SOME DEVELOPMENTS IN THE ELECTRICAL INDUSTRY DURING 1916

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The great diversity in electrical apparatus and the wide field of power application which is affected either directly or indirectly by developments in the electrical industry make it difficult to include within the limits of a single article a complete description, even in outline, of all phases of the progress achieved during the year. However, by specific reference to typical equipments and installations, the author has in this article described the salient features of the more important developments in a manner which conveys a logical and comprehensive idea of their technical and commercial values, and also indicates their influence on both the designing and manufacturing trend throughout the industry.—Editor.

Notwithstanding the intensity of productive activity imposed on the electrical industry during 1916, by the demand for equipment to meet the needs of the unparalleled manufacturing business of the United States, a considerable number of important advances were achieved in the design and construction of various classes of electrical apparatus.

The phenomenal expansion of our seaborne commerce entailed a noteworthy increase in the use of electric auxiliaries on shipboard, and there was also a further acceptance and adoption of electric propulsion for naval vessels. Perhaps the most impressive development in marine work, however, was the radical increase in the use of geared turbine propulsion for merchant ships.

The unit capacity of steam turbine generator sets was carried well beyond the maximum of previous years, and many minor changes were introduced in the construction and methods of operation of apparatus for central station generation, distribution and control systems, and for the further safeguarding of industrial electrical equipment. These developments tended to enhance the value of electric service in widely diversified industries and to further extend the field of economical electric power application.

In railway work the regular operation of electrified trunk lines on a scale which was never before possible gave gratifying practical results and rendered possible the accumulation of detailed operating data which cannot fail to have a vital influence on the future trend of railway electrification, not only in the United States but throughout the world.

Due to the nature of this article the references to each class or type of apparatus must be necessarily limited in scope and fully detailed description which might be of interest to designing and operating engineers must perforce be abridged. Therefore the omission of specific mention of certain classes of machines does not imply the absence of improvements during the year, but merely indicates that the changes made were of a minor nature and did not involve elements of radical departure from previous practice.

The electrical apparatus and turbines referred to in the various sections of the article are all of General Electric manufacture, but the character and extent of the equipments cited permit their use as criteria of the advances made in the electrical industry as a whole, in a year replete with important engineering and commercial developments.

Turbines

The greatest advances of the past year in turbine work were along the lines of better economy and greater simplicity. The tendency toward the use of higher initial steam pressure which has become increasingly evident during recent years, led to the designing of units to operate at steam pressures as high as 300 pounds gauge. Most of the larger installations have taken advantage of improved condenser design and now operate regularly at vacua within one inch of perfect vacuum.

When we consider that the volume of each pound of steam is twice as great at 29 inches as at 28 inches vacuum, it is obvious that in utilizing such high vacuum with the resulting enormous volume of steam to be handled, the proportions of the turbine must be initially designed for such conditions if the full benefit of the high vacuum is to be obtained. This has been fully provided for in G-E turbine design.

Along the lines of greater simplicity, there were under construction self-contained single flow turbines of 35,000 kw. capacity and larger. These sets consist of a turbine enclosed in a single casing and operating with steam flow in one direction, the turbine driving a direct-connected generator mounted on a base integral with the turbine casing. This construction secures a maximum of simplicity and gives the smallest number of joints, connections and possible air leaks, thereby assuring sustained economical operation.

Fig. 1. S. S. Eurana, Equipped with Geared Turbine Propelling Machinery

In the size of the turbine generators being considered and built, the year showed notable progress when compared with previous practice. In this connection the order placed by the Detroit Edison Company for a 45,000-kw. turbine-generator is of interest. This set consists of a single turbine of single flow design, connected to a single generator rated 50,000 kilovolt-amperes at 90 per cent power factor.

To meet the demand for turbine driven exciters for the large installations, a line of geared direct-current sets (Fig. 2) was developed to supplement the smaller direct-connected sets which have been on the market for some time. Turbines and gears similar to those used in these sets are also used extensively for driving pumps, air compressors and similar apparatus. For high speed rotating machines these turbines are employed without the gearing. These turbines and sets are also used on ship board for driving various auxiliaries.

A large number of geared turbine generator sets were built during the year; of which the greater part are direct current sets. The improved economy due to the higher turbine speeds made possible by the use of geared sets, combined with the advantage of the low speed direct current generator, explains this development. A number of alternating-current 25-cycle geared sets were built.

One of the most important applications of turbine and gear is for ship propulsion, and orders were received for a large number of such outfits for driving merchant vessels. These turbines range in output from 1800 to 4000 horse power. A typical ship of this class is shown in Fig. 1, while Fig. 3 shows the turbine and gear equipment that is used. Several larger sets are being built for high speed scout ships for the United States Navy.

Electric Drive for Auxiliaries on Ships

The equipment of the Union Oil Company of California's tank steamer "La Brea," which began its initial voyage on March 9, 1916, is of unusual interest due to the fact that induction motors were used throughout for driving the auxiliaries; in which service direct-current motors or steam drive had previously been used almost exclusively.

The "La Brea" is 435 ft. long, and is propelled by a steam turbine through reduction gearing. In addition to the main turbine, which is rated at 2600 h.p., two small turbo-generator sets, rated at 375 kv-a. and 125 kv-a., 3600 r.p.m., three-phase, 60 cycles, 240 volts, are installed for supplying current for the motor driven auxiliaries.

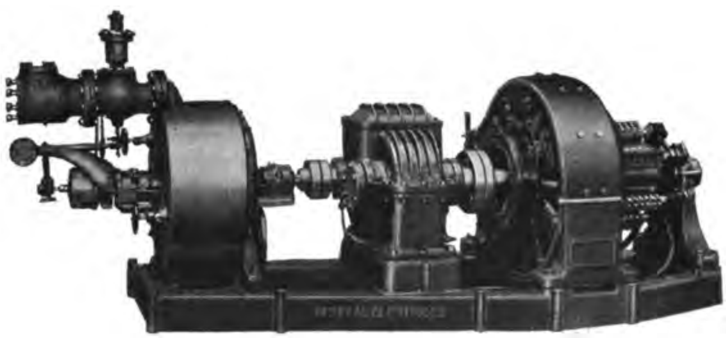

Fig. 2. Small Curtis Steam Turbine Geared to Direct-current Generator

There are twenty-two cargo tanks in the hull of the ship, each served by a 4-inch vertical shaft rotary pump, individually driven through gearing by a 40-h.p., 600-r.p.m., 220-volt horizontal shaft induction motor. (Fig. 4) These motors are of the open type and are installed on the deck in cast iron gas-tight casings, the hand-hole covers of which are opened when the motors are in operation in order to secure the necessary ventilation.

On account of the nature of the cargo carried it was not considered advisable to locate the motor starting equipment where the circuit would be made or broken on the upper deck, and all of the 22 cargo pump motors are therefore started from the engine room switchboard through a single compensator. In order to accomplish this the control panels have running and starting buses, the former being energized direct from the generators and the starting buses through the compensator. With this arrangement and the use of triple-pole double-throw switches, the pump motors are put in operation in sequence so that only the one compensator referred to is required; a spare compensator is held in reserve.

In addition to the cargo pump motors a 60-h.p., 720-r.p.m. motor is direct-connected to the circulation pump for the main condenser, while the centrifugal boiler feed pump is direct driven by 50-h.p., 3600-r.p.m. motor, and a centrifugal ballast pump by a 35-h.p., 1800-r.p.m. motor.

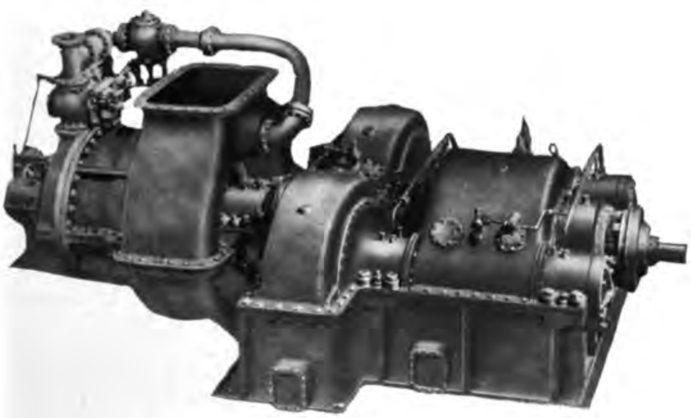

Fig. 3. Curtis Turbine and One Plane, Flexible Type, Speed Reduction Gear for Ship Propulsion

In order to avoid all possibility of the ignition of explosive gases, neither direct-current nor slip ring motors were considered, and the squirrel-cage type was adopted throughout.

Radio Apparatus

Electrical equipment more powerful than any previously installed for wireless telegraphy was produced for three high power radio stations, which, when completed, will give a service spanning the Pacific Ocean.

Fig. 4. Arrangement of Motor Drive for Cargo Pumps on S. S. La Brea

These stations are located at San Diego, California, Pearl Harbor, Hawaii, and Cavite, P.I.

The apparatus supplied by the General Electric Company includes all power and auxiliary electrical equipment, except that immediately connected with the arc and its control and operation. Current for radio service will be furnished in each case by a motor-generator set, and two complete units were furnished for each station, one of which is held in reserve, and automatic starting, with both local and remote control, was provided for. The motor-generator sets are rated as follows:

Station	Motor	Generator
San Diego	300 h.p., 1200 r.p.m., 2200 volts........	200 kw., 950 volts
Pearl Harbor	750 h.p., 900 r.p.m., 2200 volts........	500 kw., 1430 volts
Cavite, P. I.	720 h.p., 900 r.p.m., 220 volts.........	500 kw., 1430 volts

The current supply at San Diego and Pearl Habor is secured from an outside source, and enters the former station at 11,000 volts, where it is then stepped down to 2200 volts; while at Pearl Habor it is received at 2200 volts, this being the operating voltage of the driving motors of the motor-generator sets in both stations. At Cavite. however, an independent generating plant supplies current for the radio service. This equipment consists of two G-E 150-kw., 220-volt high compression oil engine generating sets, used in conjunction with a 300-kw. storage battery. There is also a battery charging booster.

Each station is provided with a contactor panel for short circuiting the regulating resistance in series with the arc, and these contactors are operated in sequence by means of a single-pole multiple blade switch. The necessary resistance is mounted back of the panel on porcelain insulators, and the 125-volt control circuit is especially insulated to enable it to withstand the heavy surges which are imposed on the circuit when the arc is broken. On the back of this panel are mounted two specially designed direct-current high voltage contactors for the main arc circuit.

Electric Railways

In the railway field the year was marked by a trend toward standardization, indicating a general acceptance of existing types of electric equipment as eminently suited to the performance of various classes of service. Both manufacturers and operating companies, therefore, were more concerned with perfecting details and eliminating minor defects than in developing new types of apparatus.

Chicago, Milwaukee & St. Paul Railway

A conspicuous example of the ability of large manufacturers successfully to design and put in operation electrification projects of any magnitude, is the Chicago, Milwaukee & St. Paul Railway now operating 335 miles of route from Harlowton to Alberton, Montana, and with additional trackage nearing completion, making a total of 440 route miles. The unqualified success of this initial 3000-volt direct current electrification is a source of gratification to all concerned. The one feature of the project which stood out as new and untried was the use of regenerative electric braking in connection with standard direct-current series motors. After trials extending over a full year, it is most significant that this portion of the equipment is operating with entire satisfaction and practically without change from the original design.

Fig. 5. Chicago, Milwaukee & St. Paul, Canadian Northern and Butte, Anaconda & Pacific Locomotives on Test Track at Erie Works

Overload line construction and the remaining substations are practically finished for the entire electric zone and electric trains will be in operation over the entire 440 miles by the beginning of 1917. One feature of the motor-generator sets supplied on the last seven substations is worthy of mention. On these sets the ventilating fans used to cool the direct-current machines have been omitted and ventilation is secured by separate blower so controlled that it operates only above a certain temperature limit. This control is entirely automatic, depending upon the action of a thermostat suitably located. (See G. E. Review, November, 1916, page 908.)

Bethlehem-Chile Iron Mines Company

Three 120-ton, 2400-volt direct-current locomotives were shipped during the latter part of the year to the Bethlehem-Chile

Iron Mines Company for operating a 15 mile ore hauling road between Cruz Grande and Tofo, Chile. These locomotives are similar in many respects to a half unit of the Chicago, Milwaukee & St. Paul locomotive without the guiding trucks. Regenerative electric braking equipment is provided and will be used for lowering the ore trains for a distance of 14 miles down a continuous 3 per cent grade. (See G. E. REVIEW, Nov., 1916, page 995.)

Butte, Anaconda & Pacific Railway

In order to take care of greatly increased traffic, the Butte, Anaconda & Pacific Railway purchased six additional 80-ton locomotives which are duplicates of the original equipment, making a total of 28 locomotives. Two additional 1000-kw. synchronous motor-generator sets were provided for the substations, these being duplicates of the five sets previously purchased. An additional 20 miles of track were also electrified in the vicinity of Butte Hill.

Canadian Northern Railway

Work on the new tunnel and terminal of the Canadian Northern Railway entering Montreal, which had been held up on account of the European War, was resumed and partial shipment made of the 83-ton electric locomotives which will be used on this new 2400-volt electrification. Substation equipment was installed and the first electric locomotives will be used for construction work.

Fig. 7. Canadian Northern 83-ton Locomotive

Fig. 6. Bethlehem-Chile 120-ton Locomotive

New York Central Locomotives

The electrical equipment of the New York Central Railroad operating on the New York Terminal Division will be augmented during the present year by ten additional 125-ton locomotives, which will be duplicates of those last furnished. Each of these locomotives is equipped with eight bipolar gearless motors designed for high speed passenger service.

Automatic Substations

Since the first automatic railway substation was placed in operation about two years ago, twenty similar equipments have been sold in various parts of the country. About half of these are now in operation, and experience to date indicates that it is entirely practicable to operate a railway substation without attendants. Furthermore, operating data now available show that the saving in power due to the elimination of no-load losses and the reduced expenditure for attendance entirely justify the initial expenditure required.

One of the novel applications of this apparatus was the portable automatic substation built for the Interurban Railway of Des Moines, Iowa. Another adaptation of the automatic feature includes the control of two units in one substation, the control equipment being so arranged that one machine carries the load up to a predetermined figure and the second machine automatically cuts in on the higher peaks. The operation of both machines is automatic, the entire station being shut down under no-load conditions.

Fig. 8. Portable Automatic Substation

Car Equipments

Orders for car equipment indicated an unusual activity in light-weight motors including Types GE-258 and GE-247 rating 25 and 40 horse power respectively. More than 800 Type GE-258 motors were sold during the year for use both as two and four motor equipments. A large number of these motors were installed on light-weight frequent service cars designed to secure better service to the public and at the same time to return satisfactory earnings on the investment.

Large equipment orders were also taken for subway and surface lines, interurban properties and storage battery cars. The Interborough Rapid Transit Company and the New York Municipal Railways of New York City purchased more than 1200 motors for new subway and elevated equipment. The New York Railways have added to their storage battery equipment, and the surburban lines of the New York Central are installing new multiple unit car equipment Other large car equipment orders were received from Detroit, Minneapolis, Providence, Boston, Milwaukee, Buffalo, Baltimore and from the Public Service Company of New Jersey. Many of these orders included PC control. This type of control, which differs in many important features from previous systems of remote control, is fulfilling the requirements of operating companies in a most satisfactory manner. (Details of this type of control are given in the GENERAL ELECTRIC REVIEW of November, 1916, page 1015.)

Automatic Synchronous Condenser Substation

As a logical result of the success achieved with automatic substations in railway operation, the same principles were applied, with certain modifications, in a synchronous condenser substation installed toward the close of the year on a transmission line of the Interstate Light & Power Company, Hazel Green, Wis., in the vicinity of a low power-factor mining load located at a considerable distance from the generating station.

The installation comprises a 3000-kv-a., 4000-volt synchronous condenser and an automatic starting and control equipment, so that the substation does not require the attention of an operator except for periodical inspection and renewal of lubrication.

When the voltage at this substation drops, because of poor power-factor or increased load, a contact-making voltmeter automatically starts a motor-driven controller, which, through contactors and oil switches operating in proper sequence, effects the starting of the synchronous condenser, and connects it to the line with its field excited from the direct-connected exciter. A voltage regulator then holds constant voltage at the station, varying the kilovolt-ampere input to the condenser. As the need for the condenser becomes less and less (to hold the proper voltage) and the load drops to about 10 per cent of normal, a contact-making ammeter shuts down the equipment.

The condenser is prevented from being overloaded by means of a stop on the voltage regulator and the equipment is further protected against unusual internal disturbances by inverse time-limit overload relays.

Industrial and Mining Locomotives

In addition to meeting an unprecedented demand for standard forms of industrial locomotives, a considerable number of unusual types were developed during the year to take care of exceptional operating conditions, and a brief reference to certain of these special units will serve to demonstrate the great flexibility which is possible in the design of the electric type of tractor. This characteristic permits it easily and successfully to overcome operating limitations which would render the adoption or modification of other forms of locomotives a matter of great difficulty and expense.

Three 25-ton locomotives, one of which is shown in Fig. 10, were built early in the year for haulage service through a restricted tunnel over a 30-inch gauge road on the property of the Braden Copper Company in Chile. They are the heaviest locomotives operating on this gauge, and are of the trolley type.

Each unit is driven by four 45-h.p., 250-volt motors, and is equipped with Type M control and automatic air brakes. In order to secure sufficient vertical clearance while traversing the tunnel, the cab roof is only 7 ft. 6 in. above the rails.

A number of uncommon features are found in a 20-ton locomotive which was specially developed for coke oven service in steel mills. The locomotive is standard gauge and operates on a 220-volt direct-current metallic circuit, the feeders being two rails mounted vertically along one side of the track, as shown in Fig. 11. Two 85-h.p. driving motors are used with hand control and straight air brakes.

The service cycle is as follows: The locomotive pushes long steel cars beneath the coke ovens, and while the coke is being discharged the car is moved slowly so that a broad ribbon of incandescent coke is evenly deposited along the bottom of the car. In order that this may be accomplished the locomotive has a two-story cab with the control centered in the upper section so that the motorman can overlook the length of the coke car and manipulate the locomotive so as to secure the required even distribution of the coke.

Fig. 10. 25-ton 30-in. Gauge Haulage Locomotive on Test Track

After being loaded the car is drawn to the quenching station where the motorman by stepping from the cab to the small platform, which forms part of the upper floor of the locomotive cab (Fig. 11), can easily reach the quenching valves. The car is thereafter brought to the coke wharf where the coke is discharged, as shown in Fig. 12.

Fig. 9. Three-unit, 2000-kw. Synchronous Motor-generator Set Arranged for External Ventilation

The doors of the coke car are controlled by the motorman and are operated by compressed air, which is supplied by a CP-26 motor driven air compressor installed on the lower platform of the locomotive. At present fifteen of these coke oven locomotives are

Fig. 11. 20-ton Coke Oven Locomotive at Quenching Station

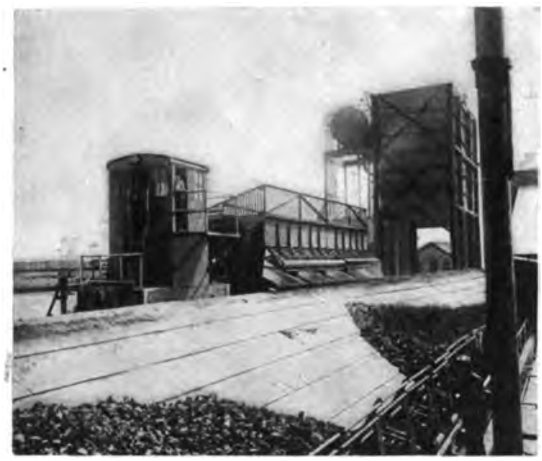

Fig. 12. Coke Car Discharging at Coke Wharf

in service, and the completion of those now under construction will bring the total number above forty. They were designed for the H. Koppers Co. of Pittsburg, Pa.

Another special type, known as a "pusher" locomotive, was designed for handling coal trains and spotting cars at the plant of the Toledo Furnace Co., Toledo, Ohio. It is rated at 25 tons with two 125-h.p., 250-volt driving motors and has Type M control with straight air brakes.

The duty of this locomotive is limited to shuttle service on a single line of 42-inch gauge track (Fig. 13), centrally located between two standard gauge tracks on which the coal cars are run. Current is supplied by a metallic circuit consisting of two rails located between the running rails.

Fig. 13. 25-ton "Pusher" Locomotive with Both Pusher Arms in Operating Position

Fig. 14. Side View of "Pusher" Locomotive Showing Construction of Pneumatically Operated Pusher Arm

At the center of each side of the locomotive (Fig. 14) a hinged heavy metal arm or wing pusher is provided, these arms are raised or lowered pneumatically. The locomotive was placed in service in July, 1916, and has been in successful operation since that time.

Radically different conditions govern the service of four 12-ton standard gauge locomotives (Fig. 15) used in the plant of the Davison Chemical Company at Curtis Bay Md., for here the locomotive must, in addition to its work as a tractor, act as a movable air reservoir. Current is supplied through an over-running third rail at 250 volts to two 65-h.p. driving motors.

The exceptional equipment for each locomotive consists of two CP-30 air compressors of 35 cu. ft. capacity each, which supply air at 70 lb. pressure to four storage tanks, two of which are located on the locomotive deck and two below. The compressed air is stored rapidly in these reservoirs, so that while the locomotive is making a relatively short haul (Fig. 16) an ample supply of air is available for dumping the cars at the end of the run. This is accomplished by delivering air from the locomotive tanks to storage tanks on the cars, so that at the end of a run the locomotive may leave the cars, which can then be dumped pneumatically by means of their own supply of stored air. Combined straight and automatic air brakes are used.

Fig. 15. 12-ton Locomotive Showing Arrangement of Compressors and Air Storage Tanks

For yard switching and industrial railway haulage, a compact 12-ton gasolene-electric locomotive (Fig. 17) was built. It runs on standard gauge tracks and its power plant consists of a 25-kw., 560-r.p.m. gasolene-electric generating set which supplies current at 250 volts to two 25-h.p. driving motors. Like the large gasolene-electric passenger cars, its operating speeds are regulated by field control of the generator, and hand brakes are used. It has proven very successful in a variety of haulage service and as it is altogether self-contained (Fig. 18) with regard to its energy supply, it is especially useful where feeder wires or other

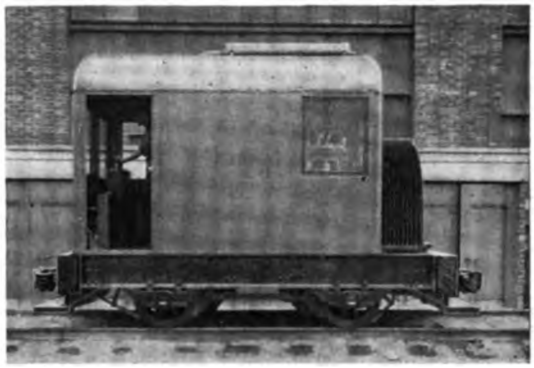

Fig. 17. 12-ton Industrial Gasolene-electric Locomotive

Fig. 16. Two 20-ton Locomotives Hauling Trips, Showing the Over-running Third Rail and Current Collectors

electrical conductors would be objectionable, and for conditions involving long hauls and continuous service which might limit the usefulness of storage battery locomotives.

The entire weight is carried on the four driving wheels and speeds up to 16 miles per hour can be obtained on level track. When it is considered that the locomotive carries its own power plant, its overall dimensions are notably small; length 16 ft., width 6 ft., 6 in., and height between rails and top of cab 10 ft. 3 in.

Fig. 18. View in Cab of Gasolene-electric Locomotive Showing Self-contained Power Plant from Generator End

The advance made in the storage battery type of locomotive was typified by the construction of a double truck locomotive with the battery on a centrally located platform joining the two trucks, thereby minimizing the vertical dimensions of the locomotive and permitting its effective application for service in low coal seams and on the short radius tracks frequently encountered in mine haulage.

With a total weight of 8 tons, about 6 tons are imposed on the two pairs of driving wheels at either end of the locomotive. The two central pairs of wheels are not drivers. Each truck has a rigid wheel base of only 30 inches, while the overall height above the rails is 34 inches, indicating unusual compactness and flexibility for a locomotive of this capacity. It is the first double-truck storage battery locomotive built by the General Electric Company, and three others of the same type were under construction at the close of the year.

Toward the end of the year, the largest G-E locomotive so far built for main mine haulage was completed. The locomotive is rated at 25 tons, but the three 125-h.p., 500-volt motors with which it is equipped have ample capacity to permit the addition of sufficient weight to give a rating of 35 tons, if required. Its overall dimensions are: length over bumpers, 300 inches; width, 77 inches; and maximum height above rails, 54 inches. The wheel base is 120 inches, with 36-inch diameter wheels; it runs on a 48-inch gauge track, and develops a drawbar pull of 10,000 pounds at 8.8 miles per hour.

Both straight air and hand brakes are provided on this locomotive, and it is also equipped with Type M multiple unit control. Where additional haulage capacity is required, the design permits the coupling together of two of these units, so that if necessary the effective rating of a tandem locomotive of this type, operating within the working limits which regulated its design, can be raised to 70 tons with a control system as easily manipulated as that of the smallest and simplest form of mine locomotive. This 25-ton unit is intended for main haulage in the Caruthers coal mine of the H. C. Frick Co. at Maxwell Station, Fayatte County, Pa.

Electric Shovels

In the fall of 1915 the Piney Fork Coal Company, Smithfield, Ohio, placed in service a 250-ton electric shovel, and a year later a similar machine, rated at 300 tons, was installed by the Beech Flats Coal Company at Rush Run, Ohio. Both of these shovels are employed in stripping overburden from coal beds, and they are the largest electric shovels in existence.

In order to gain a comprehensive idea of the improvements embodied in the operation and control systems of the 1916 shovel, a comparison of the equipment of both shovels is necessary.

The 1915 machine has a six yard dipper, and is equipped with a 300-kw., 250-volt synchronous motor-generator set having a 4000-volt, 60-cycle motor, switchboard control panel, two 170-h.p. hoisting motors, one 63-h.p. swinging motor, one 60-h.p. crowding motor, and three contactor control panels. The motors are of series mill type construction, while the control is automatic and reversible with current limit acceleration, "notching back" and plugging features.

The hoisting control, although not strictly of the reversible type, has a hoisting and lowering position corresponding to the forward and reverse positions on any reversible controller; but the lowering position is utilized for regeneration, and the energy given up by the falling dipper is in this way applied in the operation of the swinging motor on its return trip.

Magnetically operated air valves are used in conjunction with each control for releasing the friction band brakes, the air being supplied by a small self-contained motor-driven compressor. This shovel requires two men for its operation. At the time of its installation it was not only the largest electrically equipped shovel, but it embodied certain features hitherto untried on this type of machine. The 1916 shovel is not only of greater capacity than its prototype, but is so designed that its unique control system permits the carrying on of all operations by one man.

The dipper of the new shovel is of eight yard capacity, and the operator controls the entire equipment as follows:

The hoisting master controller is manipulated with one hand, and the crowding master controller with the other, while the swinging motor is started and stopped by means of two foot-operated push buttons. The dipper trip, instead of being manually operated, as in the 1915 machine, is opened and closed by a small motor, controlled through a push button in the handle of the crowding master controller.

In other details the electrical equipment of the two shovels is identical. The power is supplied in both cases from a three-phase, 60-cycle high potential line from which the current is stepped down to 4000 volts in the field in which the shovel is operating, after which it is transmitted directly to the shovel through a three-phase armored cable and taken into the cab through a three ring collector. Slack cable is wound up on a large reel mounted on the shovel frame, as shown in Fig. 19.

Some idea of the exceptional size and service capacity of the 1916 shovel may be gained from the following data:

Radius of cut at bottom, approximately 60 ft.
Center rotation to center of dump, approximately 95 ft.

Fig. 19. 250-ton Electric Stripping Shovel in Coal Field at Smithfield, Ohio

Height of dump above rail, 65 ft.
Maximum radius of cut, 103 ft.
Length of boom, approximately 90 ft.
Length of dipper handle approximately 45 ft.
Weight of dipper and handle, 45,000 lb.
Average length of cycle, 45 sec.

As an evidence of the fact that these machines have fully met the service test in a class of work which imposes the severest strains and jars on the operating mechanism, a third shovel of the "one man" type, similar to the 1916 machine above described, was nearing completion at the end of the year, and at an early date will be applied for removing overburden on coal fields near Zanesville, Ohio.

Mine Hoists

That considerable progress was made in the application of electric drive to mine hoists during the year is indicated by the fact that in that period there were installed seventy-nine equipments, aggregating more than 30,000 h.p., the average unit size being about 380 h.p. This does not include any hoisting set rated at less than 100 h.p. Of this total approximately 24,000 h.p., or about 80 per cent of the rated capacity, consisted of induction motors, the remainder utilizing direct-current equipments with flywheel motor-generator sets and the Ward Leonard system of control.

Among the more notable direct current outfits is that for the Cleveland Cliffs Iron Mining Company, provided for hoisting iron ore at the Athens Hoist, Ishpeming, Mich. The equipment here comprises a 900-h.p., 300-volt direct-current motor (Fig. 20),

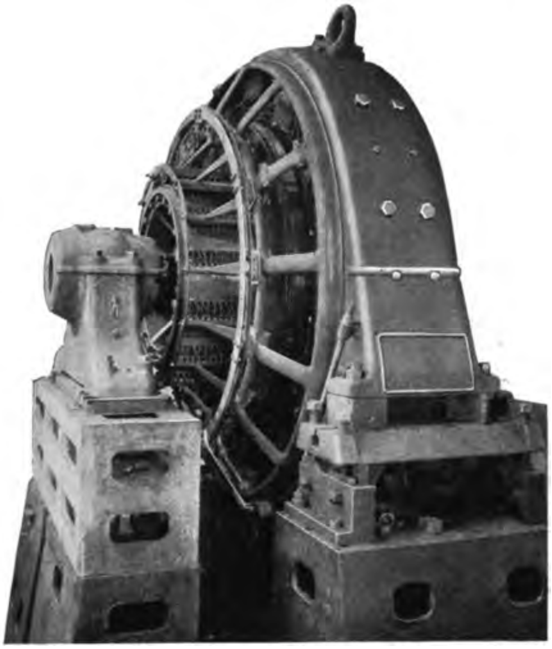

Fig. 20. 900-h.p. 300-volt 71-r.p.m. Motor for Direct Connection to Mine Hoist

direct coupled to a double drum, balanced hoist, operating at 71 r.p.m. In service the equipment hoists 12,000 pounds of iron ore per trip through a shaft having a maximum depth of 2700 ft., at a hoisting speed of 1800 ft. per minute; this duty requiring from the motor a maximum output of approximately 1700 h.p. Current is supplied to the hoist motor by a motor-generator set (Fig. 21) consisting of an 850-h.p., 2200-volt, three-phase, 60-cycle induction motor direct connected to a 675-kw., 300-volt generator. This set operates at 720 r.p.m., and is provided with a 30-ton flywheel which functions to limit the demand from the power system to approximately 960 h.p.

Another shaft hoist, for handling copper ore at a maximum depth of 3500 ft. with a rope speed of 2500 ft. per minute and a weight of 10,000 pounds per trip, was installed at the Elm-Orlu Mines at Butte, Mont. This is a balanced double drum hoist driven by an 1800-h.p., 80-r.p.m. direct current motor. It is a first motion hoist with the motor coupled directly to the hoist drums. It is of importance in connection with this motor to state that the rating of 1800 h.p. is for continuous operation with a temperature rise not to exceed 40 deg. C. The installation of this equipment was completed toward the end of the year and includes a flywheel motor-generator set having an output of 1300 kw. for supplying the hoist motor; the flywheel weighing approximately 45 tons.

About the middle of the year an induction motor driven mine hoist was put in service by the Tennessee Coal & Iron Company at Slope 4, Muscoda, Ala. This included an 1800-h.p., Form M induction motor geared to a single hoist drum through single reduction gearing, and the outfit is the largest induction motor driven mine hoist ever installed in America. The control of this hoist is secured through primary reversing air break contactors with liquid rheostat for secondary control, the primary voltage being 2200.

This equipment superseded a steam driven hoist, and the drums of the original equipment have been retained. It is utilized for hoisting iron ore on a 23 deg. slope, one mile in length, with a load of 26,880 pounds per trip, and with a rope speed of 2700 ft. per minute. The operating results obtained have been so satisfactory that a number of similar equipments are being considered for other properties of this Company.

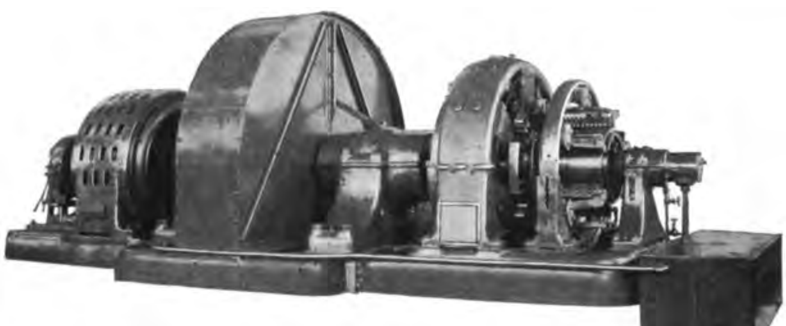

Fig. 21. Flywheel Motor-generator Set which Supplies Current to Hoist Motor Shown in Fig. 20

Another outfit having the same system of control as the above has been applied in the operation of a water hoist at Lansford, Pa., by the Lehigh Coal & Navigation Co. The induction motor in this case is rated at 1200 h.p., it is geared to a double drum balanced hoist, and is controlled by means of a liquid rheostat. Each bucket carries a load of 30,000 pounds of water, and the hoist delivers at the rate of 200,000 gallons per hour.

Fig. 22. 1800-h.p. Induction Motor Driving Converted Steam Hoist

Among the larger orders received by the General Electric Company during the year, was one for the Oliver Iron Mining Company, Ironwood, Mich., covering five 875-h.p. and five 400-h.p. motors with liquid rheostat secondary control. In connection with this order it may be stated that these hoists, together with compressor and turbine equipments, will form the first extensive mine electrification in this district.

Fig. 23. 350-h.p. Induction Motor Driving High-speed Coal Hoist

Coal Tower Hoist

Prior to 1916, steam driven coal hoists were used exclusively where extremely high rope speeds were required, but the development of an electric motor with exceedingly light flywheel effect in its armature made it possible to secure the desired rapidity in starting, stopping and reversing a motor-driven hoist, so that the benefits of electric operation were at once rendered available for this particular class of power application.

A coal tower hoist of this type was installed at the Essex Street Station of the Public Service Electric Company of New Jersey, to give a rope speed of 1260 feet per minute, with a lift of 180 ft. The bucket capacity is two tons of coal and two round trips per minute are made (see illustration on cover).

The equipment consists of a 350-h.p., 200-r.p.m., 440-volt, three-phase, 60-cycle motor, (Fig. 23) coupled direct to the hoisting drums and capable of bringing the load from rest to full speed in 2½ seconds. Solenoid brakes and magnetic controls are used, and for the trolleying a 75-h.p., 900-r.p.m. motor is geared to drums to give a speed of about 450 feet per minute.

This initial installation was placed in service early in the year, and has given entire satisfaction in operation. It is the first direct-connected motor-driven hoist designed for such high speeds and rapid acceleration as were required in this instance, and its successful application opens up a wide field of usefulness for motors having rotors with very light flywheel effect.

Mine Pumps

The mine pumping sets produced included two vertical shaft, centrifugal sinking pumps for the Iron & Silver Mining Co., Leadville, Colo., which are each direct driven by a 150-h.p., 440-volt, 1845-r.p.m. induction motor.

These pumps are used for unwatering service and deliver 1000 gallons per minute, against heads varying from 0 to 315 ft. The motors are totally enclosed and water-cooled, and are the first totally enclosed motors of this capacity to be applied to this particular class of service.

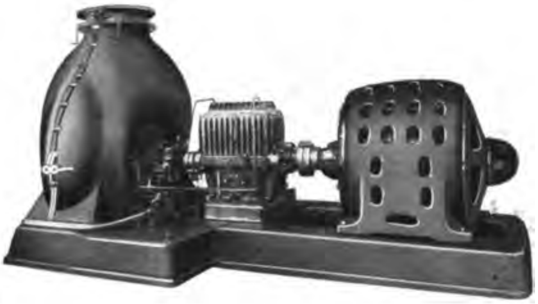

Fig. 24. Centrifugal Compressor Driven by Induction Motor Through Increasing Gears

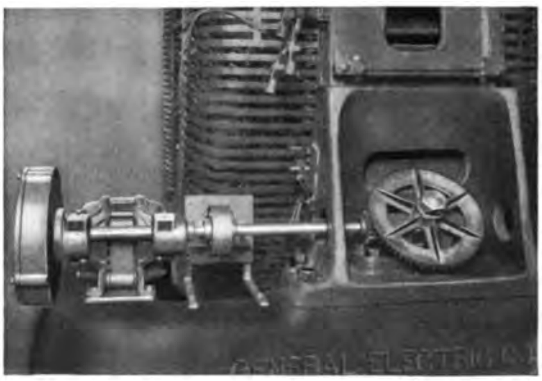

Fig. 25. Motor Driven Phase-shifting Device for Frequency Changers

Motor Driven Centrifugal Compressors

The development in this class of apparatus can be indicated by reference to three distinct classes of service for which motor-driven centrifugal compressor sets were built. In all three outfits the necessary high speeds for the rotating element of the compressors is obtained by means of increasing gears between the motor and the compressor, and in the cases cited Alquist gears, which were originally developed for reduction gearing on steam turbine equipments, were used.

The first set consists of a 25,000 cu. ft. five-pound single stage compressor employed by the Inspiration Consolidated Copper Company at Miami, Ariz., in connection with their flotation process of ore concentration. This compressor is driven through gearing by a 720-h.p., 6600-volt, three-phase, 25-cycle, 750-r.p.m. induction motor, the speed of the compressor rotor being 3850 r.p.m.

A similar motor equipment is utilized for a 20,000 cu. ft., two-stage, five-pound gas exhauster (Fig. 24) installed at the River Furnace Company's Plant, Cleveland, Ohio. The motor and compressor speeds are respectively 750 and 3850 r.p.m. and the outfit is provided with an automatic constant volume governor.

These two compressor sets were completed and shipped during the year, while two larger sets, each having a capacity of 40,000 cu. ft. of air per minute at a pressure of 30 pounds per square inch, were under construction at the close of the year. They are five-stage compressors, and are intended for use in connection with the operation of Bessemer converters by the Bethlehem Steel Co. The driving motor for each unit is rated at 5150 h.p., 6600 volts, 25 cycles, and operates at 490 r.p.m., the increasing gears giving a compressor speed of 3200 r.p.m.

Alternating-current Machines

While numerous alternating-current machines of unusual size were produced, their individual capacities did not in any case exceed the maximum of previous years. There were under construction, however, three vertical shaft generators of a higher rating than any machine of this class heretofore built. These alternators are intended for waterwheel drive and have a normal rating of 18,000 kw., 13,200 volts at 154 r.p.m. They will have a safe maximum capacity of 22,500 kw. These machines will be installed by the Aluminum Company of America, at Whitney, N. C.

Another large equipment which was not completed at the close of the year consisted of a frequency changer set for the Applachian Power Company of West Virginia. It is intended to tie in a three-phase, 13,200-volt, 60-cycle system with a single-phase, 11,000-volt, 25-cycle system. The motor is rated at 9375 h.p., and the single-phase generator has a normal rating of 10,000 kw., with a maximum capacity of 11,500 kv-a. at zero power-factor. The set is started by means of a 25-cycle repulsion induction motor which can be disconnected from the set when the set is running. This equipment represents the maximum capacity so far adopted for frequency changer sets.

A device which is unique in American power station practice was constructed early in the year. It consists of a phase shifting device for use on frequency changers and is illustrated by Fig. 25. It will be noted that the motor operates through gearing, to rotate the frame of one element of the frequency changer set, and this renders it possible to change the load on the set while it is in operation. This method has a decided advantage over the previous practice of rotating the frame of the machine by hand, which is feasible only when the set is at standstill.

Synchronous Converters

Machines of this class were built in both larger and smaller sizes than had previously been constructed in complete commercial lines, and important advances were made, particularly in the use of 60-cycle machines. The smaller 60-cycle units were designed for the transformation of current for direct-current mine industrial service.

With a previous low limit of capacity of about 150 kw., the newly developed line (Fig. 26) which has been practically standardized, included 25, 50 and 75-kw. units, operating at 1800 r.p.m., 250 volts, and 100, 150 and 200-kw. sizes at 1200 r.p.m., 250 volts; with a line of 125-volt machines up to and including 75 kw. With these machines higher efficiencies were secured than with corresponding types brought out in previous years and commutating poles were provided for all 100-kw. units and larger.

For the larger 60-cycle converters the maximum capacity represented by individual machines was more than twice that of preceding years, and some very large units were produced for use in zinc refining. Five of these have an effective output of 5800 kw. at 580 volts, 225 r.p.m., the current rating being 10,000 amperes (Fig. 27). They are provided with separate motor driven boosters to secure necessary variations in the direct-current voltage. When it is understood that the rating of the largest machines of this class built in former years did not exceed 2500 kw., the advance made during 1916 can be appreciated.

For frequencies lower than 60 cycles some very large units were completed and installed, and others were nearing completion at the close of the year. An order was received which included eleven converters, rated at 6825 kw., 525 volts, or an aggregate capacity of 75,075 kw. for this one type of machine, for a single installation.

This is the largest order for synchronous converters ever placed, and the individual machines are of record size.

Transformers

Circular coil transformers were built for larger capacities than any heretofore con-

Fig. 26. 100-kw. 1200-r.p.m. 250-volt Three-wire Synchronous Converter

structed, and reference to some of the more important units will serve to indicate the nature and extent of the advances made.

In the self-cooled type (Fig. 28) there were three-phase, 25-cycle, 4000-kv-a., 44,000Y-2300-volt circular coil transformers which, because of the low frequency for which they were wound, had considerably larger physical dimensions than the three-phase, 60-cycle, 5000-kv-a., 23,000–11,000-volt circular coil units built during 1915. There were also under construction single-phase, 25-cycle, 8000-kv-a., 44,000–6600-volt circular coil units to give a bank output of 24,000 kv-a. These are by far the largest G-E transformers of the self-cooled type.

In the development of the water-cooled type (Fig. 29) there were single-phase, 60-cycle, 10,000-kv-a., 120,000–24,000/6600-volt circular coil units, and three-phase, 60-cycle, 11,500-kv-a., 26,400Y-13,200-volt units, these capacities being nearly twice as great as that for any of this type previously built.

A three-phase water-cooled, 60-cycle auto-transformer is being constructed to give an output of more than twice that of any previously built transformer or auto-transformer of any type. It is a three-phase, water-cooled, core-type auto-transformer, stepping up from 12,200 volts, three-phase, to 24,400 volts three-phase. It has a normal output of 50,000 kv-a. at 55 deg. rise, and is to be used to double the voltage of a 45,000-

kw., 50,000-kv-a. turbo-generator. It is capable of withstanding momentary short circuits limited only by its own reactance. Its guaranteed efficiency is 99.1 per cent at ¼ load, and 99.4 per cent at all other loads.

Current-limiting Reactors

The largest reactor built before 1916 had a rating of 25 cycles, 720 kv-a., 1200 volts, 600 amperes, which was for use in a three-phase, 9000-volt, 9375-kv-a. circuit. This rating was carried to 25 cycles, 1135 kv-a., 610 volts, 1860 amperes in 1916 by the construction of three reactors for giving 8 per cent reactive drop in a three-phase, 13,200-volt, 42,500-kv-a. circuit.

Steel Mills

The polyphase induction type of motor, already long familiar to and in high favor with the steel mill engineer, had its usefulness still further increased by the development of an efficient and commercially practical means of obtaining strictly adjustable speed control under varying load for speed ranges above as well as below the normal synchronous speed of the motor.

This "double-range" speed-regulating set was the result of several years investigation of previous unsuccessful attempts to secure an efficient shunt speed characteristic for the polyphase induction motor, and is the only successful double-range system yet devised.

Fig. 27. 5800-kw. 225-r.p.m. 580-volt Synchronous Converter

The "double-range" system is, except for certain important details, practically a duplicate of the well known "single-range" system placed on the market several years ago by the General Electric Company. Briefly, the following principles are involved:

The polyphase induction motor with phase wound rotor, when excited with normal primary potential and frequency, has a secondary or slip ring frequency and voltage proportional to its speed either above or below synchronism. At synchronism, the secondary voltage and frequency are zero, and above synchronism the phase rotation is reversed. The secondary current is proportional to the mechanical load.

The secondary energy of the motor of which the speed is to be controlled is utilized at varying frequency and voltage to drive a polyphase commutator motor with shunt speed characteristics. This commutator motor forms one unit of a two-unit motor-generator, the second unit of which is a squirrel-cage induction motor wound for line frequency and voltage. When the speed of the main motor is to be adjusted below synchronism the commutator motor drives the squirrel-cage motor slightly above its synchronous speed, causing it to function as an asynchronous induction generator, thus returning to the power system, at line frequency and voltage, the secondary energy of the main induction motor.

When the speed of the main motor is to be adjusted above synchronism, the squirrel-cage motor performs its normal function as a motor, driving the commutator machine as a generator and thus supplies energy at the necessary frequency and voltage to the secondary of the main motor. The speed of the main motor is therefore the result of the algebraic sum of the primary and secondary frequencies.

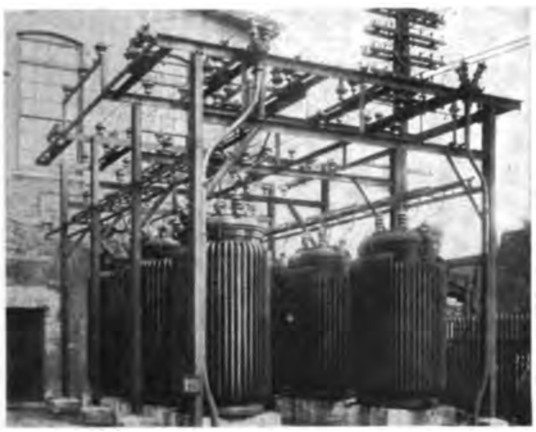

Fig. 28. An Outdoor Installation of Self-cooled Transformers

Adjustment of speed is secured by varying the excitation of the commutator machine which normally is excited from the slip rings of the main motor. Since, however, this source of excitation fails at synchronism as noted above, it is necessary to supply suitable excitation while passing through synchronism. The device for accomplishing this purpose is the essential requirement to make the single range equipment operate successfully on double range. It consists of a small winding with slip rings and commutator mounted on the main motor shaft. Suitable voltage at primary frequency is impressed on the collector rings and from the commutator is taken the necessary current for excitation of the commutator machine while the main motor is running at and near its rated synchronous speed.

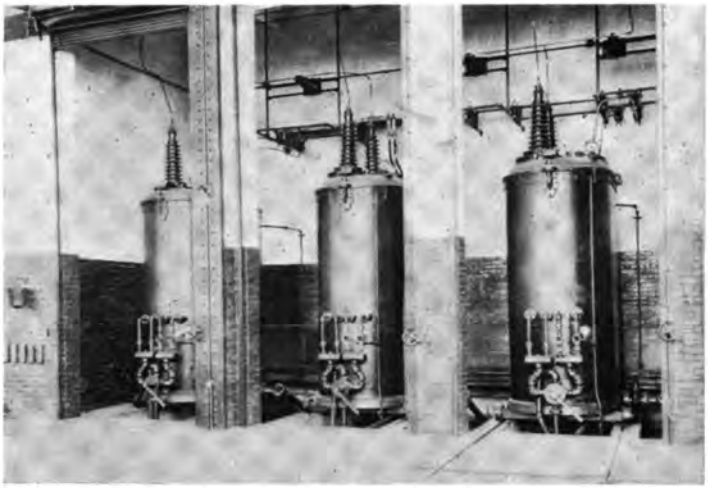

Fig. 29. An Indoor Installation of Water-cooled Transformers

The double-range system increases the range of available motor speeds at high efficiency, and for a given capacity of auxiliary equipment gives practically twice the range of adjustment of the single-range system.

The first equipment of this character was sold to the Bethlehem Steel Company in January (Fig. 30) and by the end of the year orders had been received for twenty-two equipments with an aggregate normal rating of 34,500 h.p.

The largest single installation of adjustable speed main roll drives was that for the McDonald Bar Mills of the Carnegie Steel Company, which includes nine separate and complete equipments. Construction work was in progress for other important equipments of similar character for the following companies:

Keystone Steel & Wire Co., Peoria, Ill.
Wickwire Steel Company, Buffalo, N.Y.
Donner Steel Company, Buffalo, N. Y.
Lackawanna Steel Company, Buffalo, N. Y.
Trumbull Steel Company, Warren, Ohio

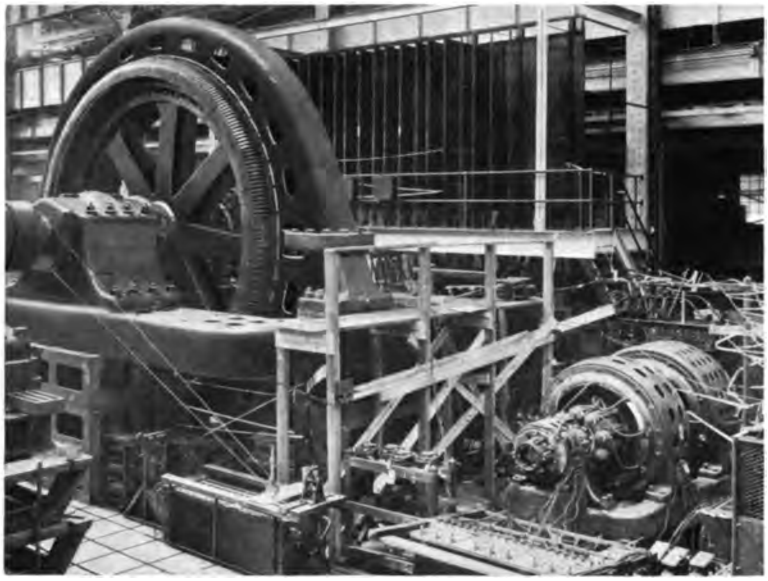

Fig. 30. 2000-h.p. Motor and Regulating Set for Steel Mill Drive

The growing demand for the reversing motor drive for blooming and plate mills, with necessary flywheel motor-generators for the equalization of widely fluctuating peak loads, was indicated by the receipt of orders for four such equipments, viz.,

- 34 in. Bloomer Mill, Ashland Iron & Mining Co., Ashland, Ky.
- 34 in. Bloomer Mill, Keystone Steel & Wire Co., Peoria, Ill.
- 36 in. Bloomer Mill, Trumbull Steel Company, Warren, Ohio.
- 40 in. Bloomer Mill, Bethlehem Steel Company, So. Bethlehem, Pa.

Rubber Mills

A new automatic push button control equipment was produced for the speed control of rubber calenders, the object being to secure a slow-down feature which would permit the operation of the calender (Fig. 31) at minimum speed for threading in new rolls of fabric without the necessity for disturbing the field rheostat setting for normal operating speed.

These equipments are designed for both single-voltage two-wire, and two-voltage three-wire circuits. By the manipulation of a push button contactors are energized and the motor is automatically decelerated until it is running at the minimum speed of which it is capable, and it continues to operate at this speed until the button is restored. The motor then accelerates to the speed at which it was previously operating.

This relatively simple arrangement has proved of considerable value in this industry, due to the fact that the operator is merely required to press the button, and can then continue the threading in operation work without giving further attention to the motor.

Shoe and Leather Industry

From time to time the use of electrically heated devices has been extended in this industry, but in many plants steam and gas heat were largely used even when part of the heating was accomplished electrically. During the year 1916, however, there was a marked increase in the number and relative importance of the electrically heated units, due to the demonstrated

Fig. 31. Motor-driven Rubber Calender Equipped with Automatic Push Button Control

value of the electric system of heating and to improvements in the heating devices themselves; so that in certain of the newer plants fuel heating for manufacturing purposes was entirely avoided and the required heat was generated exclusively by electricity.

Among the more important of these heating operations are those involved in embossing, sole drying, wax heating or stitching, and the heating of the heads of lasting machines; and in these newer factories, even where the direct application of the heat is accomplished by steam, the steam itself is produced by means of electrical heating units.

The year has also seen in this industry a very marked growth in the adoption of individual drive for all classes of shoe machinery. In preceding years a limited number of individual machines had been equipped as self-contained motor-driven units, but in most of the shoe factories the group method of driving was retained to a very large extent. However, as the extreme flexibility of individual motor drive became better understood, machines were re-located solely to facilitate production, regardless of the location of shafting, and it was demonstrated that only relatively slight mechanical changes were required for individual motor drive on machines which had previously been driven only in groups.

A considerable number of these independently driven machines have already been produced by the manufacturers of shoe machinery, and equipped with individual motors ranging in capacity from 1/50 h.p. to 7½ h.p., and among those which have already been subjected to exhaustive tests in actual service are clicking machines, gearless sole cutters, eyeletting machines, agitators, etc.

This same evolution has already been completed in a number of other industries in which extremes of power consumption for individual machines are met, and during the past year the growth of the individual drive system in shoe factories followed the same logical lines as similar developments had previously done, as for example, in machine shop practice and in the equipment of textile mills. For in both of these industries the original method of electric drive developed in successive stages from large groups to segregated groups and, finally, to a practically universal system of individual motor drive for a large percentage of the machines in all modern installations.

Switching Apparatus

It can be safely asserted that during the year 1916 more progress was made in the improvement of this class of apparatus, with regard to securing immunity from injury to the apparatus or danger to the operator, than in all the preceding decades of electrical manufacture.

The slogan "safety first" became, to an unprecedented extent, the dominating factor in the design and construction of two new types of lever switches, and in the development of a unique sectionalized, removable panel, compartment type of switchboard.

Fig. 32. Enclosed "Safety First" Lever Switch, 2-pole, 30-amp. 250-volt, Switch Locked Open, Fuse Compartment Locked Closed

Some of these "safety first" devices are illustrated here and their distinguishing features may be briefly outlined as follows:

The enclosed lever switch is made up of a standard lever switch mounted in an iron box (Fig. 32) so constructed that all current carrying parts, including fuses, are inaccessible while alive. The lid to the fuse chamber can be opened when the switch is "off," and the switch cannot be closed while this lid is open. Provision can be made for locking the switch in the "off" position.

The second type is known as the low tension dead front switch, and consists of standard knife switch and fuse clip parts mounted on a slate base (Fig. 33) which is in turn supported on iron studs at the back of a sheet steel panel. The operating handle is arranged so that it is in an upright position when the switch is "on," and at an angle of 60 deg. to the panel when the switch is "off." A sheet steel door, which opens upward, gives access to the fuses from the front of the panel, but cannot be opened while the switch is "on," and conversely, the switch cannot be closed while the door is open. Air circuit breakers of the carbon type are mounted on these panels in the same manner. These switches and circuit breakers are for use on circuits of 600 volts and under.

Fig. 33. "Safety First" Panel Switch Unit, 200-amp., 250-volt 2-pole

For circuits up to 300 amperes at 2500 volts a pedestal type switching unit is used, which has a standard oil circuit breaker and disconnecting switches so interlocked that the switch cannot be opened while the circuit breaker is closed, nor can the circuit breaker be closed while the switch is open. The disconnecting switch is operated by means of a key, which may be removed when the switch is open, thus locking the circuit breaker in the open position.

A steel switching cabinet utilizing the interlocking principle of the pedestal type switching unit in a modified form was developed for capacities up to 500 amperes on 6600-volt circuits.

Each complete unit of the "safety first" truck type switchboard panels consists of two elements (Fig. 34), viz., the truck or movable element carrying the panel, oil circuit breaker and instrument transformers, and the stationary or housing element which encloses the truck when it is in the operating position, and also contains the buses and the terminals of the incoming and outgoing cables.

The truck is mounted on wheels and can readily be withdrawn for inspection, repair or replacement; but an interlock is provided so that the truck can neither be withdrawn nor replaced in the housing while the oil circuit breaker is closed. When in operation all live current carrying parts are completely enclosed and the buses are isolated from the remainder of the housing by a heavy metal partition. The action of withdrawing the truck automatically opens the disconnecting switches.

The panels are interchangeable within reasonable ranges, and new units can be easily and quickly added to a group of panels already installed, or an extra truck held in reserve will insure a minimum interruption to service if it should be necessary at any time to withdraw a panel from the switchboard for inspection or repair. When required the oil circuit breakers may be of the electrically operated type.

In connection with switchboards and switchboard apparatus, the tendency toward further standardization of parts continued. One indication of this is the universal insulator made in 3500-volt and 15,000-volt sizes, which can be used interchangeably for the same voltage ratings on any standard busbar support, T. D. fuses, switch mountings or on pipe supports. The caps, tops, and bottoms of these insulators are interchangeable (Fig. 35), and in this way a great variety of fittings can be used with a single form of insulator.

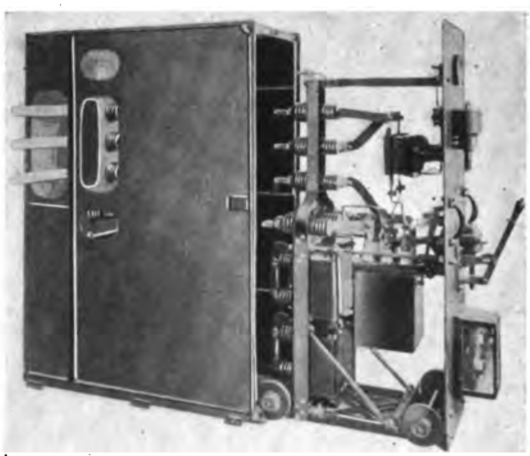

Fig. 34. Truck Type "Safety First" Switchboard Unit, Showing Truck just Entering Compartment

A further advance in the standardization of high tension insulators comprehends the eventual use of the same insulators for a given potential on different classes of apparatus, such as oil switches, lightning arresters and transformers.

It is obvious that the further this method of standardization can be safely and effectively carried, the greater will be the economies in manufacturing and operating costs, and a reduction in the number of spare parts which will be required for any power system.

In order to produce a time-limit overload relay which would be immune from the disturbing influences of heavy fluxes set up in the magnetic circuit during the operating period, a relay of entirely new design, operating on the induction principle, was developed.

Fig. 35. Universal Insulator Used with Various Fittings

A reverse phase relay was perfected (Fig. 36), the function of which is to afford protection against the accidental reversal of motor rotation. It operates on the same principle as the squirrel-cage induction motor, the operating coils corresponding to the stator, and a hollow almuinum cylinder, connected to the contacts, to the rotor. The relay is made in both circuit-opening and circuit-closing forms. The cylinder does not rotate, but moves in a straight line, either

Fig. 36. Instantaneous Circuit-opening Reverse Phase Relay with Hand Reset Contacts

up or down, depending on the phase rotation, and in the event of one of the phases of the line being reversed the movement of the cylinder operates the circuit-closing or circuit-opening contacts, depending on the form of the relay used.

It is made as a single-pole, circuit-closing device, for frequencies of 25 to 60 cycles, with a continuous rated capacity of 5 amperes, and is suitable for operation from current transformers. Its characteristics are such that selective action of two or more relays is assured when settings are made with due regard to the time element inherent in the mechanism of the circuit breaker controlled.

Changes in surrounding temperature will cause the ordinary induction time-limit relay to act with a large variation in its time delay, if uncompensated for such changes. This relay, however, is provided with an efficient temperature compensating device which keeps time delay variations within reasonable limits.

Electrically Heated Industrial Ovens

At present more than fifty different manufacturers are using G-E electrical heating equipment with automatic control for ovens for baking japan, drying paint, and other similar manufacturing purposes. It is interesting to note that more than 80 per cent of these concerns adopted the electric oven during 1916, and that while the initial installations were practically all for japanning work, their use has been extended to a great variety of other drying and baking processes which require accurate application of heat and close control of temperature.

The electric ovens already installed represent a total connected load of about 45,000 kw., and one manufacturer alone is utilizing several batteries of ovens aggregating about 20,000 kw. in capacity (Fig. 37). The remaining installations consist of one or more ovens requiring a current supply of from 25 kw. to 250 kw. each.

While not of such great commercial importance as the ovens above referred to, the use of electric furnaces for heating gun tubes and gun jackets, preparatory to inserting the lining or to shrinking on the jacket, is of considerable interest as it demonstrates the possibilities of electric heat for securing a uniform and positively controlled temperature in the manufacture of heavy ordnance. The original equipment for this work was supplied several years ago, and consisted of two sections, each 5 ft. high with about 4 ft. internal diameter, and each having a current consumption of about 30 kw. These sections were at first used in connection with oil heating for boosting the temperature at the top of the heating pits, where great difficulty had been experienced in securing the necessary high temperature with fuel heating. The electrical sections, however, proved so successful in operation that the use of fuel was entirely abandoned, and at the close of the year there were under construction for one of the large steel companies five gun furnace sections of approximately the same dimensions and with the same current consumption as the original sections.

Fig. 37. Electrically Heated Japanning Oven in Automobile Manufacturing Plant

A new development for the year consisted of an air oven for tempering steel, by the use of which more accurate results could be secured than by the previous processes of oil or fuel tempering, due to the fact that the positive control of the temperature, made possible by the use of electrical heating units, enabled the results obtained to be accurately predetermined.

Domestic Electric Heating Appliances

Improvements in the design of electric ranges, increased sales of these appliances, and a notable growth in the adoption of electric cooking, were the outstanding features in the development of domestic heating devices.

The National Electric Light Association recognized the importance of this section of the heating device industry by appointing an electric range committee to investigate conditions and to determine the possibilities of the future. The results of this investigation have been of great value to the manufacturers, central stations and the user, as it secured valuable data regarding merchandising, costs of installing and operating, heating rates, effect on day load, power-factor, etc. Many practical and useful suggestions were gathered from those who have had extended experience in the electric range business, and these will assist in the standardization of this appliance.

The rapidly increasing demand for electric ranges stimulated many central stations to establish special cooking rates, and this service gave adequate returns in increased income, added day load and a better load factor. It was demonstrated that electric cooking is thoroughly practical and economical where reasonable service rates are available, and experience indicated that an average heating rate of 5 cents or less would more than double the demand for electric service.

Statistics on cooking rates granted by the central stations throughout the country, showed that 3350 communities had heating and cooking rates of 5 cents or less per kw-hr. Approximately 60 per cent of these had rates of 4 cents or less, while 30 per cent had rates of 3 cents or less. About 65 per cent of all the communities on which data were secured are located in the eastern half of the country, and it is interesting to note that, contrary to the general impression, low rates for cooking are largely confined to the Western States.

The production of electric ranges exceeded all previous records. The largest single order ever placed for electric ranges was filled last May by the Pittsfield (Mass.) plant of the General Electric Company. The shipment comprised 611 ranges packed in eight freight cars, (Fig. 38) and had a listed value of approximately $53,000. But this enviable record was far surpassed by the receipt of another single order last November for 2000 electric ranges. This represents a listed value of $222,000, and will require approximately 25 cars when packed for shipment.

Fig. 38. Shipment of 611 G-E Electric Ranges

Rectifiers

It has been known for some time that a vacuum tube containing a hot and a cold electrode would act as a rectifier. This principle is utilized in the kenotron, which is a high voltage rectifier, and also in the Coolidge X-ray tubes; these devices depending on the emission of electrons from an incandescent filament. In the kenotron and Coolidge tubes there is the highest possible vacuum, so that the electrons themselves are the only current carriers, and the tubes operate at low currents and very high voltages. The voltage drop across the kenotron will be from 100 to 500 volts, from which it will be seen that it would be impractical to operate these on the usual commercial circuits of 110 and 220 volts.

In the recently developed Tungar rectifier bulb there is an inert gas, at low pressure, which is ionized by the electrons emitted from the incandescent filament. This ionized gas acts as the principal current carrier, with the result that the bulb operates with a much lower voltage drop (from 5 to 10 volts), and is capable of passing currents of several amperes, the current limit depending on the size of the tube.

The Tungar bulb rectifies because, on the half wave when the tungsten filament is negative, the emitted electrons from the incandescent filament are being pulled toward the anode by the voltage across the tube, colliding with the gas molecules, ionizing them, and making them conductive in the direction of anode to cathode. On the other half cycle, when the filament is positive, any electrons that are emitted are driven back to the filament, so that the gas in the bulb is non-conductive toward that half cycle; or, in other words, during the half cycle when rectification does not take place, ionization of the gas dies out, but immediately builds up on the next half cycle which the Tungar rectifies. The filament of these rectifiers is constantly excited.

At the present time this rectifier is made in three sizes for charging storage batteries: 2 amperes, 7.5 volts (Fig. 39) (which also delivers 15 volts at 1 ampere); 6 amperes, 7.5/15 volts; 6 amperes, 7.5/75 volts (Fig. 40).

Lighting

With an increasing efficiency of Mazda lamps there was evidenced a marked tendency

Fig. 39. 2-amp. 7.5-volt Tungar Rectifier

toward taking advantage of the increased light available, for the purpose of improving the effect of diffusion, or otherwise making the light more suitable for particular purposes, rather than endeavoring to secure extreme economy. This was first apparent through the rapidly increasing popularity of the indirect methods of lighting. More recently it was indicated by the demand for modified color of light. It was therefore found desirable to use lamps with tinted bulbs, either natural or dipped, as, for example, the Mazda C2 (white light) lamps, Mazda C photographic lamps, and the Mazda yellow bulb lamps.

The Mazda C2 lamps are intended for use in stores, store windows and certain manufacturing processes where an approximately white light is advantageous. The natural blue glass bulb absorbs the excess of red and yellow light which is minimized by operating the filament at a higher temperature than normal. The shortened life of the lamps is justified by their relatively high efficiency, which is only 25 per cent or 30 per cent below that of the corresponding clear bulb lamps. These lamps are now made in 100, 150, 300 and 600-watt sizes.

The Mazda C photographic lamp also has a blue bulb, but of different color from the C2. The function is to reduce the visible light without appreciably affecting its photographic value. This avoids a bright light in the eyes of the subject. It has no value in photographing inanimate objects. Economy has made it desirable to force this lamp also, so as to produce a high percentage of actinic rays. A 1000-watt unit is made. The yellow or amber bulb Mazda lamps, most of which have so far been produced by dipping, found application in the lighting of residences and other artistic interiors, where it was desired to reproduce the warm glow of fire and lamp light. They have been extensively applied in a few cities. The 60-watt size is usually employed.

The efficiency and approximation of the "point source" obtainable with Mazda C lamps have very largely increased the possibilities of incandescent lamps in projection, i.e., searchlights, headlights, floodlights, and stereopticons. Small moving picture machines were so equipped, and developments are now under way that promise to extend the application in the near future to the machines used in moving picture theaters. Such lamps are of low voltage and high current, thus being most economical on alternating-current circuits where the arc is least effective.

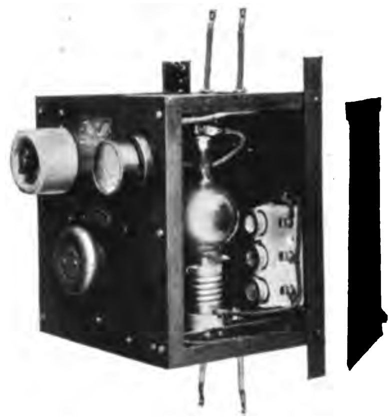

Fig. 40. 6-amp. 7.5/75-volt Tungar Rectifier

A 75-watt Mazda C lamp was brought out for use on 105 to 125-volt circuits. This lamp can be used in sockets with shades where the ordinary lamp has heretofore been used. It gives nearly as much light as a 100-watt Mazda B (vacuum) lamp, about four times as much as the 50-watt Gem, and five times that of the 50-watt carbon lamp.

A 50-watt Mazda B lamp was also developed for operation on 105 to 125-volt circuits. It is largely used by central stations previously supplying 50-watt Gem and carbon lamps, the new lamp giving the customer about two and three times, respectively, the amount of light previously obtained from the Gem and carbon lamps for the same current consumption.

Figs. 41 and 42 show the number of lamps sold by the Edison Lamp Works since its beginning. In 1906, carbon lamps attained their greatest sale, being then about thirty-millions as compared with 1916 (estimated) sales of two and one-half millions. Gem lamps reached the height of their popularity in 1912, with about twenty million lamps sold as compared with 1916 (estimated), seven and one-half millions. Mazda lamps have been increasing in popularity every year, the 1916 (estimated) sales being about forty-seven and one-half millions, and about twenty-two and one-half millions miniature Mazda lamps. The latter is largely a result of the increase use of automobiles, only Mazda lamps being used for this class of lighting.

The increase in the average candle-power of Mazda lamps used for street lighting during the past few years is as follows:

Year	Average Candle-power
1908	35
1909	45
1910	47
1911	48
1912	56
1913	62
1914	78
1915	108
1916	125 (estimated)

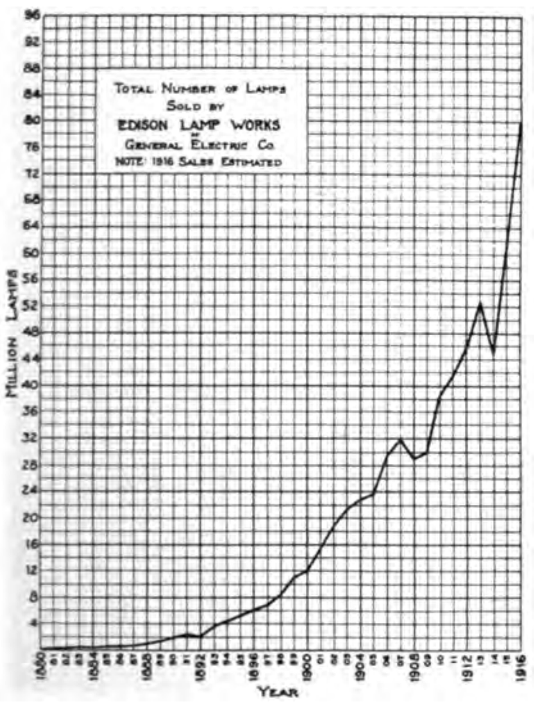

Fig. 41. Lamp Sales Chart

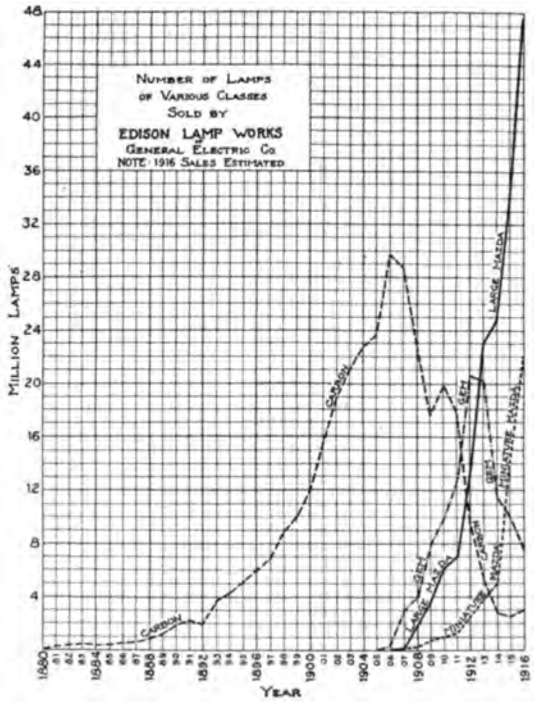

Fig. 42. Lamp Sales Chart

The relative popularity of series circuits of different amperes, compared by the number of lamps sold, is as follows:

Amperes of Circuit	Proportion of Lamps Sold (1915)
6.6	50
4.0	20
5.5	15
7.5	10
Miscellaneous	5
	100

Flood Lighting of Statue of Liberty

The more logical rating of incandescent lamps by lumens, rather than candle-power, was adopted by the Illuminating Engineering Society, American Institute of Electrical Engineers, National Electric Light Association Lamp Committee, and the various lamp manufacturers.

The arc lamp assumed the role of strictly street lighting unit and the tendency in its construction was toward the development of a more ornamental exterior and higher efficiency electrode. That this was successfully accomplished and was received with favor is evidenced by the installations at Salt Lake City, Utah and San Francisco, California. The latter city deviated from the stereotyped "white way" system and introduced color into its street lighting equipment, creating what has been called the "Path of Gold," in which a higher intensity of illumination was secured than had ever before been attempted for street lighting.

This installation (Fig. 43), consisting of 439 lamps, commences at the Ferry Building and extends along Market Street to 7th Street, taking in 15 business blocks on the north side of the street and 13 blocks on the south side, a distance of approximately 7500 feet, and including the Ferry Building Plaza, 1.5 miles.

Fig. 43. "Path of Gold" Street Lighting in San Francisco

G-E luminous arc lamps, the same as those used for the Exposition, were adopted. They operated at 6.6 amperes, but their appearance is greatly enhanced by the addition of a new sectional globe and special glassware, which has a yellowish tint that is visible in daytime, but not at night, when it prevents glare.

These lamps are mounted in the form of a triangle, with the plane of the lights at right-angles to the direction of the street, and have a combined candle-power of 4500 as compared with 225 candle-power, the capacity of the lamps previously used. The poles average 110 feet apart, and are 32 feet high, including the ornamental triangular tops.

The growing recognition of the importance of adequate lighting as a factor of safety in industrial work was indicated by the adoption of a code of lighting for "factories, mills and other work places," by the Industrial Board, Department of Labor and Industry, State of Pennsylvania. These rules and regulations went into effect June 1, 1916, and similar action was later taken by the State of New Jersey.

This resumé of achievements for the year, in the field of electric lighting, would be incomplete without reference to the flood lighting of the Statue of Liberty on Bedloes Island in New York Harbor.

While this statue has occasionally been lighted in outline by means of incandescent lamps, this lighting was of a temporary nature, and during the past thirty years only the rays from the torch in the hand of the statue could be clearly discerned in the night by those watching on the shore or from ships; but on the evening of December 2, at a signal given by the President of the United States, the entire statue was instantly bathed in a flood of light (Fig. 44) which rendered it more conspicuous, by reason of the contrast with the surrounding darkness, than when seen by daylight.

This effect was accomplished by means of 15 batteries of flood-lighting projectors, totaling 246 units, each utilizing a 250-watt Mazda lamp. Each projector was provided with an individual compensator through which the incoming line potential of 220 volts was stepped down to 35 volts for the lamps. The current supply is transmitted to the Island by submarine cable.

By this means the statue, which stands as the epitome of our national aspirations, is made perpetually visible, glowing with enhanced beauty throughout the night, until with the coming of dawn the man-made illumination is gradually superseded by the light of day.

AN ADDRESS BY E. W. RICE, JR. ON THE OCCASION OF THE PRESENTATION OF THE JOHN FRITZ MEDAL TO ELIHU THOMSON, DECEMBER 8, 1916

This address will be full of interest to every engineer. Prof. Thomson's life's work has been as varied as it has been useful. Few know the scope of his work.—EDITOR.

The medal which was awarded in January 1916 to Dr. Elihu Thomson, and which is to be presented tonight, is for "Achievements in Electrical Inventions, in Electrical Engineering, in Industrial Development and in Scientific Research."

It would be impossible in the brief time at our disposal to adequately describe the achievements of our medalist in these various fields, as it would involve describing the life work of one of the world's most prolific and industrious inventors and scientists. The impossibility of performing such a task can perhaps best be indicated by the statement that in the field of electrical inventions alone Prof. Thomson has been awarded something over 550 United States patents, and in other fields, notably mechanical work, about 150 patents, making a total of some 700 U. S. patents; that he has made contributions to the world's scientific and technical literature, set forth in several hundred articles describing not only his own discoveries and inventions but making remarkably interesting contributions to scientific speculation and thought. The range of such contributions may be indicated by some of the titles taken at random:

Nature of the Lightning Discharge
Conditions Affecting Stability in Electric Lighting Circuits
Wireless Telegraphy
Electric Welding Process
Experimental Research
Properties of Carbon in Electrical Work
Simple Steam Engine with Remarkable Economy
The Possibilities of Liquid Air in Electrical Work
An Unjust Patent Statute
The Light of the Fire Fly
Cosmic Electrical Phenomena
Safety and Safety Devices in Electrical Installations
Lightning Rods
Sterescopic Roentgen Pictures
Oil Insulation for High Tension Transformers

and so on through a long and suggestive series of subjects.

Prof. Thomson's electrical work began about 37 years ago with the invention of the 3-coil arc dynamo, which, with its automatic regulator and other novel features, formed the basis of the successful lighting system put out by the Thomson-Houston Company, beginning in 1880. This machine was remarkable for its extreme simplicity, ruggedness, flexibility and general efficiency. It was designed to operate a series of arc lamps and was the first machine to be entirely automatic in its operation. It was so constructed that it would maintain a constant current flowing in a series circuit over the extreme range from full load of, say 25 lights, down to one light or even to a complete metallic short circuit; a feature possessed by no other arc light machine at that time. This feature of automatic regulation together with its general reliability and fool-proofness were the basis of its great technical and commercial success. This 3-coil dynamo was, of course, designed for direct current and therefore provided with a commutator of only three segments.