulatory authority over utility companies. Personally, I welcome this movement, because I see in it great opportunities for good to public and corporations alike.

So far, state utility commissions have proved mighty educative forces. Usually composed of men more or less unfamiliar with practical utility operation, it has been necessary for the commissions to study the conditions very carefully in the attempt to do justice. Not a single state commission has yet failed to be impressed with the chief claims of operating companies and to base its decisions upon broad recognition of many principles which companies vainly have tried to have the people understand.

Obviously utility commissions may be good or bad, or may be neither. So may the courts; so may every department of government, and it makes little difference what style of government is in vogue. We might as well tremble at the name of a thousand imaginary dangers as to regard the tendency toward governmental regulation of utilities with dread and apprehension.

CO-OPERATIVE EFFECT VERSUS EXPLOITATION.

With all proper regard for the sensibilities of others, I am a believer in plain speaking. I believe in admitting that things are wrong, when they are wrong, in order that curative measures may be applied without loss of time.

With far too many central station companies things have always been wrong on the commercial side of the business. Indifferent management has been to blame—the kind of management which permitted progress to overtake and pass it and to put it hopelessly out of the running.

How many managers are at the head of establishments which are pointed out to visitors in showing them the good points of a city? How many central stations are properties where strangers are taken as a matter of course in the endeavor to demonstrate the progressiveness and prosperity of the community?

You know the answer as well as I do. It is "very few."

This is a true statement, despite the fact that our central station companies frequently represent the heaviest single corporate investment in the city.

As such our companies should play active parts in the whole commercial structure of the municipality. They should be made attractive physically, admirable from the point of efficiency and court the voluntary declaration from every citizen that "Our town has one of the best electric companies in the country."

No words are strong enough to de-

*A paper prepared for the Commercial Day Program of the National Electric Light Association Convention at St. Louis, Mo., May 25, 1910.

nounce the central station management which regards the community it serves as a mere field for exploitation—as a mere machine for the coining of electric service into dollars. An attitude like this will wreck any utility organization.

The commercial field of a public service company represents an opportunity to market a product. The act of supplying the demand enhances the entire value of the community. As the community becomes more attractive it grows and develops, and as this change takes place, the value of the market increases.

In other words, the central station is a part of the economic scheme of the modern city. Logically, it should profit in proportion to the co-operative value it returns to the community.

SHOULD PARTICIPATE IN MUNICIPAL ACTIVITIES.

The central station does far more than most other commercial influence to build up cities and to fill them with peole, industries and wealth.

A prevalent notion that utility companies do little or nothing to create the prosperity which occasionally comes to them is absolutely wrong. We can afford to spend a good deal of time and money eradicating this idea.

Even companies which seem to follow reluctantly in the wake of local development rather than to participate in and stimulate the communities' activities, contribute heavily in the general development.

A central station company and its officers, however, should be in the very front rank of the wide-awake individuals and corporations who are planning and striving for municipal advancement. They should lead and point the way. They should employ their talents in helping to solve the common problems confronting their municipality.

An operating company has no business skulking along and courting privacy. Wehave no right to ask the public to "Let us alone." Our business is the public's to a large extent, and the public's business is our business in the same measure, no matter what we may say or do.

A central station organization can do far more good for itself lined up with the commercial clubs, the boards of trade and similar broad gauge bodies than it can fraternizing with peanut politicians and wasting valuable time in the attempt to manipulate political machinery.

One of our most imperative duties is to prove that the lack of direct competition in the central station industry does not result in non-progressiveness nor to the disadvantage of the consumers.

We can do this only by exerting our best resources to meet the needs of consumers in the most efficient, painstaking and beneficial way.

For competition's sake, let us combat the wrong economic theories of the socialistically inclined, the twisted facts and theories of fanatics and the assaults of our personal enemies, and do our best to win.

And winning in this kind of competition, just as in any other, will come by using our brains and *taking pains.*

The time has come to quit regarding the public as a general nuisance, and instead to treat all consumers with the confidence and respect common to ordinary business transactions.

The consumer with a complaint should not be regarded as a fool or a crook. He should be accepted as a part of the day's work to be dealt with as cheerfully and as carefully as the most persuasive effort of the new business department.

RESPONSIBILITIES LAID UPON THE COMMERCIAL DEPARTMENT.

Those who contribute most to the common good should be most liberally paid. To encourage development, there should be a dependable system of compensation.

No one knows the extent to which electricity will go in the saving of manual labor, the conservation of fuels and the cheapening of light and power and heat in their most convenient and adaptable forms.

To carry out the destiny of electricity, we need the talent of the greatest number of brilliant minds which can be induced to enter the profession. They must give up many years in preparation. If the best men are to be secured for the technical advancement of our cause they must be guaranteed substantial rewards in proportion to their success.

It is the duty of those entrusted with commercial responsibilities of the central station industry to see that this guarantee is offered. They must make the business uniformly profitable if they hope to assemble the funds which will reward inventive effort properly by the quick and universal application of improved apparatus and methods.

Only by following such a course successfully can men in charge of the commercial side of electric undertakings fill their true obligations to the public.

This line of reasoning, repeated, is as follows: The public is the party most benefited by improvements in the electric art and lessening the cost of service. Improved and cheaper service can be obtained only by holding out high premiums to inventors, engineers and manufacturers. These premiums are made possible through the profitable operation of the properties as they already exist.

The task laid upon the business end of the industry is very difficult. It calls for fully as much brain power as do the professional departments, demanding a kind of ability just as special in its features as that demanded by engineering.

It seems to me far more important that the manager be a good man of business than a good electrical engineer.

If the two capacities can be combined in one man, the acquisition is highly desirable. Usually the two kinds of special ability are not so combined.

The professional point of view often fails to appreciate vital elements which the man of affairs grasps instinctively.

As a rule, the professional mind is not well suited to dealing with the public in purely business transactions—and dealing with the public is one of the largest and hardest of the manager's problems.

WHAT THE CENTRAL STATION MANAGER OUGHT TO BE.

Permit me to quote from a recent address which I made to the managers and heads of departments of the H. M. Byllesby Companies:

"The ideal manager should be a man who understands the public better than the best politician in his city; a man who is versed in practical modern sociology, and who understands, not only big financial matters and large business ideas, but the lives of the people as well.

"Our properties are usually the largest single industry in the community. It is fitting that our managers should take a position among the leading men of the city.

"The manager should have the widest possible local acquaintance, and particularly should he be in close touch with the leaders of thought, business and progress in his community. He should study the city, its people and its prospects and its needs with unceasing vigilance.

"The ideal utility manager should be an integral part of the city; in sympathy with the aspirations of the different groups of which it is composed and foremost among the planners for municipal advancement.

"Of political entanglements he should keep free. In all local quarrels and controversies he must maintain a neutral attitude, keeping always in mind the principle that it is his duty to serve the whole community to the best of his ability.

"Too often have I gone into one of our local offices and found the manager pouring over diagrams, charts and figures at his desk, when his time should have been employed to far better advantage in dealing with broad problems of policy and management.

"Too many times I have found managers busy tinkering with some weighty mechanical problem, such as the color which meters should be painted, while important questions of public policy were being totally neglected.

"Managers should be men who can see over their desk-tops, and who refuse to let their imagination be obscured and their activities paralyzed by annoying trivialities. They should not be hampered with mechanical and professional details for which they should have competent technical men to handle.

"To get into the heart of his business, a utility manager must know a good deal about financial affairs. He must be able to plan years ahead and to weigh and consider various questions of financing and expenditure. He should understand the terms and meaning of a trust deed, for instance, and should know the best plans for securing additional capital to develop the properties."

These are a few of the things I told our own managers, and I meant every word of it.

I have been amazed, disheartened and discouraged time and again with the narrowness and inefficiency of men who posed as managers of utility properties. I have found them railing at men and conditions when they themselves were the biggest pessimists and the worst croakers in the community. I have observed them sitting like ugly frogs on a log, bewailing the state of the public mind and the cussedness of the consumer, letting their property go to pieces and their services deteriorate, creatures of weak and shameless despair.

What is more natural but that people join in throwing the handiest objects at the croaker? The impulse is human and common. The people have no use for the men or the management filled with bitterness and inefficiency—devoid of energetic action and confidence in the future.

I recognize the fact that in the smaller plants the manager must perform many duties not enumerated in my partial conception of the ideal manager, yet between the technical detail and the question of public relations, my advice is to take care of the question of public relations first, for it is by far the most important.

It is wholesome for us to try to see our faults as others see them. Try to get the other person's point of view. Let us stop complaining when we ourselves are to blame.

Are any of us so foolish as to imagine that the business of serving the public with electric service is a task in which we expect a continual succession of smiles and kind words and sweet thoughts showered upon our operating companies? The complaints, the misunderstandings and a certain proportion of ill-nature are simply parts of the game, to be looked upon as every-day business problems and to be handled without heat or hysteria.

VIEWS FUTURE WITH ENCOURAGEMENT.

It is far easier to find the man of professional training to handle technical emergencies than it is to discover the individual combining the gifts of the executive and the diplomat—the man who can succeed in popularizing his institution against overwhelming odds.

There is a sharp difference between the kind of ability which does things behind closed doors with the aid of science and the kind of ability which satisfies the multitudinous demands, needs and prejudices of a large number of people.

It does not follow that, because a man is equipped mentally so that he can construct a great central station property, he is the right man to manage the property and to make the undertaking a commercial success.

Let managers keep themselves free from petty details, particularly technical details. They should organize their force so this can be possible. Their first duty should be to popularize the company, and to see that it occupies the position in the community which it deserves, both as a right and as an obligation.

It has become a considerable problem how to obtain managers and commercial department heads for electric properties—men who possess the executive skill, the tact and the breadth of view necessary for the positions.

My personal view of the future is very hopeful and encouraging. The fact that a "Commercial Day" has been set aside by the National Electric Light Association is a splendid indication of the change which is taking place in the methods of central station management toward the public.

During the last year much educational advertising work has been done by operating companies. A large proportion of it has been effective; none without value.

Scores of new business departments have been created and equipped within a short time.

Both these movements go to show the tendency to inject the genuine commercial spirit into operating companies; to meet the people a little more than halfway and to put ourselves in tune with existing industrial and sociological conditions.

Definitions*

Ampere-Hour Meter—An instrument giving the total time integral of the amperes.

Auto Balancer—An auto transformer for equalizing the load or voltage when a three, or more, wire circuit is derived from a two-wire circuit.

Auto Transformer—A transformer in which a part of the primary winding is used as the secondary winding, or conversely.

Block Rate—Method of charging for electric service at different successive rates per kilowatt-hour consumed, each successive rate applying only to a corresponding successive block or quantity of the total current purchased during the period covered; as an example, during each month 10 kilowatt-hours or less at 15 cents per kilowatt-hour. The next 10 kilowatt-hours over the first are charged for at 12 cents per kilowatt-hour. All current in excess of the foregoing 20 kilowatt-hours is charged for at 10 cents per kilowatt-hour.

Choke Coil—A reactance used in connection with lightning arresters and placed in series with the line to be protected.

Capacity Factor—Ratio of the station output in kilowatt-hours to the maximum capacity of the station in kilowatts.

Compensated Alternator—A separately excited alternator, which automatically compensates for the drop in voltage in its armature, or in its armature or the line, by sending around its field a rectified portion of the main current, or of the current derived from a series transformer in the main circuit.

Converter—A dynamo-electric machine having one armature and one field for converting alternating current to direct current, or direct current to alternating current. The term to be preceded by the words "alternating current-direct current" (A.C.-D.C.) or "direct current" (D.C.).

Constant—(1) Of an electrical instrument is that quantity which used as a factor with indications of instruments gives results in the desired unit.

(2) Of a watt-hour meter is 3600× watt-hours passing through the circuit during one revolution of the meter disc.

Corrective Motor—A synchronous motor running either idle or under load, whose field charge may be varied so as to modify the power-factor of the circuit to which it is connected or through such modification to also influence the voltage of the circuit (this term is proposed instead of the term "rotating condenser").

Demand—Demand is a load specified, contracted for or used, expressed in terms of power as K.W. or P.

*N. A. E. L., 1910.

Demand Factor—Unless otherwise specified, demand factor shall be the maximum connected kilowatts of capacity divided into the actual kilowatts of demand, and expressed in terms of per cent.

Demand Rate—The price, or part of the price, of power charged for the demand as designated for the price paid for the kilowatt-hour consumption.

Discriminating Rate—A rate which does not give the same price to two or more customers, when all other conditions are equal.

Differential Rate—A rate consisting of two opposed factors; one tending to give a high rate and the other tending to give a low rate.

Dispersion Factor—The factor applied to light intensity after dispersion, which gives the intensity if the dispersion agent were removed.

Diversity Factor—Diversity factor shall be used to express the relation between the simultaneous demand of all individual customers and the sum of the maximum demand made by these customers; the sum of the maximum demand of the customers, no matter at what time they occurred divided into the simultaneous greatest maximum demand when expressed in per cent. will give the diversity factor.

Effective Demand—The demand taken at the time of the system's greatest maximum.

Effective Load-Factor—The meaning suggested is the main load of a part of a system determined by the load at the time of the system's maximum. This value would be infinity if the service were off at the time of the system's maximum as in the case of non-peak service. The term "effective demand" is suggested as a substitute.

Equalizing Rings—Rings connected to equi-potential points of multiple-wound armature to equalize the voltage between the brushes.

Feeder—An electric circuit, used to supply power to a station or service, as distinguished from circuits confined to a single station or used for other purposes than supplying power.

Flaming Arc Lamp—An arc lamp using carbon electrodes impregnated with some light-giving material.

Flat Rate—Method of charging for electric service only a fixed sum per month, or per annum, for a specified service, as supplying a certain number of outlets, or up to a certain maximum demand without reference to the quantity of electricity actually consumed.

Frequency Changer—A piece of apparatus for changing from one frequency to another, consisting of a motor driving either an ordinary alternating-current generator or a machine constructed like an induction motor. In the former case the term is to be preceded by the words "motor generator," and in the latter case by the word "induction."

Fuse—Electric—A conductor designed to melt or fuse at a certain value of current and time and by so doing to rupture the circuit.

Gem Lamp—An incandescent lamp using a carbon filament, which has a positive temperature coefficient or resistance.

High Frequency—A frequency so high that Ohm's Law does not apply even approximately.

Hydro-Electric System—An electric system with generator driven by water-power.

Induction Generator—A machine similar to the induction motor, but driven as an alterating-current generator.

Induction Starter—A device used in starting induction motors, converters, etc. (when they are started by voltage control), consisting of an auto transformer in connection with a suitable switching device.

Inductor Alternator—An alternating-current generator in whose armature windings the main magnetic flux pulsates but never reverses.

Instantaneous Peak—The highest value reached by the quantity under consideration as measured by some device which indicated high actual value of the quantity at every moment.

Insulator — Electric — A body or substance which offers such resistance to the passage of electric current that it is used to prevent the passage of current.

Intensified Arc Lamp—A term used for an arc lamp, with one of the carbons of small diameter to give a large current density per unit of arc, on which the arc plays to thereby intensify the light.

Leakage Reactance—That portion of the reactance of any piece of induction apparatus which is due to stray field.

Load-Factor — The fraction expressed in per cent., obtained by dividing the average load over any given period of time by the highest average load for any one minute during the same period of time.

Load-Factor Rate—A rate based on load-factor.

Low Tension—A relative term used to designate a winding or conductor of less voltage than that with which it is related or compared.

Maximum Demand—The maximum demand may be stated in kilowatts, horse power, 16-c-p. equivalents, or any other term specified, but preferably should be stated in terms which leave no opportunity for error, and wherever possible should be stated in kilowatts. Unless specified, it shall always mean absolutely the greatest actual maximum demand. If the greatest actual maximum demand is not intended, but it is intended to express the greatest maximum demand for a given day or a given minute, then it shall be so stated.

Maximum Instantaneous Demand—The highest load reached as measured by indicating or recording instruments at any moment.

Maximum Simultaneous Demand—A maximum simultaneous demand shall be used to express the greatest absolute aggregate sum of certain individual demands, such as

(a) Customers,
(b) Classes of customers,
(c) Classes of current,

and all rules made to define maximum demand shall apply to simultaneous maximum demand.

Momentary Peak — The highest average load carried during any fifteen seconds of a specified period.

Moonlight Schedule—A schedule of burning hours for lamps which are not lighted when the moon shines.

Non-Peak Rate—See "Off-Peak Rate."

Off-Peak Rate—A rate conditioned on the non-use of service during specified hours of central-station peak-load.

Operating Time-Factor—The ratio of the number of hours of operation to the number of hours in the interval considered. This can best be fixed by an example: There are 8760 hours in the year. If a given shop operates ten hours a day, for 300 days in a year, it may be said to have an operating factor of 34.11 per cent.

Operating Time Load-Factor—The load-factor considered only during the time of operation. This can also best be defined by example, and would be used to express the load-factor for the running time of a shop. That is, if a shop operates ten hours a day and 300 days in a year, the divisor would be 3000 hours, or such other number of hours, as represented the time of running instead of the usual divisor of 8760 hours in the year.

Peak—The highest average load carried during one minute of any specified period.

Peak-Load—The highest average load carried during one hour of any specified period.

Power-Factor Indicator—A device to indicate the power-factor of an electric current.

Primary—That winding of an induction motor or of a transformer

NOTE.—In the case of momentary peak load-factor, peak-loads, the terms may be preceded for the qualifying terms "hourly," "daily," "monthly," "yearly," etc.

which directly receives power. The term is to be preceded, in the case of transformers, by the words "high voltage" or "low voltage," in the case of induction motors by "rotating" or "stationary."

Quantity Increment Rate — See "Block Rate."

Quarter-Phase—A term implying the supplying of power through two circuits. The vector angle of this voltage is 90 degrees. This term is recommended instead of the term "two-phase."

Reactance Coil—A coil for producing difference of phase or for eliminating current.

Recording Ammeter, Recording Voltmeter, Recording Wattmeter—Instruments which make upon a chart a continuous record of the value of quantities they measure.

Regenerative Arc Lamp—A flaming enclosing arc lamp in which the products of combustion are circulating and brought rapidly in contact with the arc. The objects accomplished thereby are:

1. To conserve the heat;
2. To condense and deposit the solid products of combustion where they will not obstruct the light, and
3. To exclude the oxygen and utilize rapidly the chemicals in the circulating gases.

Reverse-Current Relay—A relay used on a direct-current circuit, which operates when the current flows in the direction opposite to the normal direction.

Reverse-Power Relay — A relay which operates when the power in the circuit flows in the direction opposite to the normal direction.

Rotor—The rotating, whether primary or secondary, of any alternating-current machine.

Secondary—That portion of an induction motor or of a transformer which receives power by induction. The term is to be preceded by the same words as in the case of "primary."

Simultaneous Demand—The sum of the demands of a number of services occurring at the same time.

Simultaneous Demand Factor—The ratio of the simultaneous demand divided by the connected load.

Simultaneous Maximum Demand—See "Maximum Simultaneous Demand."

Static Converter—A term not recommended for a transformer.

Stator—The stationary member, whether primary or secondary, of any alternating-current machine.

Step Rate—Method of charging for electric service at definite successive rates per kilowatt-hour consumed. Each rate applying to the entire quantity purchased during the period covered. As, for example, during each month 10 kilowatt-hours or less at 15 cents per kilowatt-hour. If over 10 kilowatt-hours and less than 20 kilowatt-hours are used all are charged for at 12 cents per kilowatt-hour. If 20 or more kilowatt-hours are registered during the month, all are charged for at 10 cents per kilowatt-hour.

Strain Insulator—An insulator used for the double purpose of taking the mechanical strain at a bend or at the end of a conductor, and also insulating the same electrically.

Synchronism Indicator—A phase indicator. A device for indicating the phase relation or the condition of synchronism between two or more periodic quantities.

Synchroscope—A synchronizing device which, in addition to indicating synchronism, shows whether the machine is synchronized fast or slow.

Transformer—A stationary piece of apparatus for transforming, by electro-magnetic induction, power from one circuit to another, or for changing, through such transformation, the values of the electromotive force.

Turbo-Generator—A steam turbine coupled to an electrical generator.

Voltage Regulator—A device for regulating or varying the voltage of a circuit. When it consists of a transformer (whose primary is in shunt to a circuit and whose secondary is in series with the circuit), whose ratio may be varied, the term is to be preceded by the term "induction" or "contact," according as the voltage is varied by changing the amount of magnetic flux between the primary and the secondary, or by changing the number of turns in the secondary in series with the circuit.

Voltmeter Compensator—A device used in connection with a voltmeter to make it read low by the amount of the line drop, and thus cause it to indicate the voltage delivered at the end of the line or at any other predetermined point of the line.

Watt-Hour Meter—An instrument giving the total time integral of the watts.

Wattless Component Indicator—A device for measuring the product of voltage of a circuit, and the component of current at 90 degrees with the voltage. This product is the heating effect in excess of the heating that would be given by a circuit of the same voltage and power at 100 per cent load-factor. The device is a wattmeter with coils connected to measure volts times current at 90 degrees from the voltage phase.

A course of lectures on illuminating engineering will be given at Johns Hopkins University, October 26, November 8, 1910. There will be 36 lectures by the ablest men in the profession. Admission fee will be $25 plus the laboratory charges.

The Wilmington City Electric Co. has suffered a loss of $50,000 by lightning entering the power station.

National Electric Light Association Officers

The National Electric Light Association has chosen the following officers: President, Mr. W. W. Freeman, Brooklyn; first vice-president, John F. Gilchrist, Chicago; second vice-president, Frank M. Tait, Dayton; executive committee, Alexander Dow, Detroit; H. A. Wagner, Baltimore; W. C. L. Eglih, Philadelphia; treasurer, Gen. Geo. H. Harries, Washington; secretary, T. C. Martin. Chas. H. Hodskinson, Boston, is the newly appointed master of transportation.

New Developments in Selectors for Train Dispatching

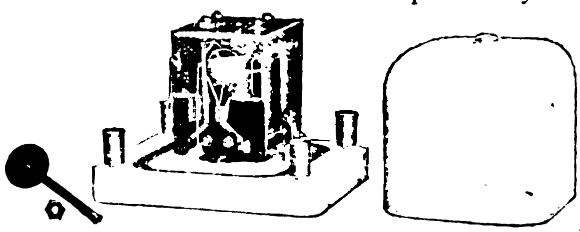
Since the introduction of the telephone for train dispatching, numerous selective devices for signaling the stations have been proposed and have been used with more or less success.

The Western Electric Company, which has furnished more than 90 per cent. of the telephone equipment used for this service, is now prepared to furnish a selector of its own design and manufacture, so that customers can obtain a complete Western Electric train dispatching equipment.

The new selector is the simplest device available for this service. It consists of a simple step-by-step mechanism with but one contact, and is free from all relays or local batteries. It is not polarized and operates at a high speed with absolute accuracy.

The selector is compact and is enclosed by a glass dust-proof cover. The selective system, including the bells at the stations, is operated from a battery located at the dispatcher's office, thus reducing the maintenance charges.

If desired, the bells at the station can be operated by local batteries.



The Voltage Control of Generators and Feeder Systems

By F. W. SHACKELFORD

In our consideration of this subject, we will discuss only alternating-current systems as the method most commonly used.

The study of central-station conditions may be classified under three heads:

1st.—The source of energy.
2d.—Its generation.
3d.—Its distribution.

The first has no part in this paper, but in the construction of a station it bears a most important relation to the second. The selection of the kind of energy—that is, whether coal, gas or water power, will, of course, depend upon the existing conditions, but I wish to point out that the selection is made only after a most careful consideration as to economical operation. The generation of electrical energy comes most vitally into our consideration, and, to a large extent, the form of generating units will be dependent upon the system selected in the first case.*

Assuming that the speed and regulation characteristics of the generating units have been most carefully selected, we are still confronted by the fact that the station may be required to deliver current not only for lighting, but also for power and electric railways. The power and railway loads can, in general, be readily handled during the day hours, but always conflict with the lighting peak, and during the winter months considerably overlap it. Many plants are required to furnish lighting during the entire day and are consequently more difficult to handle. Without some form of automatic voltage regulator it is impossible to take care of the heavy swings in voltage caused by fluctuating power and railway loads. Even in the case of purely lighting loads it is an exceedingly hard matter to take care of the voltage properly by hand regulation, and especially so at peak load. It is essential, therefore, for good service and economical operation of the generators to automatically control their voltage.

Accurate generator voltage regulation means that the exciters and generators deliver energy in exact proportion to the demands made upon them. A slight increase in voltage of a large station means increased losses in transformer cores; likewise a decrease in voltage at maximum station load means actual losses in revenue. Many forms of generator voltage regulators have been developed, but on account of the many variable elements entering into the problem few have met with any great success.

Regulators have been designed which operate directly on the alternating-current generator field rheostat by varying the resistance. Such a scheme may be made to give fairly good results where only one generator is concerned, but at best it is sluggish and not anti-hunting. With any such scheme it is impracticable to operate two or more such devices in parallel, where more than one generator is operated on the same bus, on account of hunting and cross currents.

It is always best from a standpoint of regulation to operate both the generators and exciters in parallel, or groups in parallel, by which it is possible to regulate all of the machines from a single regulator.

The most successful and best-known device for this purpose is the Tirrill type of generator voltage regulators. The principle of operation, etc., of this type of regulator is so well known that I do not consider it necessary to dwell upon it. For convenience, however, I have shown an elementary diagram of its connections in Fig. 1, and given below an outline of its method and cycle of operation.

The regulator contains a direct-current control magnet and a relay, the former being connected to the exciter 'bus bar. This magnet has a fixed core at the bottom and a movable core at the top, the latter being attached to a pivoted lever, on the opposite end of which is arranged a flexible contact. Opposite the direct-current magnet is the alternating-current control magnet, which is provided with a potential winding connected through a suitable potential transformer to the alternating-current bus bar. In addition, the control magnet is provided with a compensator winding, which in the elementary diagram is shown connected to a current transformer placed in the principal lighting feeder. This compensating winding is adjustable, so that any degree of compensation from 1 to 15 per cent. may be obtained depending on the requirements of the line. The core of this magnet is movable and is attached to a pivoted lever, on the opposite end of which is arranged a contact similar to that of the direct-current magnet and in combination with which it forms what is known as the "Floating Main Contacts." These contacts control one of the differential windings of the relay magnet, the other winding being permanently connected across the exciter bus, as shown.

The relay windings have a "U"-shaped magnet core and a pivoted armature, the latter controlling the relay contracts which are connected across the exciter field rheostat. To prevent destructive sparking at these contacts condensers are connected across them.

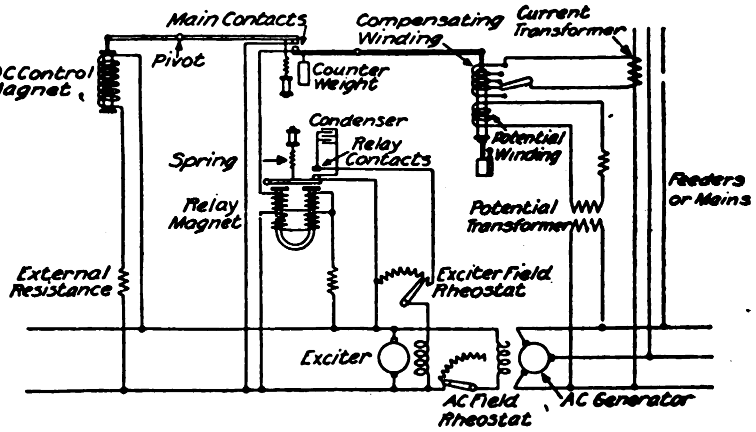


FIG. 1

CYCLE OF OPERATION.

The shunt circuit across the exciter field rheostat is opened by means of a single-pole switch located at the bottom of the regulator, and the rheostat is set until the alternating-current voltage is reduced 65 per cent. below normal. This reduction in voltage weakens the alternating-current magnet, whereupon its core will fall and cause contact to be made with the upper main contact carried by the di-

* N. E. L. A., 1910.

rect-current main control magnet. This latter magnet has also been weakened, thus allowing a spring to pull down its contact lever, affecting a definite closure of the floating main contacts. The closing of these contacts completes the circuit of the other winding of the relay, the magneto-motive force of which opposes that of the permanently connected winding, thus demagnetizing the relay core and releasing the armature. With the release of the armature the relay contacts are closed, due to the action of

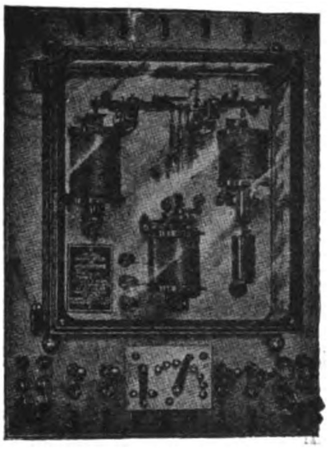


Fig. 2.

a spring connected to the armature. Then upon the closing of these contacts the exciter field rheostat will be short-circuited, thus building up the exciter voltage rapidly until the alternating-current voltage becomes normal, at which time the upward movement of the alternating-current magnet core and the downward movement of the lower main contact will cease. The direct-current control magnet will then open the floating main contacts, which in turn opens the relay contacts, thereby inserting the resistance in the exciter field circuit. This tends again to lower the exciter voltage, causing a closure of the main and relay contacts, and in this way they will continue to vibrate at a high-rated speed, maintaining a steady exciter voltage and a constant alternating-current voltage.

It will readily be seen that the number of relays depends mainly upon the characteristics of the exciters and, to a large extent, upon that of the generators. The number of relays applying to any particular installation is determined after carefully considering the following points: The normal and maximum voltage of exciters; the exciter field amperes at each of these voltages; the excitation volts required for the generator fields at no load and full load, taking into account the power factor at maximum load and the speed regulation of the generators. With such variable features, it is a hard matter to set a general rule for determining the proper number of controlling relays.

These regulators are now designed with from 1 to 24 relays, and I believe it would be safe to say that with a properly designed station equipment the largest regulator would take care of an output of from 50,000 to 60,000 kw. For reference, I have shown in Fig. 2 the smallest and in Fig. 3 the largest types of regulators.

Before leaving this subject, it might be well to mention that, by installing one regulator on each side of the system, this type of regulator has been adapted to the control of direct-current stations and has also proven most successful in the control of three-wire direct-current systems where the neutral is derived by using two 125-volt generators.

These regulators have also been adapted to the control of power factor and have been used successfully on long transmission lines in connection with synchronous condensers for boosting the power factor and the voltage.

We now come to the third consideration, namely, that of the feeder systems of distribution.

It would seem as though, in some instances, after the power and generating plant had been constructed and the lowest cost per kilowatt obtained at the switchboard, the feeder systems had been laid out indiscriminately. It should, however, be borne in mind that a station may lose in the feeding system that which has been saved by carefully designing and selecting prime movers and generators. It is in the feeding system and the distributing net-work that we suffer the greatest losses, having to consider both transformer losses and the loss in the lines. Without regulators it becomes a question of putting up not the most economical copper, but copper of such section as will take care of the drop within at least 2 per cent.

Such a great section of copper could, in a large number of cases, be avoided by the use of regulators, and it is, therefore, a question of the cost of copper only to keep the drop within that required, as against the cost of the most economical copper plus the cost of regulators.

Considering that a station has designed its feeders with a 2 per cent. drop to the centers of distribution, we also find it necessary to deal with the fluctuations on each individual feeder, which cannot be compensated for even by increasing the copper.

In any city of average size, we have three distinct groups of lighting consumers:

1st.—Business.

2d.—Manufacturing.

3d.—Residence.

It is practically impossible to regulate the voltage of the generators at the station so that the voltages at the centers of distribution in each of these three divisions are approximately normal. The lighting of the business section in nearly every case demands first attention, and as its load is generally at peak in advance of that of the others its voltage could be maintained fairly well, while that of the other sections would be, with few exceptions, above normal.

The following curves will serve to give you a clear idea of the performance of incandescent lamps. Fig. 4 shows the life of the lamp in percentage, the normal life being taken at 100 per cent., at 100 per cent. voltage. Fig. 5 shows the power consumed by a lamp in percentage, corresponding to the voltage in percentage. Fig. 6 shows the candle-power of a lamp corresponding to the percentage of voltage applied to its terminals.

It will be noted the life of a lamp is affected most seriously by increases of voltage. This becomes a source of much expense to a station giving free

Fig 3.

lamp renewals and much trouble to those which do not supply lamps free, as it then becomes a burden on the consumer, which in turn reacts on the station.

The useful life of a lamp at 4 per cent. excess voltage is only 45 per cent. of the life at normal voltage.

On the assumption that the average

lamp is operated at 4 per cent. excess voltage for one-half the time, and at normal voltage the remaining time, this condition would decrease by one-

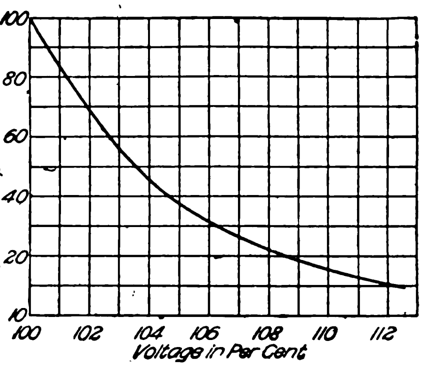


FIG. 4

third the life of the lamp. On the further supposition that each connected lamp is used two hours per day, 300 days per year, and that the average useful life of a lamp is 800 hr., the excess cost of lamp renewals is shown in the following tabulation:

Total Number of Lamps Connected	Total Lamp Renewals at Normal Voltage (800 Hours)	Total Lamp Renewals Under Conditions Given (532 Hours)	Cost of Excess Renewals Taking Cost a 10 cents per Lamp
10,000	7,500	11,200	$37C
20,000	15,000	22,400	740
30,000	22,500	33,600	1, 110
40,000	30,000	44,800	1,480
50,000	37,500	56,000	1,850
100,000	75,000	112,000	3,700
500,000	375,000	560,000	18,500
1,000,000	750,000	1,120,000	37,000

By reference to Fig. 5, it will be noted that the decrease in power consumed by a lamp at reduced voltage is in the ratio of 2 to 1—that is, a 2 per cent. drop from normal voltage results in a 4 per cent. loss in power.

This fact may be insignificant when considering a single unit, but its importance will be appreciated by the tabulation given below, which shows a direct loss to a station without beneficial or compensating features.

Assuming, as in the previous case, that each lamp is used two hours per day, 300 days per year, and that the voltage is maintained at normal one-half the time and 4 per cent. below normal the remainder (which latter condition would necessarly occur at peak load) the average loss in power for the total time is 4 per cent. On the basis of using 56-watt lamps, and taking the average selling price per kilowatt-hour at 9 cents, the loss per year is as follows:

Total Number of Lamps Connected	Anticipated Revenue per Year	Loss in Revenue per Year Resulting from Above Condition
10,000	$30,240	$1,209
20,000	60,480	2,418
30,000	90,720	3,627
40,000	120,960	4,836
50,000	151,200	6,045
100,000	302,400	12,090
500,000	1,512,000	60,450
1,000,000	3,024,000	120,900

The candle-power of a lamp is affected most seriously by a decrease in voltage, and because of the poor and variable illumination is often the cause of righteous indignation on the part of the consumer. The watchword of any station should be "good service," whereby is gained satisfied customers and increased business.

Feeder circuits, like individuals, have their own characteristics, and when the load on a feeder becomes of importance it is necessary to regulate it individually.

It is apparent from the foregoing that the need of regulation would develop many schemes for correcting voltage troubles. Some of the schemes proposed embody the use of a permanent boosting transformer to take care of peak conditions, or the use of two transformers, one with saturated and the other with unsaturated cores, the primaries opposing and the secondaries in series, thus boosting the voltage as the load increases. Each of these schemes present several objections, which I believe are so well understood that it is un-

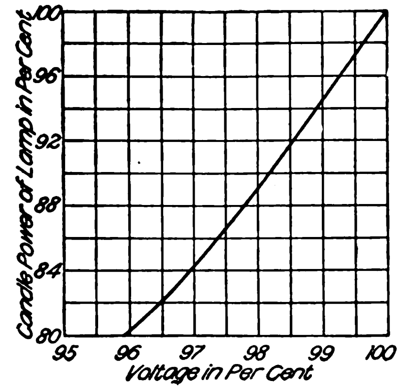


Fig. 5.

necessary for me to take up your time in explanation.

Of all the methods tried, that of a variable ratio transformer is the only one which has given satisfaction. This may be a standard transformer with primary in shunt and secondary in series with the circuit to be controlled, the secondary being provided with a number of taps which are connected to a dial switch or controller, so that the line voltage may be raised or lowered, as required. The induction type of regulator is essentially a variable ratio transformer, but instead of the voltage being raised or lowered in a few steps the voltage is adjusted by almost infinite steps.

Such devices may be hand, motor or automatically operated. The hand and motor operated, however, are necessarily dependent upon the station operator for service, while the automatic regulator when once adjusted for line conditions is always on the job.

I desire to describe two particular automatic regulators, one of the switch, the other of the induction type.

INDUCTION TYPE.

The induction regulator is built in both the single-phase and poly-phase types, and its automatic operation is effected by an auxiliary contact-making voltmeter so connected to a potential and current transformer that a rise or fall of line voltage from a predetermined value will cause contact to be made in a relay switch, this in turn closing the circuit of a small motor, which is mounted directly on top of the regulator case and which drives the regulator armature by means of suitable gearing. The primary contact-making voltmeter is shown in Fig. 7.

This regulator comprises two separate and distinct windings arranged on concentric laminated cores, as shown in Fig. 8. The primary or shunt winding is mounted on a vertical shaft, which can be partially rotated and which is enclosed by and separated from the secondary or series winding by a small air-gap.

The shunt winding produces a magnetic flux that has a constant value, the direction of which is fixed with relation to the movable core, but variable with respect to the secondary core and consequently with respect to the series or stationary winding. This flux, when passing through the secondary coils in one direction, induces a potential in these coils which is added directly to the line potential, or which, when the direction of the flux is reversed by rotating the primary core through an angle of 180 degrees, is subtracted from the line potential.

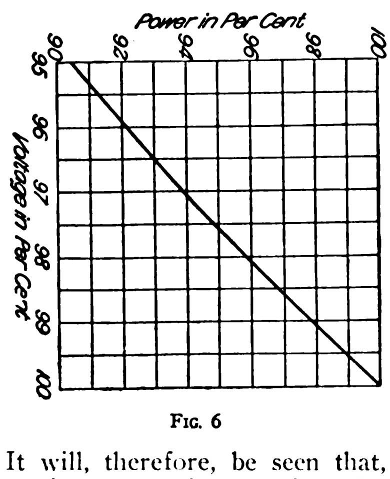


FIG. 6

It will, therefore, be seen that, as the primary core is rotated gradually, the direction and amount of the flux is varied, this variation producing a graduated potential in the secondary from maximum boost, through zero, to maximum buck.

SWITCH TYPE.

The automatic switch type as manufactured by the General Electric Company and styled "BR" is radically different from a step-by-step dial switch regulator. This regulator is oil-immersed and its coils are assembled on the shell type of core, its operating mechanism is mounted on,

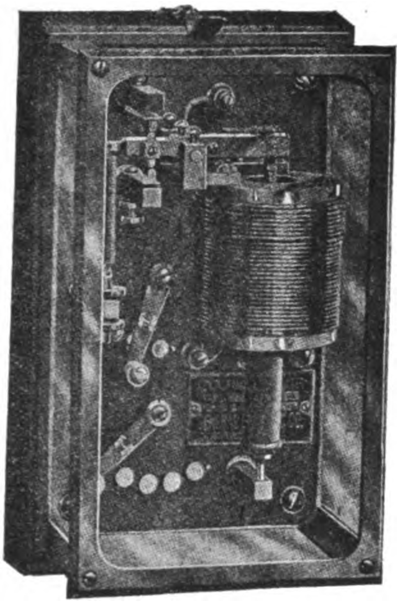


Fig. 7.

and the core and windings suspended from, the cover. This type of regulator is shown in the internal connections in Fig. 9.

As the only moving element is a small switch-arm having little inertia, and the only torque is the friction of a number of small contacts, it will be seen that the switch can be shifted to different positions very quickly. The moving part consists of a metal carrier, which has mounted on it 10 fingers insulated from each other. These fingers bear on the contacts of the stationary part and are also connected to 10 collector rings on the central stationary part. It will be seen that several of these fingers are in contact with the stationary contacts at the same time, and in order to prevent a short-circuit a small resistance is connected between them. This resistance limits the flow of current between different taps, and by such construction a gradual boost or lower is obtained with no sparking at the contacts, as the circuit is never broken. The operating motor, which runs continuously, is of the single-phase, self-starting type and is geared direct to the horizontal shaft carrying two positive mechanical clutches, one or the other clutch being thrown into mesh by the action of its alternating-current control magnet, which in turn is energized by the closing of the circuit through the contact-making voltmeter shown in Fig. 7.

Fig. 10 shows a section of a voltage chart, the upper line representing the incoming voltage to a substation carrying both light and power, and the lower line the regulated voltage as delivered to the load.

The demand for quick operating regulators has become most pronounced within the past two years, due probably to variable and mixed power requirements and the further extension and application of electrical power for various purposes. For this reason the two types of regulators described above have been designed with a view to obtaining the maximum speed of operation. The switch type or BR is capable of completing the entire range of boost and lower in from three to four seconds, and the induction type covers the same range in 10 seconds.

Now, as to the method of applying such regulators to different systems, it will be necessary to discuss briefly the following systems of distribution:

1st.—Single-phase.
2d.—Two-phase, three-wire and four-wire.
3d.—Three-phase, three-wire and four-wire.

SINGLE-PHASE SYSTEM OF DISTRIBUTION.

The single-phase system of distribution is very simple and has been widely used in the past for lighting circuits. In such a system it is only necessary to supply one single-phase regulator to each feeder.

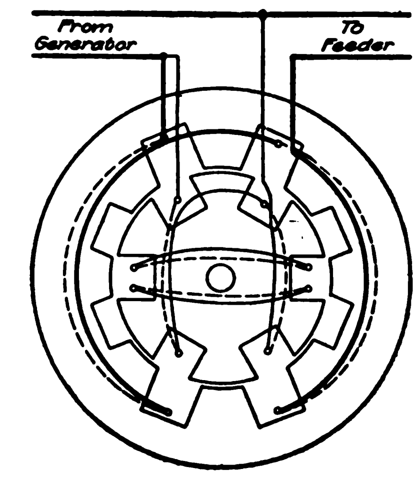


Fig. 8.

TWO-PHASE SYSTEM OF DISTRIBUTION.

The two-phase system of distribution may be divided into two classes, *i. e.*, two-phase, three-wire, and two-phase, four-wire. The two-phase, three-wire system possesses an advantage over the single-phase in that it can take care of a power load as well as a lighting load. In applying regulators to such a system it is necessary to use two single-phase regulators, since under certain conditions the load on one phase tends to unbalance the voltage of the other phase.

The two-phase, four-wire system, which is established by inter-connecting the phases at the middle point or by maintaining the phases entirely separated, is an improvement over the two-phase, three-wire system. It is preferable to operate the phases entirely separated, and the application of regulators is made by installing a single-phase regulator on each phase in cases when the phases are not balanced, and by using a quarter-phase regulator where the phases are practically in balance. In some stations it is advantageous to use both methods of regulating, though this is an exception to general practice.

THREE-PHASE SYSTEM OF DISTRIBUTION.

The three-phase system of distribution can be either three-wire or four-wire. In applying regulators to a three-phase, three-wire system it becomes necessary, in case the three phases are unbalanced, to employ three single-phase regulators, one in each phase. Wherever practicable, however, it is advisable to use only one phase of a three-phase feeder to handle the lighting load, installing a regulator in this phase and letting the other two phases shift for themselves. Where a three-phase power load is regulated it is desirable to distribute the load, so as to maintain as nearly as possible a balanced system, and therefore to use a three-phase regulator for controlling it.

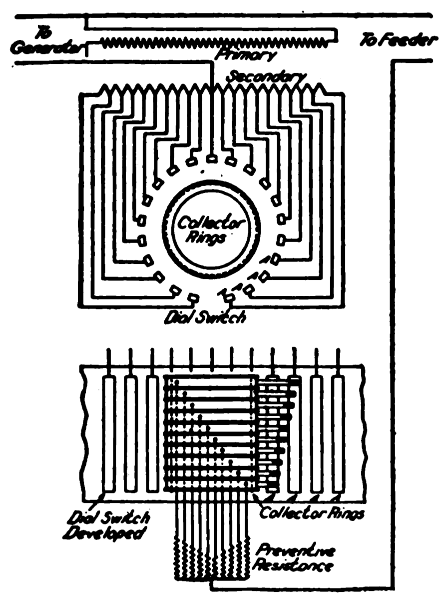


Fig. 9.

Where the three-phase, four-wire system is used, it is generally necessary to employ single-phase regulators, one in each leg, operating be-

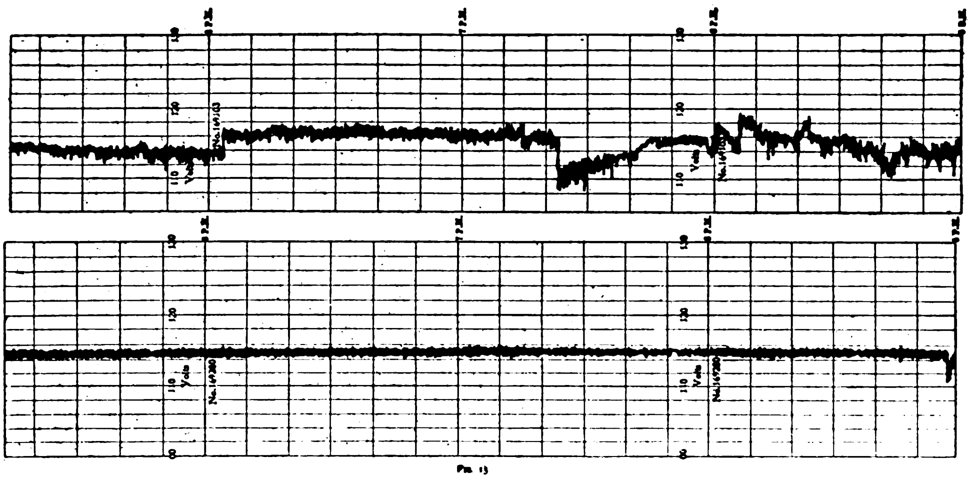


Fig. 10.

tween this leg and the neutral wire. However, by properly balancing, it is possible to employ a single three-phase regulator on each feeder.

Residence Lighting

H. J. GILLE

Residence lighting is among the most important subjects confronting central-station men to-day, as it is the largest undeveloped field for the use of our product. The development of this business has received little attention by central-station men until recently. Most of our development work has been centred on commercial lighting and power, which is probably due to the fact that it apparently produces larger returns on our investments.*

Residence lighting does not differ materially in different cities. The density of population may vary somewhat, but so far as the use of light in the individual home is concerned, it is practically the same. The use of heating devices and fans may vary, but this does not materially change the average results. In the average city, where commercial lighting and power have been developed, the peak of this class of business comes on earlier in the evening than the peak for residence business, so that the increase in residence business does not increase proportionately the demand on the station and distribution system.

From data which has been presented to this Association at previous Conventions it would appear that less than 50 per cent. of the residence lighting peak overlaps the commercial lighting and power peak. We should, therefore, be able to improve very greatly our total station load-factor by means of this class of business and thus assist in reducing the average cost of production and distribution of all our business.

In serving a large number of residence customers the question of relation between the total of the individual customers demands and the total station demand (being known as the diversity factor) is a very important matter, because it determines to a large extent the relative cost of furnishing this class of service. This ratio is to some extent dependent upon the number of customers served as well as the class of homes; separate dwellings having a different ratio from flats, and small houses different from large. The difference in these classes from the standpoint of cost to serve is, however, not so great as to prevent the establishing of a general class of residence lighting independent of commercial lighting.

There is not sufficient data available to form any very definite conclusions; but from what has been presented to commissions and from discussions at various conventions, the diversity factor for residence lighting appears to vary from 1:4 to 1:5. It seems certain that it does not require much more than about one quarter of a kilowatt of station capacity for every kilowatt of consumer's demand based on the total residence lighting load. It is therefore obvious that if our average revenue for each residence consumer is $20 per year, and the average consumer's demand is one kilowatt, the average gross revenue per kilowatt of station demand would be $80 per year. This total revenue is not far from the average gross revenue per kilowatt of maximum station demand at the present time, for combined commercial light and power, when the diversity-factor between these classes is taken into consideration.

Residence lighting is, therefore, not only profitable in itself but makes our present business more profitable. Therefore, I think, we should have, not two general classes of service, light and power, but three—commercial lighting, power and residence lighting—and if all three are well developed it will be found that each class bears a definite relation to the total station demand and contributes to the increase in load-factor, which we are striving to obtain.

Only during the last few years has the development of residence lighting received special attention. Many of our companies still maintain a rather indifferent attitude, showing little or no desire to develop this line of business; the reason probably being a general impression that it is unprofitable.

It may be interesting in this connection to consider roughly the possibilities of this class of business. According to reports, over 50 per cent. of the population of the United States lives in cities and villages; therefore, with our population of approximately 80,000,000, about 40,000,000 people or 8,000,000 families are prospective users of electric service. If we assume an average of 15 50-watt lamp equivalents per family, it appears that the total prospective business amounts to 120,000,000 50-watt lamps or 6,000,000 kw. of connected load, not including heating devices. At the above diversity factor of 1:4, the station capacity required to furnish this service would be 1,500,000 kw., and on the assumption, of an average gross earnings per family of $20 per year, the total gross earnings from this business would be $160,000,000 per annum. Of course, it is difficult to state just what proportion of this business is developed, but I think it is safe to say that it is very small. Hence, if we assume that these figures are even approximately correct, it is very evident that an enormous field for the use of our service has practically been neglected.

Aside from the economic question of residence lighting, every public utility assumes an obligation when it undertakes to furnish the public with any service. The position it occupies in a community, therefore, depends not only upon its furnishing good service at reasonable rates but upon how well it serves that community. We realize fully the necessity of occupying

* N. E. L. A., 1910.

the territory, as the success of any public utility depends to a very large extent on the greatest good that will come to the greatest number. Therefore it must be evident that it is not only profitable but highly desirable to develop residence business. In order to accomplish this it is necessary that the public should understand our rates, our methods of production and distribution, the conditions surrounding the furnishing of service, and the best and most economical manner of using it, as well as the great benefit to be secured from its use.

How can we best accomplish this? How can we expect the public to know all about these things unless we tell them? How are we going to get their confidence and support unless they understand, in some measure, the inside facts? The people are eager to learn; they are interested in things electrical. The only danger lies in the fact that they are likely not to learn the truth, and we should tell them the truth in language they can understand. This resolves itself into a question of education, covering not only the conditions surrounding the furnishing of electric service but particularly the use of such service. People are not as familiar as they should be with the great comfort and many conveniences and benefits made possible through the proper installation and use of electric light and electric labor-saving devices in the home. They understand only in a general way the convenience, cheerfulness and cleanliness of electric light, and the desire for its use in a general way exists. This desire has been very largely increased during the last year through the introduction of high efficiency lamps and the advertising campaign carried on all over this country, not only by central-station companies, but by manufacturers of lamps and other current-consuming devices.

There can be no question regarding the benefits to be derived from electric service by our customers. The healthfulness, cheerfulness and cleanliness, the convenience, safety, artistic effect and economy of electric light in the home cannot be equaled with any other illuminant. The effect of these benefits cannot be overstated, and these with the comparatively recent development of labor-saving devices make electric service in the home seem almost a necessity. As the public becomes familiar with the possibilities of this service increased development should inevitably follow.

The question of rates is, of course, a very large factor in popularizing electric service in the home. I do not wish to enter into a discussion of the rate problem, but simply to say that any rate fixed should accomplish maximum development at maximum profit; in other words, it should establish a fair balance between consumer and producer, one which will permit the use of current liberally by the consumer, and compete, all things considered, with any other method of producing similar results. It should encourage the use of electrical appliances of all kinds in the home without separate meters for such appliances. It should be simple, because the people fear the thing they do not understand.

The development of residence lighting presents many interesting problems that are materially different from commercial lighting. Convenience and economy depend largely upon the proper location of switches. It is therefore important that the wiring be properly laid out before the work is done. The outlets, the style of fixture, the kind and size of lamps, are all more or less controlled by decorations and furnishings.

In the past, when combustible illuminants were used, it was necessary to place these far enough from the ceiling to avoid danger from fire and damage to decorations. This has been entirely changed through the introduction of electric lights, especially since the introduction of high efficiency units and artistic fixtures for their use.

We must not forget that many considerations outside of our immediate field are factors in a residence installation. Interior decoration should be the consistent relationship between light, color, form, proportion and dimension. In music it is an established fact that certain notes used in pleasing combination produce sounds we call harmony; unless the right notes are struck our sensibilities are jarred. In the use of light and color the same immutable law applies. No more delightful harmony of color can be imagined than that provided by nature; it starts in with the brown of the earth and runs into several shades of green, and from that touches upon yellow and from yellow to orange, from orange to red, and red to violet, and from violet to the blue of the sky.

Learned scientific men have put forth remarkable statements concerning the physiological influence of color. An eminent London physician spoke highly of the beneficial effect upon the nerves and the eye of soft-toned greens; vivid yellow produces exhilaration and confidence; violet tones have a tendency to depress; softened or broken white is quieting to the brain of the busy man; quiet tones in the sleeping room are soothing and delightful. The effect upon the brain where a color treatment has been carried out not consonant with the personality of the occupant is more serious than is generally realized, as it extends to the entire system. The constant dropping of water wearing a stone illustrates this action of color upon the nerves of the brain. The constant presence of irritating color is so real as to produce physical distress, and medical aid is often called in when what is really needed is a change of wall paper.

Many houses are left in white for a year or more until the new plaster settles. In this condition a small unit of light is sufficient; but when the decorator completes his work, adding fabrics and wall-paper which absorb and diminish the light, the consumer does not always comprehend why his lighting bills increase, being unaware that the cause is his taste for dark-colored furnishings. These facts must be understood to be remedied, and it remains for the illuminating engineer to learn by experiment the value of light as it affects or influences color, as well as the value of color as it affects light, in order to determine the amount of light required to produce the best results.

The development of residence lighting, therefore, depends not on the economic question only, but upon the character of the light, its color influence and the structural character of its introduction. Any plan to develop residence lighting must include the co-operation of architect, contractor, fixture dealer and decorator. They are important agents in the proper installation and arrangement of the electrical equipment, and are in a position to materially assist us in bringing to the attention of the public the value of electric service in the home.

The public uses our service, not from compulsion but from choice. The desire for it may in a general way exist, but through some misunderstanding, fear of danger, high cost of current, cost of installation, lack of information regarding proper methods of wiring or use of current, or numerous other reasons, the choice be delayed. It is therefore necessary to prosecute a vigorous campaign of well-planned publicity in addition to energetic and enthusiastic personal solicitation to correct erroneous impressions and properly place the true merit of our product before the public.

Mr. John Boyer has been appointed Superintendent of the Marion, Ohio, Railway & Light Co.

Arthur Williams sailed June 9 for a ten-week tour of Europe.

The annual convention of the A. I. E. E. will be held at Jefferson, N. H.

Methods of Deriving the Neutral for Direct-Current Three-Wire Systems

JAMES R. WERTH, JR.

The direct-current three-wire system of distribution furnishes relatively low voltage suited to incandescent lamps of moderate candle-power, and at the same time offers the economy incident to the distribution of energy at a higher voltage. In selecting the generating apparatus for a plant of this kind engineers have the choice of several different types and combinations of machines.*

The purpose of this paper is to compare the several types of generating apparatus with particular reference to the method of deriving and controlling the neutral. Three-wire systems are generally operated at approximately 250 volts between the outside wires, with half that voltage between either outside and the neutral wire; therefore a 250/125-volt system has been selected as the basis for the comparisons made in this paper.

The following order will be observed in making these comparisons:

(A) One 250/125-volt three-wire generator with collector rings and compensator.

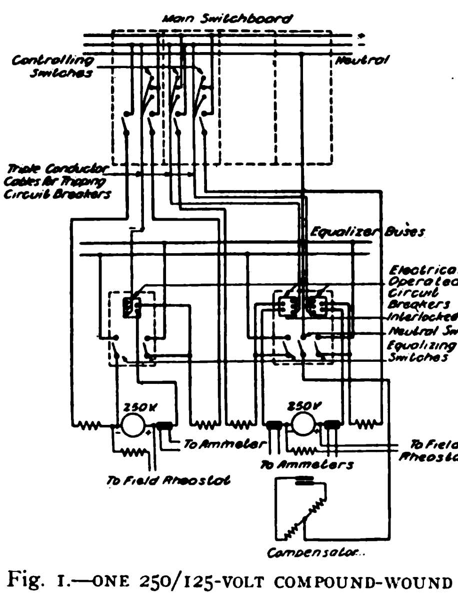


Fig. 1.—ONE 250/125-VOLT COMPOUND-WOUND THREE-WIRE GENERATOR WITH SINGLE-PHASE COLLECTOR RINGS AND COMPENSATOR; ALSO CONNECTIONS WHEN RUN IN MULTIPLE WITH 250-VOLT GENERATOR.

(B) One 250/125-volt three-wire generator with auxiliary winding in the main armature slots, and one collector ring.

(C) One 250-volt two-wire generator with motor generator balancer set.

(D) Two 125-volt generators in series, each having half the kilowatt capacity of "A."

(E) Rotary converter with step-down transformers.

The three-wire 250/125-volt generator is very similar to the standard 250-volt two-wire machine. Its armature is tapped at points 180 electrical degrees apart, after the manner of a single-phase rotary and leads brought out to a pair of single-phase collector rings. The compensator used with this machine is a transformer with a single winding, having its extreme ends connected to the brushes which bear on the collector rings. A tap is brought out from the middle point of the winding on the compensator and

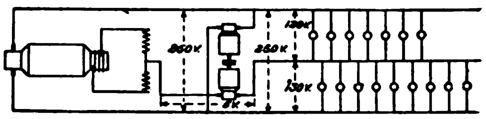


Fig. 2.—ONE 250/125-VOLT THREE-WIRE GENERATOR WITH COMPENSATOR AND BOOSTER.

connected to the neutral wire of the three-wire system to which it supplies continuous current.

If the generator is compound wound the series field is divided into two equal parts, one of these parts being connected between the positive bus bar and the positive brush and the other between the negative bus bar and the negative brush. This connection divides the resistance of the series field equally between the two sides of the system and secures with unbalanced loads a compounding across the outside wires approximating that with balanced loads. It is apparent that with the series fields divided and connected as described two equalizer connections are necessary for successful parallel operation with other compound generators, and the number and location of the protective devices ordinarily used with two-wire generators does not provide adequate protection for three-wire generators. To thoroughly protect these generators it is essential that a circuit breaker be placed on each side of the armature and connected between the brushes and the point where the equalizer connections are made.

The unbalanced current flowing in the neutral wire of a well-designed lighting system seldom exceeds 10 per cent. of the rated full-load current in the outers. Standard three-wire generators, however, are so designed that when 25 per cent. of the rated full-load current is flowing in the neutral and 250 volts is held constant the voltage at the machine between either outside wire and the neutral will be maintained within 2 per cent. of 125 volts or 2½ volts.

The 250 volts generated between the outers is, therefore, divided unequally, the voltage across the loaded side being less than 125 volts, whereas, it should be greater, and one of the inherent limitations of a three-wire machine is that it offers no means of shifting the neutral to compensate for the difference in CR drop between the two sides of the system.

A booster may be inserted in series with the neutral wire to shift the potential, although on account of the added expense and complication it is seldom advisable.

The principal advantage of a three-wire machine when contrasted with the other methods are saving in floor space and weight, reduction in first cost, gain in efficiency and ease of inspection and repair. The compensator being a static piece of apparatus means one less machine with revolving parts to engage the attention of the operator.

The lack of means for shifting the neutral is generally more than offset

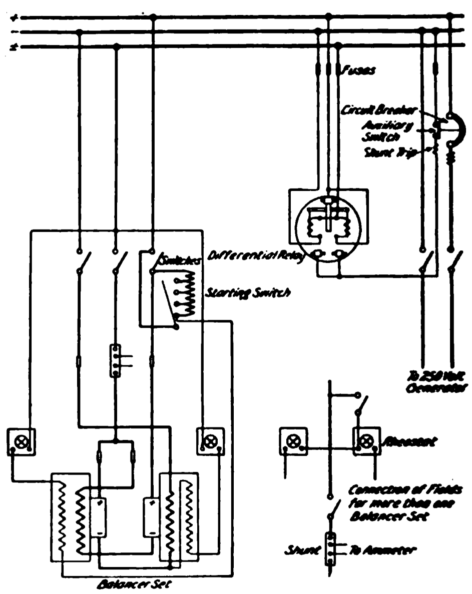


Fig. 3.—ONE 250-VOLT GENERATOR AND 250/125-VOLT SHUNT-WOUND BALANCER SET.

by the advantages named, and in consequence we find the three-wire generator with collector rings and compensator very widely used in isolated lighting and power plants.

* N. E. L. A., 1910

The three-wire generator considered under this heading has an auxiliary winding imbedded in the same slots as the main armature winding, the middle point of this winding being connected to the neutral wire through a single collector ring. This

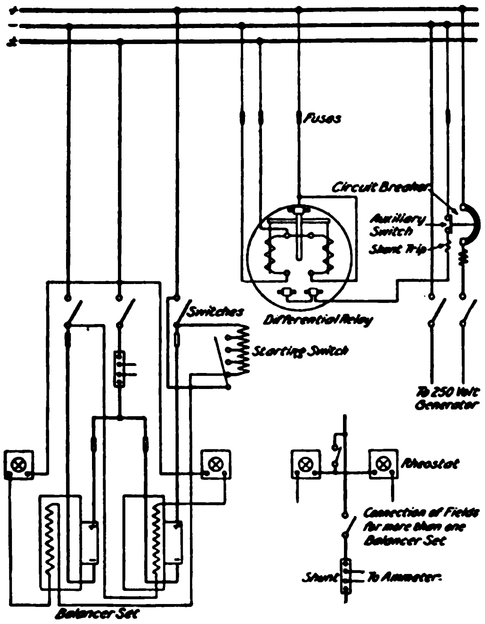


Fig. 4.—ONE 250-VOLT GENERATOR AND .. 250/125-VOLT COMPOUND-WOUND BALANCER SET.

method of construction renders an external compensator unnecessary and reduces the number of parts to a minimum. It should be noted that any damage to the auxiliary winding means a complete shut-down while the repairs are being made, and in case of a short-circuit in this winding the main armature coils are apt to be injured. Its characteristics and limitations are similar to those of the three-wire generator with external compensator. It is somewhat more expensive but occupies less floor space, and although not so generally used as the external compensator method previously described it is nevertheless very widely used in lighting and power plants.

This method employs a standard 250-volt two-wire generator to furnish power and a motor generator balancer set consisting of two standard 125-volt machines operating in series between the 250-volt mains to establish and control the neutral. On those systems where the feeders are long, or where the load is such that it would materially unbalance the lamp voltage if no method of controlling the neutral were available, the balancer set is particularly serviceable.

If the load is balanced no current flows in the neutral wire, the voltages across each side are equal, and, therefore, both machines float on the line as motors, only the running light current being consumed. When the load is unbalanced the voltage on the loaded side falls below 125 volts and the machine on that side immediately begins to act as a generator.

Balancer sets should always be rated in neutral current. Approximately one-half of this current is supplied by each machine, the division being governed by the voltages and losses. The motor, since it supplies the losses of the set, must carry the greater load, and although the generator carries the lesser load it must be a duplicate of the motor, so that the set may be reversible. The current capacity, therefore, which determines the rating of the individual machines is generally from 55 to 60 per cent. of the neutral current. For example, a 100-ampere balancer set would consist of two 57-ampere machines.

Since the advent of commutating poles the balancer set along with other direct-current machines has increased in efficiency, decreased in cost, weight and floor space and improved in operation. These improvements are particularly marked in the case of balancers, due to the fact that commutating poles render unnecessary the forward shift of the generator brushes,

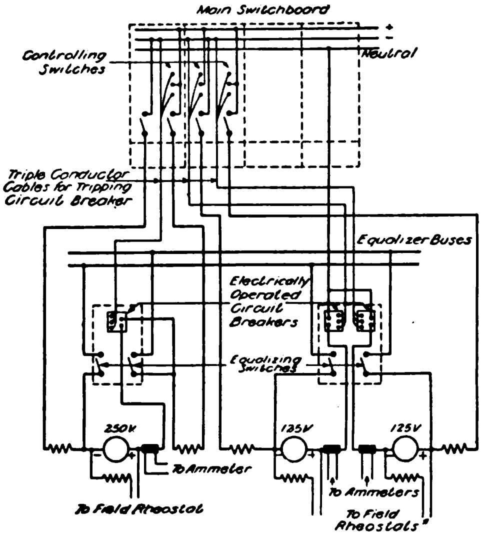


Fig. 5.—TWO 125-VOLT COMPOUND-WOUND GENERATORS IN SERIES; ALSO CONNECTIONS WHEN RUN IN MULTIPLE WITH 250-VOLT GENERATOR.

or the backward shift of the motor brushes to secure successful commutation for changes in the load. With non-commutating pole machines it was necessary, in order to secure the full output of the set, to shift the brushes not only for changes from the motor to the generator condition, but also for changes on the value of the load. If the operating conditions were such as to render it impracticable to shift the brushes for these changes, it was customary to leave the brushes on the neutral and consequently reduce the permissible output of the set 25 per cent. The fields of these sets may be either shunt or compound wound, but it is desirable in either case to cross-connect them, as shown in Figs. 3 and 4. This method of connecting the fields improves the regulation on unbalanced load by increasing the excitation of the generator. It further improves the regulation by decreasing the excitation of the motor

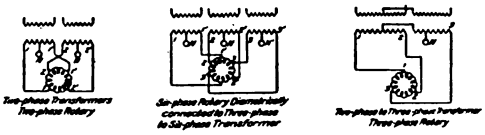


Fig. 6.—ROTARY CONVERTER AND TRANSFORMER CONNECTIONS FOR DERIVING DIRECT-CURRENT NEUTRAL FOR THREE-WIRE.

on shunt-wound sets, and lessening the differential action between the shunt and series fields if the motor is compound wound. The series fields may be so adjusted as to compensate very closely for inequalities in the CR drop of the two sides of the system. Excellent voltage regulation may be obtained from either shunt or compound wound sets by hand adjustment of the field rheostats, and herein lies the principal advantage of this method.

A system of distribution depending upon a balancer set for its neutral should be protected against the effects of overload or short-circuits on one side of the system, which may impress a relatively high voltage on the other side and burn out the lamps or other apparatus which it supplies with current. The protection sought may be gained by the use of a differentially wound relay connected across the two sides of the system, and so adjusted that with balanced voltages its contacts will remain open. If, however, the voltages unbalance beyond a predetermined amount the relay contacts will close a circuit through the shunt trip coils and thereby open the circuit breakers on the main generators.

When contrasted with the methods previously described, the two-wire generator with balancer is found to be higher in first cost, to occupy more floor space and to require a greater amount of care to operate. It affords, however, a very convenient means for controlling the neutral, and for this reason alone there are many cases where it can be used more advantageously than the generator with collector rings and compensator.

The simplest method of operating a three-wire system is, of course, to connect in series two 125-volt generators. They are subject to the disadvantages, when compared with methods previously mentioned, of weighing more, requiring more floor space and being less efficient, and in common with three-wire generators giving reduced kilowatt output on unbalanced loads. For example, the rated output of two 50-kw. generator operating on a system with 25 per cent. unbalancing would be reduced from 100 kw. to 87½ kw. It has the practical advantage of permitting entirely independent voltage regulation on each side of the system and of being able to safely handle large amounts of unbalancing.

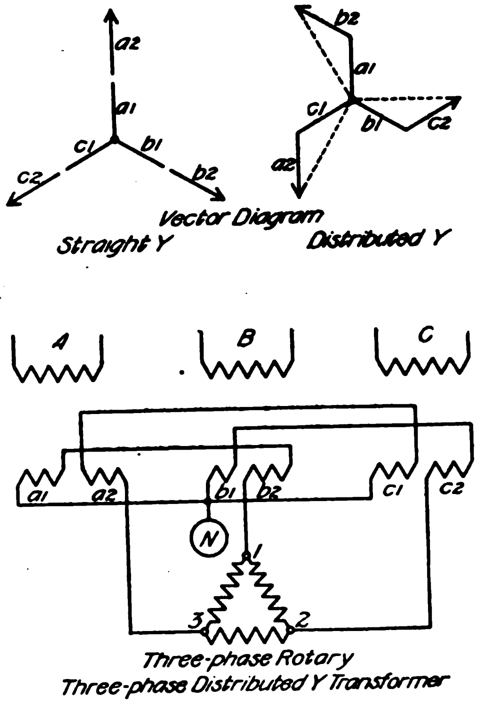


Fig. 7.—TRANSFORMER CONNECTIONS FOR THREE-PHASE ROTARY AND THREE-PHASE DISTRIBUTED "Y" TRANSFORMER FOR DERIVING DIRECT-CURRENT NEUTRAL FOR THREE-WIRE SYSTEM.

The fact that collector rings are already a part of the rotary converter equipment immediately suggests the desirability of deriving the neutral from the secondary of the step-down transformers. When this method is used great care must be taken to see that the windings of the transformer are so arranged that they cannot operate reactively and prevent the flow of current necessary to maintain the neutral. A diametrical connection of the transformer secondaries is satisfactory for furnishing the neutral of a three-wire system supplied from a six-phase rotary. In case of a three-phase rotary using a Y-connected transformer it is necessary to distribute the winding in such a manner that the current flowing through any one leg of the winding will affect the core of two of the legs. The method of arranging the distributing coils is shown in the Fig. 7. The arrangements described can safely handle large amounts of unbalancing, but possess no means for shifting the neutral, and balancer sets for this purpose are often installed with rotary converters.

It is practicable to operate a rotary inverted from a direct-current source of supply and obtain a neutral from the point of the compensator connected to its collector rings, as shown in Fig. 8. This arrangement is seldom found in practice, as it offers no means of controlling the voltage.

Automatic voltage regulation can be obtained on three-wire systems supplying a mixed lighting and power load by the installation of generator voltage regulators. The field-current of the generators usually exceeds the capacity of the largest regulator available, and it becomes necessary to separately excite them from a three-wire exciter set and control the voltage of the bus by varying the fields of the exciters, and consequently the excitation supplies the main generators.

The arrangement here described is particularly applicable to three-wire systems with neutral derived from two 125-volt generators operating in series, since it can be adjusted to hold the proper voltage on both sides of the system for any degree of unbalancing within the limits of the apparatus controlled.

Central stations supplying a mixed lighting and power load with motors connected across the outers and between the neutral, and the outers can secure equal voltages between the two sides of the system at the centre of distribution by connecting the pressure wires from this point to the control magnets of the regulators.

SUMMARY.

In conclusion it may be suggested that the selection of the different types of apparatus for a direct-current three-wire system of distribution should, therefore, be governed by the amount of unbalanced current to be handled and the necessity for shifting the neutral to compensate for inequalities in the CR drop between the two sides of the system. Generally speaking, it is advisable where the unbalancing is excessive to use two low-voltage generators in series, and where the unbalancing is small to use a high-voltage generator with suitable facilities to establish and control the neutral, thereby securing the advantages of

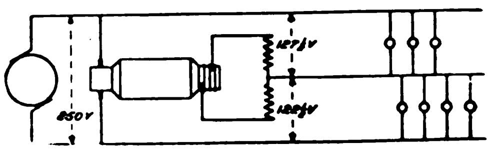


Fig. 8.—INVERTED ROTARY CONVERTER AND COMPENSATOR.

higher efficiency, cheaper first cost, decreased weight and economy of floor space.

The relative advantages of the three-wire generator method and the balancer set may be summarized by saying that, when the approximately even division of voltage at the bus bars which the former type gives results in good service at the lamps, the three-wire generator is desirable, on acount of its rugged construction, cheapness and efficiency. The balancer set requires more careful attention, but in those cases where skilled operators are already employed, for the purpose of looking after other machinery, the balancer set justifies itself not only by reason of its ability to give extra voltage where such voltage is needed but also because it permits the 250-volt generator with which it is used to deliver full kilowatt output when the load is unbalanced.

GENERATORS WITHOUT BASE, SHAFT OR BEARINGS, BUT WITH RHEOSTATS FOR DIRECT CONNECTION TO HIGH-SPEED ENGINES

		1-250-Volt Gen. with 250/125-Volt Balancer	1-250-Volt Gen. with Collector and Compensator	2-125-Volt Gens. in series of ½-Kw capacity of 250-Volt Gens.
Weight per kilowatt of generating equipment	50 Kw	87.00 lbs.	+3.4%	+10%
	100 "	78.40 "	+ 4.0%	+ 0%
	150 "	91.5 "	+ 2.0%	—20%
	200 "	82.42 "	+ 2.1%	—12.5%
Efficiency full load; no current in neutral	50 Kw	89%	90.5%	87.5%
	100 "	90%	91.25%	90%
	100 "	90%	91.25%	90.%
	150 "	90.5%	91.5%	90.5%
	200 "	90.5%	91.5%	90.75%
Floor space of generating equipment	50 Kw	15.35 sq. ft.	—10.%	+13.%
	100 "	20.40 " "	+ 1.%	+16.%
	150 "	28.50 " "	+ 4.5%	+ 2.5%
	200 "	33.26 " "	+ 3.%	+15.%
Size of switchboard panels	50 Kw	20″+24″	20″	20″
	100 "	20″+24″	20″	20″
	150 "	20″+24″	22″	20″
	200 "	20″+24″	20″	20″
Cost per kilowatt, including switchboard 10 per cent. unbalancing	50 Kw	$26.70	— 9%	+ 5%
	100 "	18.26	— 5.5%	+10%
	150 "	19.40	—14.0%	—14.5%
	200 "	16.55	— 4.5%	— 3.5%
Compensation for line drop on heavier side?	XXX	Yes XX	No XXX	Yes
Designed for extreme unbalancing?	XX	No. XX	No XXX	Yes
Percentage of rated kilowatts delivered when 10 per cent. unbalanced current is flowing in neutral wire?		100%	95%	95%

Prompt Execution of Orders

By CLARE N. STANNARD

The definition of promptness we find to be, "Ready and quick to act as occasion demands."

A close observer of nature soon discovers that it is governed by an unerring system and that certain changes promptly follow one another, as, for instance, daylight follows darkness, one season follows another, winter follows the fall, cold weather is followed by warm; so there are many lessons to be learned from nature, the principal ones being promptness and system.*

Another example of promptness is to be found in Army and Navy discipline; having such examples before us ordinary corporations would be neglectful if they did not incorporate into their work two of the most vital underlying principles of all successful business, namely, promptness and system.

We are all of us familiar with certain exceptions; for instance, suppose one was to attempt to recover damages or a rebate from the United States Government, you can imagine the time necessary in order to secure an adjustment of the claim. Such dilatory methods cause trouble and hard feelings and make enemies.

If such dilatory and slothful methods were practised by an electric company it would result in our creating a demoralized condition and in our employees becoming inefficient; they would constantly, from the example set them, put off to-day what they thought might be done to-morrow. Consequently, wasteful and extravagant methods would be encouraged. Wastefulness would apply both as to time consumed and money spent. Such methods frequently result in something being started, and one never knows where it will end. They invariably cause a company to lose prestige in the community in which it operates. A loss of revenue is occasioned through orders not being promptly executed. The writer is familiar with some cases where companies never execute orders for a week or ten days; on a large number of orders, think of the loss of revenue which such methods occasion.

The company loses the respect of the public, an asset which has a tangible value. Confidence is also lost; such methods invariably result in a great deterioration of the value of a property, and the bankruptcy of some companies, we believe, could quickly be traced to such a policy as above mentioned. The methods thus far discussed frequently result in the public feeling that the company is independent and that it has a monopoly, and this leads to the ofttime wish for competition which frequently materializes.

In order to offset the evils enumerated a complete system is necessary to secure promptness. We would recommend under the heading of PROMPTNESS, a system somewhat similar to the following, subject, of course, to the local conditions governing the policy of the company.

Upon a customer entering an office, especially if the office be a large one, a man, perhaps styled Director, should be found near the entrance, whose duty it is to direct consumers to the proper window, thus avoiding a frequent series of annoyances to the consumers of going from one window to another until they accidentally stumble upon the right one.

Assuming that a consumer wishes to make an application for light or power, there should be a sufficient number of clerks at the application window to handle the people, not requiring a consumer to stand in line any length of time.

A clerk should decide promptly about a man's credit; orders for the execution of the work should be promptly issued. We would recommend that all applications taken in the forenoon be written up and given to the shop foreman so that they may be executed promptly in the afternoon. All orders taken in the afternoon should be similarly handled, so that they may be executed the following forenoon. Our promptness on orders should not end at this point, but they should immediately upon execution be returned to the office, given to the bookkeeper and written up on the books, so that bills may be promptly sent at regular intervals to the consumer.

Bills for current should, so far as possible, cover a uniform period, otherwise consumers will complain, for if a bill covers, instead of the usual 30 days, a period of 35 or 40 days, the consumer ofttimes does not notice the difference in time on the bill and complains on its size, whereas had the bill covered the usual 30-day period no complaint would have been made.

Should a consumer come to the office to pay a bill, having neglected to bring the bill, upon his request for a duplicate it should be immediately and cheerfully given, without there being an intimation of his having been negligent in failing to bring the original bill.

Assuming application for electricity or power, the meter having been set, the bill at the end of 30 days rendered, he comes to the office to make payment. There should be a sufficient number of cashiers to receive the money and receipt the bill. We have observed that where consumers are obliged to stand a long time in line they became impatient, and make remarks which ofttimes lead to complaints being registered, whereas, on the other hand, had they been able to promptly pay their bill all of this annoyance would have been avoided.

Assuming that the consumer desires to make a complaint, he should, upon his going to the complaint window, be very promptly taken care of. He should not be obliged to stand and listen to a number of other complaints. Each complaining consumer should be given immediate attention; if possible, he should be invited to be seated and given every attention and courtesy possible. He should be impressed that the clerk is actuated only by methods of fairness and justice. The man at the complaint window should be an intelligent, competent and experienced employee, preferably one who has had actual experience in the remedying of complaints. A man thus equipped can more readily grasp the situation and can more easily understand what the consumer is trying to explain. If the consumer cannot explain just what he wishes to say, an experienced man can often save trouble and much time in assisting the consumer to make plain the desired complaint.

The head of the complaint department should be an experienced trouble man and have direct charge of the men executing the complaint orders, for by listening to exaggerated cases he can often give personal instruction to the trouble man which will facilitate the execution of the work.

All complaint orders should be, if possible, executed the day received, or, in case of orders received late in the day, they should be taken care of promptly on the following forenoon. Promptness in this department will have a beneficial effect upon the complaining consumer; on the other hand, companies dilatory in caring for complaints cause the consumer to lose confidence, and to believe the company is not anxious to give relief.

We would recommend that with some companies, a night force of men

* N. E. L. A., 1910.

be employed who could almost immediately answer special and emergency calls. This would not only make many friends for the company, but ofttimes result in the saving of property and even life. This is particularly true through being able to promptly care for pole and line troubles, to cut wires at time of fire and to meet other emergencies with which you are all familiar.

It is advisable to occasionally call together the employees of the company who come into direct contact with the public. At these meetings timely and interesting talks and discussions should be given and the policy of the company be outlined. By the officers coming into personal contact with the employees it will be found much easier for the policy of the company to be reflected in the men than if the meetings were not held. In fact, the result will be an enthusiastic endeavor on the part of the employees to give the public proper attention and the best service. When it is explained that promptness and system are necessary in order to secure best efficiency, the men will immediately co-operate in order to secure the desired results.

Now, for a moment, let us assume that the consumer has called at the office to purchase an electric consuming device, such, perhaps, as a flatiron, a motor or a toaster, the same promptness should characterize our efforts to please as outlined for the other departments.

A sufficient number of salesmen should be maintained to explain all appliances promptly and intelligently. Upon the sale having been made, the appliance should be promptly delivered and connected. We would pay special attention to consumers, who make the purchase in case of an emergency, by our showing them that we are willing to go out of our way to be accommodating, thus frequently establishing pleasant relations which often become of great value to the company.

We do not think it advisable for orders to be held up for some trifle in detail, neither do we advise that all orders be marked "Rush," though, of course, rush orders are permissible, but it is much better for one when taking an order to give as much time as possible for its execution or perhaps specify a certain time when the order should be completed. Much friction, trouble, annoyance and expense are avoided by the one taking the order making sure that everything is in readiness for its execution; in other words, proper thought and care should be used in taking all orders and applications according to some fixed, just and proper rule.

Some companies have found that they secure better results and prompter service by paying the men in the order and installation departments upon a salary and bonus basis; as, for instance, those setting and removing meters are paid a certain fixed salary per day plus a small bonus for each meter set or removed and for each appliance connected and service installed. The result is that the men accomplish a larger amount of work per day, that they work with greater efficiency, that their orders are executed more promptly and that the total cost to the company for this class of work is decreased, thus proving the system to be an excellent one.

Promptness should be an essential quality in the Commercial Department. Slothful and dilatory methods result in the department becoming ineffective. Commercial men should be prompt in going out and finding business. Much revenue is secured through this method, instead of waiting for business to come in. Business can be created in many ways; as an illustration, sign and display lighting create revenue, as was once remarked by a prominent gas and electric captain of industry, "out of the thin air." Think of the thousands and thousands of dollars of revenue which has been secured for central-station companies through the recognition and prompt taking advantage of this opportunity.

Manufacturers of electrical appliances have greatly assisted electric companies in finding additional ways for the use of increased current. It is our duty to promptly put on the market and sell the many excellent current consuming devices constantly brought to our attention.

Our commercial men have a field in addition to the old regularly recognized commercial field. They can sell many appliances which not only bring a revenue, but also popularize the use of electricity. Under this head may be mentioned the electric flatiron, toaster, chafing dish, the mirror reflector, curling iron heater, warming pad, many ornamental designs, and other appliances too numerous to mention.

The commercial men should use promptness in discovering and remedying poor service. We have been told our consumers are not so much interested in the price they are paying for current as they are in the securing of good service. We have all repeatedly proven this to be true.

It has been said the sooner an order is executed the less time there is for a consumer to change his mind, and cancel it. In order to secure promptness, the representative after making a sale should follow up the order and make sure that it has been promptly excuted. Through the prompt execution of orders the embarrassment is done away with that a representative meets when he calls at a house and says, "Now, whenever there is anything we can do for you let us know," and then meets with the reply, "Three weeks ago we asked for a certain thing to be done and it has not as yet received any attention." If a company is operated as above outlined it establishes a reputation for promptness which reduces complications in the office and operating departments, and demonstrates that we have system in our business. The company is given credit by the public for being aggressive, up to date, using proper business methods in the execution of its work, complaints are lessened and the company is not open to just attacks.

This reputation for promptness has often a monetary value, having an influence on the increased revenue. It indicates a desire on the part of the company to look after the patron's welfare.

Classified Directory of Manufacturers

ADJUSTERS
Morse, Frank W., Boston, Mass.

AIR AND GAS COMPRESSORS
Allis-Chalmers Co., Milwaukee.
American Air Compressor Works, N. Y
Blake Mfg. Co., Geo. F., New York.
Chicago Pneumatic Tool Co., Chicago.
Clayton Air Compressor Works, N. Y.
Curtis & Co., Mfg. Co., St. Louis.
Dean Bros. Steam Pump Wks., Indianapolis.
Emerson Elec. Mfg. Co., St. Louis, Mo
Hall Steam Pump Co., Pittsburg.
Ingersoll-Rand Co., New York.
Knowles Steam Pump Works, New York
Laidlaw-Dunn-Gordon Co., New York
McGowan Co., John H., Cincinnati
National Brake & Elec. Co., Milwaukee
Norwalk Iron Works, Norwalk, Conn
Platt Iron Works Co., Dayton
Providence Engine Works, Providence
Snow Steam Pump Works, New York.
Sullivan Machinery Co., Chicago
Worthington, Henry R., New York.

ALTERNATORS
Allis-Chalmers Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Elec. Works, Indianapolis.
General Electric Co., Schenectady, N. Y
National Brake & Elec. Co., Milwaukee
Wesco Supply Co., St. Louis
Western Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., Pittsburg

ANCHORS (GUY)
Holden Anchor Co., Des Moines, Ia.
Matthews & Bro., W. N., St. Louis, Mo

ANNUNCIATORS
Central Electric Co., Chicago, Ill.
Doubleday-Hill Electric Co., Pittsburg.
Electric Appliance Co., Chicago.
Haines, J. Allen, Inc., Chicago.
Manhattan Elec. Supply Co., New York
Ostrander & Co., W. R., Chicago.
Van Dorn-Elliott Elec. Co., Cleveland.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago

ATTACHMENT PLUGS
Hubbell, Harvey, Bridgeport, Conn.

BATTERIES—PRIMARY
Bunnell & Co., J. H., New York.
Burnley Battery & Mfg. Co., Painesville Ohio.
Central Electric Co., Chicago
Doubleday-Hill Elec. Co., Pittsburg.
Eastern Carbon Works, Jersey City, N. J
Edison Mfg. Co., New York.
Elec. Motor & Equipment Co., Newark N. J
French Battery Co., Madison, Wis.
Gordon Battery Co New York.
Lawrence Elec. Co., F. D., Cincinnati, O
Leclanche Battery Co., New York.
Manhattan Electrical Supply Co., Chicago.
Waterbury Battery Co., Waterbury Conn.
Wesco Supply Co., St. Louis, Mo
Western Electric Co., Chicago.

BATTERIES—STORAGE
American Battery Co., Chicago.
Doubleday-Hill Electric Co., Pittsburg
Electric Storage Battery Co. Philadelphia.
General Storage Battery Co., New York.
Gould Storage Battery Co., New York
National Battery Co., Buffalo, N. Y.
Railway Safety Service Co., Springfield, Mass.
Universal Electric Storage Battery Co., Chicago.
Willard Storage Battery Co., Cleveland.

Classified Directory of Manufacturers—Cont'd

BELLS
Central Electric Co., Chicago.
Manhattan Electrical Supply Co., New York and Chicago.
Ostrander & Co., W. R., New York
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.

BELT DRESSING
Cling Surface Mfg. Co., Buffalo
Dixon Crucible Co., Jos., Jersey City, N. J.

BELTING
Boston Belting Co., Boston.
Eureka Fire Hose Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Philadelphia.
Pittsburg Gage & Supply Co., Pittsburg.
Robins Conveying Belt Co. New York.

BLOWERS
Allis-Chalmers Co., Milwaukee.
American Blower Co., Detroit.
American Gas Furnace Co., New York.
Buffalo Forge Co., Buffalo.
Chicago Flexible Shaft Co., Chicago.
Crocker-Wheeler Co., Ampere, N. J.
Dean Bros. Steam Pump Works, Indianapolis.
Green Fuel Economizer Co., Matteawan, N. Y.
Platt Iron Works, Dayton, O.
Smith, J D., Fdy. Supply Co., Cleveland.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

BLUE PRINT MACHINERY
Buckeye Engine Co., Salem, O.
Keuffel & Esser Co., New York.
Kolesch & Co., New York.
Resolute Machine Co., New York
Wagenhorst & Co., J. H., Pittsburg.

BOILERS
Atlantic Works, East Boston, Mass.
Babcock & Wilcox Co., New York.
Harrison Safety Boiler Works, Phila
Heine Safety Boiler Co., St. Louis.
Platt Iron Works, Dayton, O.
Riter-Conley Mfg. Co., Pittsburg
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.
Walsh's Holyoke Steam Boiler Co., Holyoke, Mass.
Wetherill & Co., Robt., Chester, Pa.

BOXES—JUNCTION
Bossert Electric Construction Co., Utica.
D. & W. Fuse Co., Providence. R. I.
Steel City Electric Co., Pittsburgh

BOXES—OUTLET
Bossert Electric Const. Co., Utica, N. Y.
Steel City Electric Co., Pittsburgh

BRUSHES—CARBON
Central Electric Co., Chicago.
Eastern Carbon Works, Jersey City, N. J.
Holmes Fibre-Graphite Mfg. Co., Germantown, Pa.
Le Valley Carbon Brush Co., New York.
National Carbon Co., Cleveland.
Speer Carbon Co., St. Mary's, Pa.
Western Electric Co., Chicago.

BUSHINGS-OUTLET
Steel City Electric Co., Pittsburgh

CABLE HANGERS
Barron & Co.. Jas. S., New York
Bissell Co., F , Toledo, O.
Standard Underground Cable Co., Pittsburg
Steel City Electric Co., Pittsburg.
Wesco Supply Co., St. Louis, Mo
Western Electric Co.. Chicago.

CABLE JOINTS
Dossert & Co., Inc., New York

CARBONS
Central Electric Co., Chicago.
Eastern Carbon Works Jersey City, N. J.
National Carbon Co., Cleveland.
Reisinger, Hugo, New York.
Speer Carbon Co., St. Marys, Pa.
Wesco Supply Co., St. Louis.

CASTINGS
American Steel Foundries Chicago.
Alton Machine Co., New York.

Classified Directory of Manufacturers—Cont'd

Lunkenheimer Co. Cincinnati.
New England Butt Co., Providence, R. I.
Phosphor-Bronze Smelting Co., Ltd., Philadelphia.

CHAINS FOR ARC LAMPS
Oneida Community, Ltd., Oneida, N. Y.

CIRCUIT BREAKERS
Cutler-Hammer Mfg. Co., Milwaukee.
Cutter Electrical Mfg. Co., Philadelphia.
Doubleday-Hill Electric Co., Pittsburg.
Fort Wayne Electric Works, Fort Wayne, Indiana
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
La Roche Co., F. A., New York.
Sundh Electric Co., New York.
Switchboard Equip. Co., Bethlehem, Pa
Ward Leonard Electric Co., Bronxville, N. Y.
Wesco Supply Co., St. Louis
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co. Pittsburg.

CLAMPS—CABLE
Matthews, W. N., & Bros., St. Louis.

CLEATS
Blake Signal & Mfg. Co., Boston, Mass.
Imperial Porcelain Works, Trenton, N. J
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.

CLIMBERS
Klein & Co., Mathias, Chicago.

CLUSTERS
Benjamin Elec. Mfg. Co., Chicago
Hubbel, Harvey, Bridgeport, Conn.

COAL AND ASH-HANDLING MACHINERY
Brown Hoisting Machinery Co. land
Case Mfg. Co., Columbus, O.
Hunt Co., C. W., New York.
Jeffrey Mfg. Co., Columbus, O.
Link Belt Co., Philadelphia.
Mead-Morrison Mfg. Co., Boston.
Northern Engineering Works, Detroit
Robins Conveying Belt Co., New York

COILS—INDUCTION
Ostrander, W. R., & Co., New York.
Splitdorf, C. F., New York.

COMMUTATOR LUBRICANT
Allen & Co., L. B., Chicago.
Dixon Crucible Co., Jos., Jersey City.

COMMUTATORS
Homer Commutator Co., Cleveland, O.

CONDENSERS—ELECTRIC
Marshall, William, New York.

CONDUIT RODS
Barron & Co., Jas. S., New York.
Cope, T. J., Philadelphia.
Doubleday-Hill Electric Co., Pittsburg.

CONDUITS
American Circular Loom Co., Chelsea, Mass.
The Gillette-Vibber Co., New London, Conn.
American Conduit Co., Chicago.
American Vitrified Conduit Co., N. Y.
Camp Co., H. B., New York.
Doubleday-Hill Electric Co., Pittsburg.
Gest, G. M., New York.
National Conduit & Cable Co., N. Y.
National Metal Molding Co., Pittsburg
Orangeburg Fibre Conduit Co., Orangeburg, N. Y
Sprague Electric Co., New York.

CONDUIT FITTINGS
Steel City Electric Co., Pittsburgh

CONDUIT REAMERS
Steel City Electric Co., Pittsburg.

CONDUIT TOOLS
Cope, T. J., Philadelphia.
Steel City Electric Co., Pittsburg.

CONTROLLERS
Allis-Chalmers Co., Milwaukee.
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Cutler-Hammer Mfg. Co., Milwaukee.
Elec. Controller & Supply Co., Cleveland

Classified Directory of Manufacturers—*Cont'd*

N. Y. Electric Controller Co., New York.
Simplex Electric Heating Co., Cambridge, Mass.

COPPER CASTINGS
Anderson Mfg. Co., A. & J. M., Boston.
Ward-Leonard Co., Bronxville, N. Y.

CRANES
Northern Engineering Works, Detroit.

CROSS ARMS
Locke Insulator Mfg. Co., Victor, N. Y.

CUT-OUTS AND SWITCHES
Bissell Co., The F., Toledo, O.
Bossert Electric Const. Co., Utica, N. Y.
Central Electric Co., Chicago.
Crouse-Hinds Co., Syracuse, N. Y.
Cutter Elec. & Mfg. Co., Philadelphia.
Ft. Wayne Elec. Wks., Inc., Fort Wayne.
General Electric Co., Schenectady, N. Y.
Hart Mfg. Co., Hartford, Conn.
Manhattan Elec. Supply Co., New York.
Sorenson, P., Brooklyn.
Switchboard Equip. Co., Bethlehem, Pa.
Trumbull Elec. Mfg. Co., Plainville, Conn.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

DIRECT MOTOR DRIVE FOR PLANERS
The Electric Controller & Supply Co., Cleveland.

DRILLS
Morse Twist Drill & Machine Co., New Bedford, Mass.

DRYING MACHINERY
Aiton Machine Co., New York.
Buffalo Foundry & Machine Co., Buffalo.
Devine Co., J. P., Buffalo.
Sturtevant Co., B. F., Boston

DYNAMOS AND MOTORS
Allis-Chalmers Co., Milwaukee.
American Engine Co., Bound Brook, N J.
Bogue Electric Co., C. J., New York.
Burke Electric Co., Erie, Pa.
C. & C. Electric Co., Garwood, N. J.
Central Electric Co., Chicago.
Century Electric Co., St. Louis.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Doubleday-Hill Electric Co., Pittsburg.
Eck Dynamo & Motor Wks., Belleville, N. J.
Electro-Dynamic Co., Bayonne, N. J.
Elwell-Parker Electric Co., Cleveland.
Emerson Electric Mfg. Co., St. Louis.
Fort Wayne Electric Works, Fort Wayne.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., Columbus, O.
National Brake & Elec. Co., Milwaukee
New England Motor Co., Lowell, Mass.
Ridgway Dynamo & Motor Co., Ridgway, Pa.
Robbins & Myers Co., Springfield, O.
Sprague Electric Co., New York.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Boston.
Triumph Electric Co., Cincinnati.
Wagner Electric Mfg. Co., St. Louis.
Wesco Supply Co., St. Louis.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg.

ELECTRIC RAILWAY SUPPLIES
Railway Safety Service Co., Springfield, Mass.

ELECTROMAGNETS
Acme Wire Co., New Haven, Conn.
Schureman, J. L., Co., Chicago.
Splitdorf, C. F, New York.

ELEVATORS
American Tool & Machine Co., Boston
Caldwell & Son Co., H. W., Chicago.
Jeffrey Mfg. Co., Columbus.
Link Belt Eng'g Co., Philadelphia.
Obermayer Co., S., Cincinnati.
Otis Elevator Co., N. Y.
Poole Eng'g Mch. Co., Baltimore

ENGINEERING CONSTRUCTION
Elm City Engineering Co., New Haven, Conn

Trade Notes

The Pawling & Harnischfeger Company, Milwaukee, Wis., designers and builders of electric cranes and hoists, has recently appointed Albert B. Bowman, 720-N. Second Street, St. Louis, Mo., a special sales representative.

The Holophane Co. announces that on July 1st all Holophane material will be on the same discount basis—60 per cent.; that there will be no further charge for packing; and that they will offer a new line of reflectors to replace the "High Efficiency Line."

News

The electric lighting system at Fort Rosencrans, which is located near San Diego, Cal., has been connected with the transmission lines of the San Diego Consolidated Gas & Electric Company for service. The connected load is equal to about 1400 16-c-p. equivalents.

The Frisco Extends Its Telephone Dispatching System

The St. Louis & San Francisco Railroad, which has been active in the campaign among the railroad systems of the country to supplant the use of the telegraph with the telephone for train despatching, is now installing new telephone circuits over about 500 miles of its line.

Trains on the 'Frisco are now being despatched by telephone between Kansas City, Mo., and Springfield on the northern division, and on the Lebanon division between Springfield and Monett, Mo., a total distance of about 246 miles. This part of the 'Frisco is single track, and the traffic between Kansas City and Fort Scott is unusually heavy. Message circuits, on which the commercial business is handled, parallel in every case the despatching circuits, which are used exclusively to direct train movements and traffic. Western Electric apparatus is used exclusively in this work.

Modern Elevator Conductors

The use of alternating-current induction motors in elevator and crane work has now become as well standardized as any other motor application. While, from its constant speed characteristics, the induction motor is more suitable for slow-speed elevators than for those where rapid lifting is the principal requirement, the slip-ring type of motor is being used in

(*Continued on page 22.*)

Classified Directory of Manufacturers—Cont'd

ENGINES—GAS AND GASOLINE
- Allis-Chalmers Co., Milwaukee
- Buckeye Engine Co., Salem, O.
- Carlisle & Finch Co., Cincinnati. O.
- De La Vergne Machine Co., New York.
- Elbridge Engine Co., Rochester, N. Y.
- Marine Engine & Machine Co., N. Y.
- Mietz, A., N. Y.
- Otto Gas Engine Works, Philadelphia.
- Power & Mining Machinery Co., Cudahy Wis.
- Westinghouse Machine Co., Pittsburg.
- Wood & Co., R. D., Philadelphia.

ENGINES—STEAM
- Allis-Chalmers Co., Milwaukee.
- American Blower Co , Detroit.
- Am. Engine Co., Bound Brook, N. J.
- Ball Engine Co. Erie, Pa.
- Blake Mfg. Co., Geo F., New York.
- Buckeye Engine Co., Salem, O.
- Buffalo Forge Co., Buffalo.
- Frick Co., Waynesboro, Pa.
- Hooven, Owens, Rentschler Co., Hamilton, Ohio.
- Mecklenburg Iron Wks., Charlotte, N. C.
- Providence Eng'g Works, Providence
- Shepherd Eng'g Co., Franklin, Pa.
- Southwark Fdy. & Mch. Co., Philadelphia
- Struthers-Wells Co., Warren, Pa.
- Sturtevant Co., B. F., Hyde Park, Mass.
- Watertown Eng. Co., Watertown, N. Y.
- Westinghouse Machine Co., Pittsburg.
- Wetherill, Robert & Co., Chester, Pa

EXHAUST HEADS
- American Spiral Pipe Works, Chicago
- Direct Separator Co. Syracuse.
- Hoppes Mfg. Co., Springfield, O.
- Pittsburg Gage & Supply Co., Pittsburg.
- Sturtevant Co., B. F., Hyde Park, Mass.
- Watson & McDaniel Co., Philadelphia.
- Wright Mfg. Co. Detroit.

FANS AND MOTORS
- Century Electric Co., St. Louis.
- Diehl Mfg. Co., Elizabethport, N. J.
- Doubleday-Hill Elec. Co., Pittsburg.
- Eck Dynamo & Motor Wks, Belleville, N.J.
- Elec. Motor & Equip. Co., Newark, N. J.
- Emerson Electric Mfg. Co., St. Louis.
- Ft. Wayne Elec. Works, Ft. Wayne, Ind.
- General Electric Co., Schenectady, N. Y.
- Robbins & Myers Co., Springfield, O.
- Sprague Electric Co., New York.
- Wesco Supply Co., St. Louis.
- Western Electric Co. Chicago
- Westinghouse Elec. & Mfg. Co., Pittsburg.

FANS—EXHAUST AND VENTILATING
- Allen Electric Co., Chicago.
- Century Electric Co., St. Louis.
- Crocker-Wheeler Co., Ampere, N. J.
- Diehl Mfg. Co., Elizabethport, N. J.
- Emerson Elec. Mfg. Co., St. Louis.
- Green Fuel Economizer Co., Matteawan
- Sprague Electric Co., New York.
- Sturtevant Co., B. F., Boston.
- Western Electric Co., Chicago.

FIXTURES—GAS AND ELECTRIC
- Benjamin Elec. Mfg. Co., Chicago.
- Cleveland Gas & Fixture Co., Cleveland
- Gail-Webb Mfg. Co., Buffalo
- Goodwin & Kintz, Winsted, Conn
- Wells Light Mfg. Co., New York

FLASHERS
- Advertising Mirrograph Co., Brooklyn.
- Campbell Electric Co., Lynn, Mass.
- Elec. Motor & Equip. Co., Newark, N. J
- Haller Machine Co., Chicago.
- Reynolds Elec. Flasher Mfg. Co., Chicago

FLEXIBLE SHAFTS
- Chicago Flexible Shaft Co., Chicago.
- Stow Flexible Shaft Co., Philadelphia
- Stow Mfg. Co., Binghamton, N. Y

FRICTION TAPE AND CLOTHS
- Massachusetts Chemical Co.

FUSES
- Arknot Co., Hartford, Conn.
- Chase-Shawmut Co.
- Chicago Fuse Wire & Mfg. Co.
- D. & W. Fuse, Providence, R. I.
- Johns-Manville Co., H. W., New York

Classified Directory of Manufacturers—*Cont'd*

GAS ENGINE SPECIALTIES
Lunkenheimer Co.

GAUGES—PRESSURE, STEAM, WATER
Am. Steam Gauge & Valve Co., Boston.
Ashton Valve Co., Boston.
Bristol Co., Waterbury, Co., Conn.
Hohmann & Maurer Mfg. Co., Rochester.
Manning, Maxwell & Moore, New York.
Pittsburg, Gauge & Supply Co., Pittsburg.
Star Brass Mfg. Co., Boston.
Walworth Mfg. Co., Boston.

GEARS
New Process., Rawhide. Co
Nuttal Co., R. D. Pittsburg

GERMAN SILVER
Seymour Mfg. Co Seymour, Conn

GLASS
Phoenix Glass Co., New York

GLOBES, SHADES, ETC.
Holophane Glass Co., New York
Phoenix Glass Co., New York.

GRAPHITE
Dixon Cruc. Co., Jos., Jersey City, N. J.

GUARDS—INC. LAMPS
Gail-Webb Mfg. Co., Buffalo.
Hubbell, Harvey, Bridgeport
Matthews & Bro., W. N., St. Louis.

HANGER BOARDS
Ft. Wayne Elec. Works, Ft. Wayne, Ind.

HANGERS—CABLE
Chase-Shawmut Co., Newburyport, Mass.
Standard Underground Cable Co., Pittsburg.

HEATING DEVICES, ELECTRIC
American Elec'l Heater Co., Detroit.
Barr Elec. Mfg. Co., W. J., Cleveland.
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Simplex Electric Heating Co., Cambridge, Mass.
Vulcan Electric Heating Co., Chicago

HEATING—EXHAUST STEAM
Am. District Steam Co., Lockport, N. Y.
Diamond State Fibre Co., Elsemere, Del.
Mica Insulator Co. New York.

HOISTS AND CONVEYORS
Hunt, C. W., Co., New York.
Jeffrey Mfg. Co., Columbus, O.
Northern Engineering Works, Detroit.

HYDRAULIC MACHINERY
Dayton Globe Iron Works Co., Dayton.
Dean Bros. Steam Pump Wks., Indianapolis.
Leffel & Co., James, Springfield, O.
Pelton Water Wheel Co., San Francisco.
Platt Iron Works Co., Dayton, O.
Risdon-Alcott Turbine Co., Mount Holly, N. J.
Smith Co., S. Morgan, York, Pa.

IMPREGNATING APPARATUS
Buffalo Foundry & Machine Co., Buffalo
Devine Co., J. P., Buffalo.
Hubbard's Sons, Norman, Brooklyn.

INDICATORS
American Steam Gauge & Valve Mfg Co:

INSTRUMENTS—ELECTRICAL
American Instrument Co., Philadelphia.
Atwater Kent Mfg. Co., Philadelphia.
Baillard, E. V., New York.
Biddle, James G., Philadelphia.
Bristol Co., Waterbury, Conn.
Clark Electric Meter Co., Chicago.
Connecticut Telephone & Electric Co., Meriden, Conn.
Cutter Elec. & Mfg. Co., Philadelphia.
Dongan Instrument Co., Albany, N. Y.
Duncan Elec. Mfg. Co., Lafayette, Ind.
Eldredge Elec. Mfg. Co., Springfield, Mass.
Foote-Pierson & Co., New York.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady.
Keystone Elec. Instrument Co., Phila.
Leeds & Northrup, Philadelphia.
Machado & Roller, New York.
Pignolet, Louis M., New York.
Queen & Co., Philadelphia.
Robert Instrument Co., Detroit.
Sangamo Electric Co., Springfield, Ill.

Classified Directory of Manufacturers—Cont'

Schaeffer & Budenberg, New York
Simplex Co., Newark, N. J.
Wagner Electric Mfg. Co., St. Louis.
Westinghouse Elec. & Mfg. Co., Pittsburg
Weston Elec. Instr. Co., Newark, N. J.
Whitney Elec'l Instr. Co., New York.

INSULATING MACHINERY
Aiton Machine Co., New York.
New England Butt Co., Providence, R. I

INSULATING MATERIAL COMPOUNDS—CLOTH AND PAPER
Anderson Mfg. Co., A. & J. M., Boston.
Johns-Manville Co H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago.

INSULATING MATERIAL—COMPOUNDS PAINTS AND VARNISHES
Macon-Evans Varnish Co., Pittsburg.
Massachusetts Chem. Co., Walpole, Mass.
Standard Paint Co., New York.
Sterling Varnish Co., Pittsburg.

INSULATING MATERIAL—FIBRE
Am. Vulcanized Fibre Co., Wilmington.
Diamond State Fibre Co., Elsmere, Del
Kartavert Mfg. Co., Wilmington, Del.
Morris Elec. Co., Wilmington, Del.
United Indurated Fibre Spec. Co., Lockport, N. Y.
Wilmington Fibre Spec. Co., Wilmington.

INSULATING MATERIAL—LAVA
American Lava Co., Chattanooga, Tenn
Kruesi, P. J., Chattanooga.
Steward Mfg. Co., D. M., Chattanooga

INSULATING MATERIAL—MICA
Johns-Manville Co., H. W., New York
Mica Insulator Co., New York.
Munsell & Co., Eugene, Chicago

INSULATING MATERIAL—PORCELAIN
Imperial Porcelain Works, Trenton, N J.
Locke Insulator Mfg. Co., Victor, N. Y.
National Porcelain Co., Trenton, N. J.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATING MATERIAL—TAPE
Amer. Electrical Wks., Philipsdale, R. I.
Massachusetts Chem. Co., Walpole, Mass
Morgan & Wright, Detroit
New York Insulated Wire Co., N. Y.
Okonite Co., Ltd., New York
Schott, W. H., Chicago.
Standard Underground Cable Co., Pittsburg.

INSULATORS—GLASS
Hemingway Glass Co., Louisville
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.

INSULATORS—PORCELAIN AND COMPOSITION
Anderson Mfg. Co., A. & J. M., Boston.
Imperial Porcelain Works, Trenton, N. J.
Johns-Manville Co., H. W., New York.
Locke Insulator Mfg. Co., Victor, N. Y.
Sears, Henry D., Boston.
Thomas & Sons Co., R., E. Liverpool, O.

INSULATOR SUPPORTS
Steel City Electric Co., Pittsburgh

JACKS
Watson-Stillman Co., New York.
Henderer's Sons, A. L., Wilmington, Del.

JUNCTION BOXES
Standard Underground Cable Co., Pittsburg, Pa.
Bossert Elec. Const. Co., Utica, N. Y.

KNIFE SWITCHES
Anderson Mfg. Co., A. & J. M., Boston.

LAMPS—ARC
Adams-Bagnall Elec. Co, Cleveland.
Am. Arc Lamp Co., Kalamazoo, Mich.
Anderson Mfg. Co., A. & J. M., Boston.
Beck Flaming Lamp Co., New York.
Excello Arc Lamp Co., New York.
Ft. Wayne Electric Works, Ft. Wayne.
General Electric Co., Schenectady.
Hamburger, Felix, New York.
Helios Mfg. Co., Philadelphia.
Marquette Elec. Mfg. Co., Chicago.
Tearing Co., C. J., Philadelphia.
Warner Arc Lamp Co., Muncie, Ind.

Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LAMPS—INCANDESCENT
American Electric Lamp Co., Phila., Pa.
Banner Electric Co., Youngstown, O.
Bay State Lamp Co., Danvers, Mass.
Boston Incandescent Lamp Co., Danvers, Mass.
Brilliant Electric Lamp Co., Cleveland.
Bryan-Marsh Co., New York.
Buckeye Electric Co., Cleveland.
Columbia Inc. Lamp Co., St. Louis.
Economy Electric Co., Warren.
Edison Dec. & Min. Lamp Co., Harrison, N. J
General Electric Co., Harrison, N. J.
New York & Ohio Co., Warren.
Novelty Incandescent Lamp Co., Emporium, Pa.
Rooney Elec. Lamp Co, New York.
Shelby Electric Co., Shelby, O.
Stuart Howland Co., Boston.
Wesco Supply Co., St Louis.
Western Electric Co., Chicago.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LIGHTNING ARRESTERS
Anderson Mfg. Co., A. & J. M., Boston.
D. & W. Fuse Co., Providence, R. I.
Electric Service Supplies Co., Phila.
Lord Electric Co., New York.
Westinghouse Elec. & Mfg. Co., Pittsburg.

LINE MATERIAL
Anderson Mfg Co. A & J. M., Boston.

LOCKERS
Edward Darby & Sons Co., Philadelphia
Merritt & Co., Philadelphia.

LOCOMOTIVES—INDUSTRIAL
Goodman & Co., Chicago.

many of the latter class of elevators.

These motors, when installed with proper control, will start and accelerate smoothly and give as good results as a direct-current motor, over which they have a decided advantage as to hardiness and durability. With this kind of motor it is also impossible for the machine to tend to run away on down trips, and in general the operating characteristics are quite as good as those of a shunt-wound direct-current machine.

In the manufacture of elevator controllers and safety devices no company has had a longer or more varied experience than the Cutler-Hammer Company, of Milwaukee, one of whose neat alternating-current elevator outfits is shown in the accompanying illustration. In this particular

(*Continued on page 24.*)

Classified Directory of Manufacturers—Cont'd.

Jeffrey Mfg. Co., Columbus, O
Porter Co., H. K., Pittsburg
Vulcan Iron Works, Wilkesbarre, Pa.

LUBRICANTS
Dixon Cruc. Co., Jos., Jersey City, N. J

MAGNET WIRE
Acme Wire Co., New Haven, Conn.
Griffin, Frank B., Oshkosh, Wis.
Roebling & Sons, Trenton, N J.
Seymons Mfg. Co., Seymons, Conn

MALLEABLE CASTINGS
Jeffrey Mfg. Co., Columbus, O.

METAL POLISH
Hoffman, George W., Indianapolis, Ind.

METALS
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

MICA—(See Insulating Material.)

MINING MACHINERY
Allis-Chalmers Co., Milwaukee
Dean Bros. Steam Pump Wks., Indianapolis.
General Electric Co., Schenectady, N. Y
Jeffrey Mfg. Co., Columbus, O.
Power & Mining Machinery Co., Cudahy.

PINS—STEEL
Locke Insulator Mfg. Co., Victor, N. Y

PLATINUM
American Platinum Wks., Newark, N. J
Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.

PLUGS
Dickinson Mfg. Co., Springfield, Mass.
Freeman Elec. Co., E. H., Trenton, N. J.
General Mfg. & Sup. Co., Trenton, N J.
Paiste Co., H. T., Philadelphia.

PLUGS—ATTACHMENT
Hubbell Harvey, Bridgeport, Conn.

POLES—ARC LAMP
Mott Iron Works, J. L., New York.

POLES, BRACKETS, PINS, ETC.
Bissell Co., F., Toledo, O.
Cresap Co., The, Bristol, Tenn.
Humbird Lumber Co., Sandpoint, Ida.
Kellogg Switchboard & Sup. Co., Chicago.
Sand Point Cedar Co., Sandpoint, Ida.
Southern Exchange Co., New York.
Worcester Co., C. H., Chicago.

PORCELAIN—(See Insulating Machinery).

POWER TRANSMISSION MACHINERY
Case Mfg. Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Engineering Co., Phila., Pa
Mead-Morrison Mfg. Co., Boston, Mass
Robins Conveying Belt Co., New York.

DRESSES, DIES AND SPECIAL MACHINERY
Watson-Stillman Co., New York.

PULLEYS
Rockwood Mfg. Co., Indianapolis, Ind.

PUMPS—ELECTRIC
Allen Electric Co., Chicago, Ill.
Allis-Chalmers Co., Milwaukee, Wis.
Conover Condenser Co., Paterson, N. J.
Dean Bros Steam Pump Wks., Indianapolis.

PUMPS—STEAM
Dean Bros. Steam Pump Wks., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Emerson Elec. Mfg. Co., St. Louis, Mo.
Platt Iron Works Co., Dayton, O.
Quimby, Wm. E., New York.
Watson Machine Co., Paterson, N. J.
Worthington, H. R., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Deming Co., Salem, O.
Morris Company, I. P., Philadelphia, Pa
Platt Iron Works Co., Dayton, O.

PUMPS—VACUUM
Alberger Condenser Co., New York.
Dean Bros. Steam Pump Wks., Indianapolis.
Hubbard's Sons, Norman, Bklyn., N. Y.
Platt Iron Works Co., Dayton, O.

Classified Directory of Manufacturers—Cont'd

PUSH BUTTONS
Dunbar Bros., Bristol, Conn.
Sarco Company, New York.
RAIL-BONDS
Chase-Shawmut Co., Newburyport, Mass
Lord Electric Co., New York.
Roebling's Sons Co., J. A., Trenton, N J
RECEPTACLES
Benjamin Electric Mfg. Co., Chicago, Ill
Freeman Elec. Co., E. H., Trenton, N. J
Paiste Co., H. T., Philadelphia, Pa
RECORDING INSTRUMENTS
Bristol Co., Waterbury, Conn.
Bristol, Wm. H., New York.
REFLECTORS
Frink, I. P., New York.
Goodwin & Kintz, Winsted, Conn.
National X Ray Reflector Co., Chicago Ill.
Phoenix Glass Co., New York.
REPAIRING
Gregory Electric Co., Chicago, Ill.
Heck, Louis, Newark, N. J.
Van Dorn-Elliott Electric Co., Cleveland, Ohio.
Ward, Leonard Electric Co., Bronxville, N. Y.
RESISTANCE UNITS
Cutler-Hammer Mfg. Co., Milwaukee.
Simplex Electric Heating Co., Cambridge, Mass.
RHEOSTATS
Automatic Electric Co., Chicago, Ill
Cutler-Hammer Mfg. Co., Milwaukee.
Schureman & Co., J. L., Chicago, Ill.
Sundh Electric Co., New York.
Ward Leonard Electric Co., Bronxville, N. Y.
ROSETTES
General Mfg. & Supply Co., Trenton.
Hart Mfg. Co., Hartford, Conn.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Inc., Solvay, N. Y.
Sears, Henry D., Boston, Mass
Trumbull Elec. Mfg. Co., Plainville, Conn.
RUBBER MACHINERY
Aiton Machine Co., New York.
SEARCHLIGHTS
Bogue Elec. Co., C. J., New York.
Carlisle & Finch Co., Cincinnati, O.
SECOND-HAND APPARATUS
Bender, George, New York.
Chicago House Wrecking Co., Chicago.
Dustin Co., Chas. E., New York.
Gas & Electric Development Co., N. Y.
Gregory Electric Co., Chicago, Ill.
Linder, H. J., New York.
Richter, Eugene, Philadelphia, Pa.
Station Equipment Co., Chicago, Ill.
Thompson, Joseph H., Jr., New York.
Toomey, Frank Philadelphia, Pa.
Yearsley & Levene, Philadelphia, Pa.
SHADE HOLDERS
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.
SHADES
Holophane Co., New York.
Hubbell, Harvey, Bridgeport, Conn.
J. E. M. Shade Holder Co., New York.
SIGNS—ELECTRIC
A. & W. Sign Co., Cleveland, O.
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C., Parkersburg, W. Va.
Metropolitan Engineering Co., N. Y.
Reynolds Elec. Flasher Mfg. Co., Chicago, Ill.
SIGN LETTERS
Day & Night Sign Co., Easton, Pa.
Elec. Motor & Equip. Co., Newark, N. J.
Haller Machine Co., Chicago, Ill.
Jackson Elec. Co., H. C, Parkersburg, W. Va.
Matthews & Bro., N. W., St. Louis, Mo.

equipment the controller is mounted on the top of the motor and the whole layout is arranged to economize space. For simplicity, durability and general effectiveness this arrangement has few equals and no superiors. It is the outcome of a long and careful study of the best method of meeting the exacting requirements of modern conditions in elevator and hoisting work.

Classified Directory of Manufacturers—Cont'd

SLEEVING
- Belden Mfg. Co., Chicago, Ill.
- Benjamin Electric Mfg. Co., Chicago, Ill.
- Bryant Electric Co., Bridgeport, Conn.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Electrical Mfg. Co., Rochester.
- Crouse-Hinds Co., Syracuse, N. Y.
- Dunton & Co., M. W., Providence, R. I.
- Federal Electric Co., Chicago, Ill.
- Freeman Electric Co., E. H., Trenton.
- General Mfg. & Supply Co., Trenton.
- Johns-Manville Co., H. W., New York.
- Marshall Elec. Mfg. Co., Boston, Mass.
- Pass & Seymour, Solvay, N. Y.
- Peru Electric Mfg. Co., Peru, Ind.
- Porcelain Electrical Mfg. Co., Trenton.
- Stanley & Patterson, New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn.
- Weber Electric Co. (Henry D. Sears, General Sales Agent, Boston, Mass.).
- Yost Electric Mfg. Co., Toledo, O.

SOLDER
- Belden Mfg. Co., Chicago, Ill.
- Walworth Mfg. Co., Boston, Mass.
- Western Electric Co., Chicago, Ill.

SOLDERING FLUX
- Allen Co., L. B., New York.
- Dunton & Co., M. W., Providence.
- Uebelmesser, Chas. R., Bayside, N. Y.

SOLDERING IRONS
- Simplex Electric Heating Co., Cambridge, Mass.
- Vulcan Elec. Heating Co., Chicago, Ill.

SOLENOIDS
- Cutler-Hammer Mfg. Co., Milwaukee.
- Schureman, J. L., Co., Chicago, Ill.

SPEED INDICATORS
- Schaeffer & Budenberg, New York.

SPRINGS
- Barnes Co., Wallace, Bristol, Conn.
- Dunbar Bros. Co., Bristol, Conn.
- Manross, F. N., Forestville, Conn.

SUPPLIES—ELECTRICAL
- Am. Elec'l Supply Co., Chicago, Ill.
- Central Electric Co., Chicago, Ill.
- Central Electric Supply Co., New York.
- Cobb, H. E., Chicago, Ill.
- Commercial Electrical Supply Co., St. Louis, Mo.
- Dearborn, Electric Co., Chicago, Ill.
- Doubleday-Hill Elec. Co., Pittsburg, Pa.
- Electric Appliance Co., Chicago, Ill.
- Electrical Material Co., Baltimore, Md.
- Erner & Hopkins Co., Columbus, O.
- Ewing-Merkle Elec. Co., St. Louis, Mo.
- Garton Co., W. R., Chicago, Ill.
- Hudson Electric Supply Co., New York.
- Latham & Co., E. B. New York.
- Machado & Roller, New York.
- Manhattan Elec'l Supply Co., New York.
- Metropolitan Elec'l Supply Co., Chicago.
- Nagel Electric Co., W. G., Toledo, O.
- Novelty Electric Co., Philadelphia, Pa.
- Ostrander & Co., W. R., New York.
- Patrick, Carter & Wilkins Co., Phila., Pa.
- Pettingell-Andrews Co., Boston, Mass.
- Robertson Electric Co., Buffalo, N. Y.
- Sherman-Brown-Clements Co., N. Y.
- Stuart-Howland Co., Boston, Mass.
- Union Electric Co., Pittsburg.
- United Electric & Apparatus Co., Boston.
- Wesco Supply Co., St. Louis, Mo.
- Western Electric Co., Chicago.

SUPPLIES—TELEPHONE
- Am. Elec. Telephone Co.
- International Teleph. Mfg. Co.
- Kellogg Switchboard & Supply Co., Chicago.
- Western Electric Co., Chicago.

SWITCHBOARDS
- Adam Electric Co., Frank, St. Louis, Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Burke Electric Co., Erie, Pa.
- C. & C. Electric Co., Garwood, N. J.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Crescent Elec'l Mfg. Co., Rochester, N.Y.
- Crocker-Wheeler Co., Ampere, N. J.
- Crouse-Hinds Co., Syracuse, N. Y.
- D'Olier, Jr., Co., Henry, Philadelphia.
- Ft. Wayne Elec. Wks., Ft. Wayne, Ind.
- General Electric Co., Schenectady, N. Y.
- Grady Co., S. S., Cambridge, Mass.
- Hill Electric Co., W. S., New Bedford, Mass.
- Ideal Elec. & Mfg. Co., Mansfield, O.
- Jones Electrical Co., New York
- La Roche Co., F. A., New York.
- Trumbull Elec. Mfg. Co., Plainville, Conn.
- Westinghouse Elec. & Mfg. Co., Pittsburg

SWITCHES
- Anderson Mfg. Co., A. & J. M., Boston.
- Dickinson Mfg. Co.

ARC LIGHTS
- Sarco Co., New York.

CANOPY
- Sarco Co., New York.

CEILING
- Jones Electrical Co., New York.
- Krantz Mfg. Co., H., Brooklyn, N. Y.
- Sorensen, P., Brooklyn, N. Y.

CLOCK
- A. & W. Electric Sign Co., Cleveland, O.
- Campbell Electric Co., Lynn, Mass.
- Elec. Motor & Equip. Co., Newark, N. J.
- General Electric Co., Schenectady, N. Y.
- Hartford Time Switch Co., Hartford.
- Manhattan Elec'l Supply Co., New York.
- Prentiss Clock Improvement Co., N. Y.
- Specialty Mfg. Co., Youngstown, O.
- Sorensen, P., Brooklyn, N. Y.
- Trumbull Elec. Mfg. Co., Trumbull, Conn.

SWITCHES— KNIFE
- Adam Electric Co., Frank, St. Louis, Mo.
- Anderson Mfg. Co., A. & J. M., Boston, Mass.
- Chase-Shawmut Co., Newburyport, Mass.
- Cleveland Switchboard & Electric Mfg. Co., Cleveland, O.
- Condit Elec'l Mfg. Co., Boston, Mass.
- Connecticut Electric Mfg. Co., Bantam, Conn.
- Crescent Elec'l Mfg. Co., Rochester, N. Y.
- Crouse-Hinds Co., Syracuse, N. Y.
- Garton Co., W. R., Chicago, Ill.
- General Electric Co., Schenectady, N. Y.
- Hill Electric Co., W. S., New Bedford, Mass.

THE ELECTRICAL AGE will pay 30 cents for copies of November and December, 1906.

Classified Directory of Manufacturers—Cont'd

Ideal Elec. & Mfg. Co., Mansfield, O.
La Roche Co., F. A., New York.
Lang Electric Co., J., Chicago, Ill
Lundin Electric & Machine Co., Boston.
Manhattan Elec'l Supply Co., New York.
Marshall Elec. Mfg. Co., Boston, Mass.
Mutual Electric & Machine Co., Wheeling, W. Va.
Ohio Brass Co., Mansfield, O.
Paiste Co., H. T., Philadelphia, Pa.
Pass & Seymour, Solvay, N. Y.
Trumbull Elec. Mfg. Co., Plainville Conn.
Wesco Supply Co., St. Louis, Mo.
Western Electric Co., Chicago.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

OIL

Adam Electric Co., Frank, St. Louis, Mo.
Condit Elec'l Mfg. Co., Boston, Mass.
General Electric Co., Schenectady, N. Y.
Hartman Circuit Breaker Co., Mansfield, Ohio.
Helios Mfg. Co., Philadelphia, Pa.
Hill Electric Co., W. S., New Bedford, Mass.
Pettingell-Andrews Co., Boston, Mass.
Trumbull Elec. Mfg. Co. Plainville, Conn.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

SNAP

Bissell Co., F., Toledo, O.
General Electric Co., Schenectady N. Y.
Hart Mfg. Co., Hartford, Conn.
Sarco Company, New York.

PENDANT

Sarco Company, New York

TACHOMETERS

Schaeffer & Budenberg, New York.

TAPE

American Elec'l Wks., Philipsdale, R. I.
Boston Woven Hose & Rubber Co. Cambridge, Mass.
Brixey, W. R., New York.
Diamond Rubber Co., Akron, O.
Dunton & Co., M. W., Providence.
Electric Appliance Co., Chicago.
Garton Co., W. R., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goodrich Co., B. F., Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
Hartford Rubber Works, Co., Hartford, Conn.
Johns-Manville Co., H. W., New York
Knowles, C. S., Boston, Mass.
Marion Insulated Wire & Rubber Co., Marion, Ind.
Massachusetts Chem. Co., Walpole, Mass.
Mica Insulator Co., New York.
Morgan & Wright, Chicago, Ill.
National Insulator Co., Boston, Mass.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Pennsylvania Rubber Co., Jeannette, Pa.
Republic Rubber Co., Youngstown, O.
Revere Rubber Co., Boston, Mass.
Standard Paint Co New York

TELEPHONES

American Bell Telephone Co., Boston.
Connecticut Telephone & Electric Co., Meriden, Conn.
Couch Co., S. H., Boston, Mass.
Electric Goods Mfg. Co., Boston, Mass.
Gail-Webb Mfg. Co., Buffalo, N. Y.
Manhattan Elec'l Supply Co., New York.
Novelty Electric Co., Philadelphia, Pa.
Russell Electric Co. Danbury, Conn.
Schmidt-Wilckes Elec. Co., Weehawken, N. J.
Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
Vote-Berger Co., La Crosse, Wis.
Wesco Supply Co., St. Louis, Mo
Western Electric Co

THEATER DIMMER

Campbell Electric Co., Lynn, Mass.
Cutler-Hammer Mfg. Co., Milwaukee

Allis-Chalmers Notes

The Omaha & Council Bluffs Street Railway Co. has placed an order for a 3750-kw. steam turbo-generator.

The Toledo Railways and Light Co. has placed an order for a 6400-kw. steam turbo-generator.

The Evansville Gas & Electric Co. has placed an order for a 2000-kw. steam turbo-generator.

Personals

W. M. McFarland of the Babcock & Wilcox Co. delivered an address to the graduating class of Stevens Institute, May 31, on "The Utility of Engineering Education."

A New Magneto

An improved type of high-tension magneto has been placed on the market by the Connecticut Telephone & Electric Company, of Meriden, Conn. It is said to have the many advantages of the double-wound armature type and of the low tension type with separate coil on the dash. The transformer coil is easily replaceable in case of a burn-out. The rotation direction is changeable by changing three screws. The machine is tightly enclosed so as to be waterproof and dust-proof.

The construction of this magnet has been greatly simplified by reducing the number of parts. It cannot be short-circuited by too much oil, as there is a special drain which carries off all excess.

Classified Directory of Manufacturers—*Cont'd*

Weston Elec'l Inst. Co., Newark, N. J.
Whitney Electrical Inst., Co., New York.

WIRE—

COPPER

Am. Electrical Heater Co., Detroit, Mich.
Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill
Ansonia Brass & Copper Co., New York
Bishop Gutta Percha Co., New York.
Chicago Insulated Wire Co., Chicago.
Crescent Insulated Wire & Cable Co., Trenton, N. J.
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Monarch Electric & Wire Co., Chicago.
Moore, Alfred F., Philadelphia, Pa.
National Conduit & Cable Co., New York
Phillips Insulated Wire Co., Pawtucket R I.
Roebling's Sons Co., John A., Trenton.
Seymour Mfg Co., Seymour, Conn.
Standard Underground Cable Co., Pittsburg, Pa
Western Electric Co., Chicago.
Wire & Telephone Co. of America, Rome, N. Y.

MAGNET

Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago, Ill.
Ansonia Brass & Copper Co., New York.
Belden Mfg. Co., Chicago, Ill.
Chicago Insulated Wire Co., Chicago.
D. & W Fuse Co., Providence, R. I.
Driver-Harris Wire Co., Harrison, N. J
Hazard Mfg. Co., Wilkesbarre, Pa.
Kellogg Switchboard & Supply Co., Chicago. Ill.
Moore Alfred F., Philadelphia, Pa
Roebling's **Sons Co., John A.,** Trenton
Seymour **Mfg. Co.,** Seymour, Conn.
Standard Underground Cable Co., Pittsburg. Pa
Stuart-Howland Co., Boston, Mass.
Washburn Mfg. Co., Phillipsdale, R. I.
Waterbury Brass Co., Waterbury, Conn.
Western Electric Co., Chicago, Ill.
Wire & Telephone Co. of America, Rome

RUBBER COVERED

Am. Electrical Wks., Phillipsdale, R. I.
American Steel & Wire Co., Chicago.
Atlantic Ins. Wire & Cable Co., New York.
Bishop Gutta Percha Co., New York.
Boston Insulated Wire & Cable Co., Boston, Mass
Brixey, W. R., New York
Crescent Insulated Wire & Cable Co., Trenton, N. J.
General Electric Co., Schenectady, N Y.
Hazard Mfg. Co., Wilkesbarre, Pa.
India Rubber & Gutta Percha Insulating Co., New York.
Indiana Rubber & Insulated Wire Co., Jonesboro, Ind
Lowell Insulated Wire Co., Lowell, Mass
Marion Insulated Wire & Rubber Co., Marion, Ind.
National India Rubber Co., Bristol, R I.
N. Y. Insulated Wire Co., New York.
Okonite Co., New York.
Phillips Insulated Wire Co. Pawtucket, R. I
Reed Electrical Cordage Co., Syracuse, N. Y.
Roebling's Sons Co., John A., Trenton.
Safety Ins. Wire & Cable Co., New York.
Simplex Electrical Co., Boston, **Mass.**
Standard Underground Cable Co., Pittsburg.
Waterbury Co., New York.
Wire & Telephone Co. of America, Rome

DIRECTORY

EMBRACING THE LEADING AMERICAN ENGINEERS, CONTRACTORS AND ARCHITECTS