General Electric Company

Schenectady, N.Y.

RAILWAY DEPARTMENT

May, 1912 **Bulletin No. 4950*

† WASHINGTON, BALTIMORE & ANNAPOLIS 1200 VOLT DIRECT CURRENT RAILROAD

Note—The Washington, Baltimore & Annapolis Electric Railroad has now been operating as a 1200 volt road for over two years and special attention is called to the operating data given on pages 17 to 22.

The Washington, Baltimore & Annapolis Railroad is of more than ordinary interest, both on the score of its having been converted from a 6600 volt single-phase to a 1200 volt direct current road, and on account of the class of service it is providing. The system comprises two divisions, the first consisting of a double track, high speed line connecting Washington, D. C., with Baltimore, Md. The plans for this portion of the system have been under consideration for a number of years, but the property only passed into the hands of the present company in 1905, and the work of electrification as a single-phase road was completed in two years from that date. The second portion of the system is a single track road connecting Annapolis Junction with Annapolis. The traffic to Annapolis is large, owing to the Naval Academy, which is one of the most important naval depots of

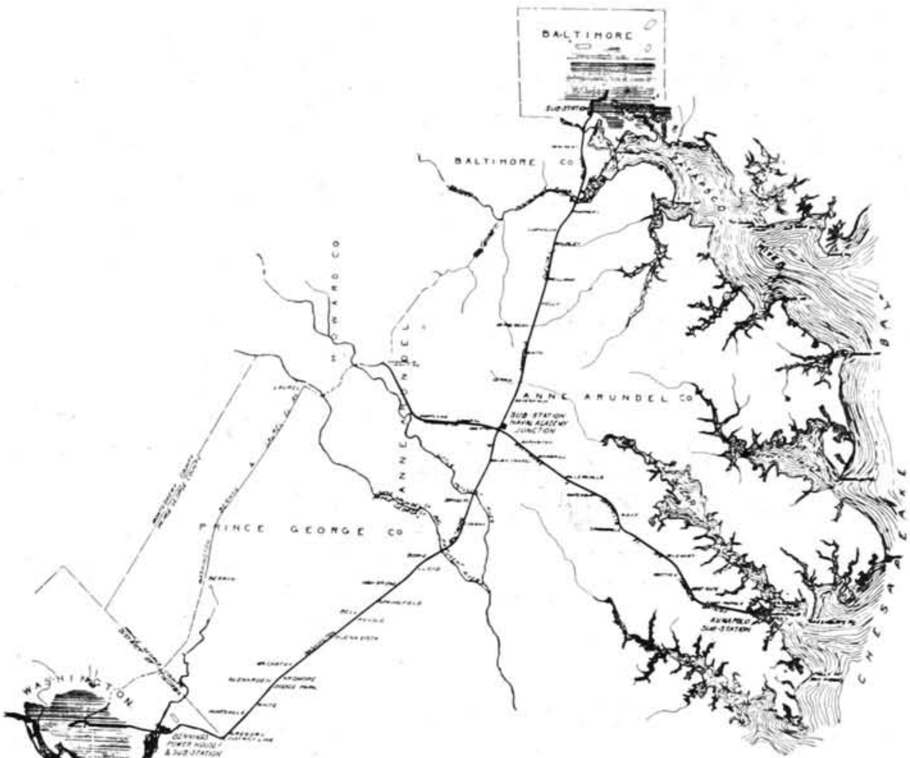

Fig. 1
MAP OF THE WASHINGTON, BALTIMORE & ANNAPOLIS RAILROAD

*Supersedes No. 4808

†Reprint of article by John R. Hewett in GENERAL ELECTRIC REVIEW.

the United States. This road was formerly known as the Annapolis, Washington & Baltimore Railway and was in operation as a steam road nearly eighty years ago. The equipment of this road is now similar to the double track road connecting Washington with Baltimore.

The map (Fig. 1) shows the route taken by both lines and also the location of the power house and substations.

Every detail of the road and its equipment has been designed with the view of giving a high class, high speed service. The city running necessarily takes up a disproportionate part of the running time, but the schedule on the interurban section, which is as high as 44 miles per hour compensates for this, and the run from terminal to terminal takes but 85 minutes. The steam road service between Washington and Baltimore is good, there being a very great number of trains per day, and it is therefore imperative that the electric lines should give an attractive schedule.

The electrical equipment of all the substations and cars was manufactured by the General Electric Co.

General Scheme of Electrification

Fig. 2 will give a good idea of the general scheme of electrification, and will also show the distances between the more important points.

The energy for operating the Washington, Baltimore & Annapolis Railroad is generated by Curtis turbines in the Bennings power house of the Potomac Electric Power Company and is delivered to the Bennings substation at a potential of 6600 volts.

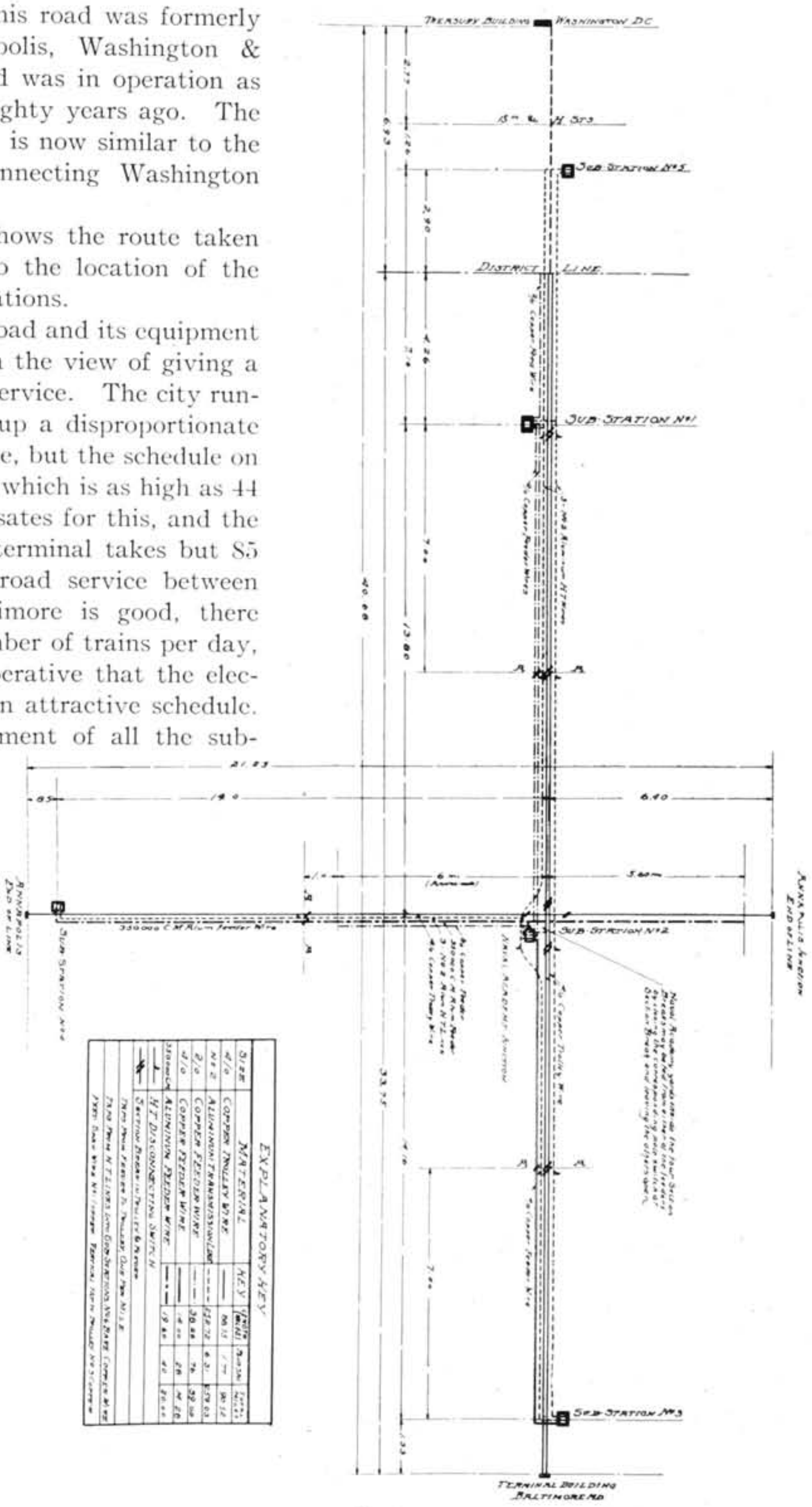

Fig. 2
WIRING DIAGRAM OF THE WASHINGTON, BALTIMORE & ANNAPOLIS RAILROAD

Figs. 3 and 4, respectively, are diagrams of the transmission lines and of the feeders and trolley. These together with the explanatory key to Fig. 2 render a written description in detail unnecessary.

Bennings Substation

The function of the Bennings substation is to receive the power which is generated at

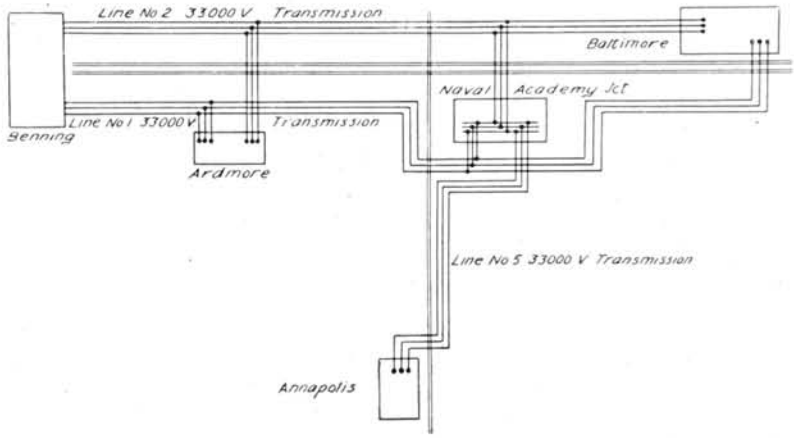

Fig. 3
DIAGRAM OF TRANSMISSION LINE

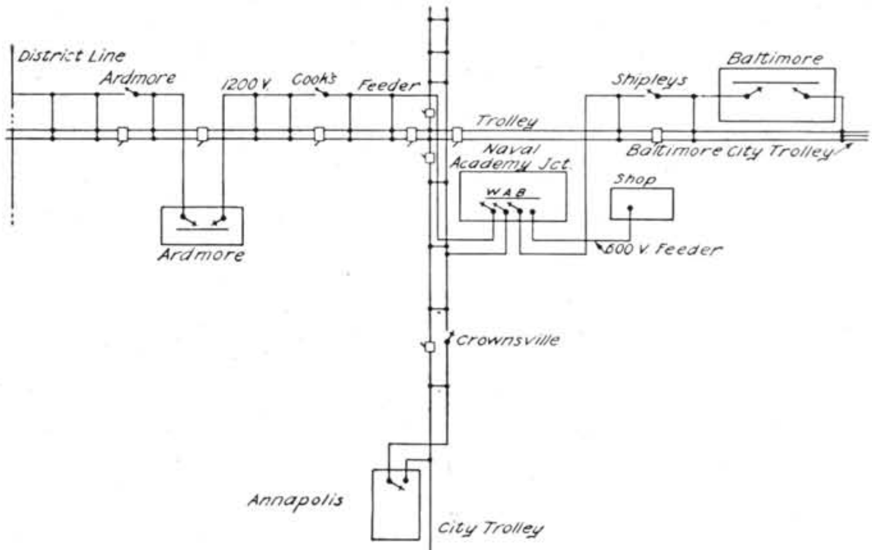

Fig. 4
DIAGRAM OF TROLLEY AND FEEDER LINES

Substations

There are five substations located at the following points: Ardmore, Naval Academy Junction, Baltimore, Annapolis and Bennings. The diagrams and map will show the relative positions of, and the distances between, these substations, as well as the manner in which they are connected electrically.

the Potomac power house at 6600 volts, transform it to 33,000 volts, and distribute it at this potential to the duplicate transmission lines which feed the other substations of the Washington, Baltimore & Annapolis system. There are no 1200 volt feeders from this substation.

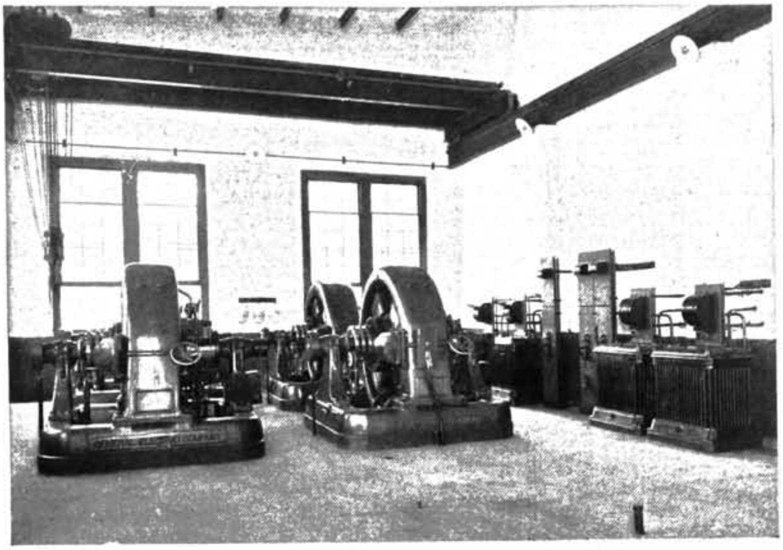

Fig. 5
MAIN SECTION ARDMORE SUBSTATION

The switchboard consists of the following:

Two 33,000 volt, three-phase incoming line panels.
Two 33,000 volt, 600 kw. rotary converter panels.
Two 33,000 volt aluminum cell lightning arresters.
Two 600 kw. 1200 volt d-c. converter panels.
Two 8 amp., 1200 volt d-c. feeder panels.
One 750/1200 volt, D-2 voltmeter on swinging bracket.

Naval Academy Substation

This substation is situated near the car barn and is constructed with a reinforced concrete frame filled with red brick panels.

The substation proper is divided into two portions, namely, a common room for the transformers and rotary converters, and the high tension compartment. A small annex houses the boiler and pumping machinery that supplies the heating and sprinkler system for the barns and an air compressor for car barn use.

Both transmission lines are tapped into this substation and 1200 volt feeders extend from

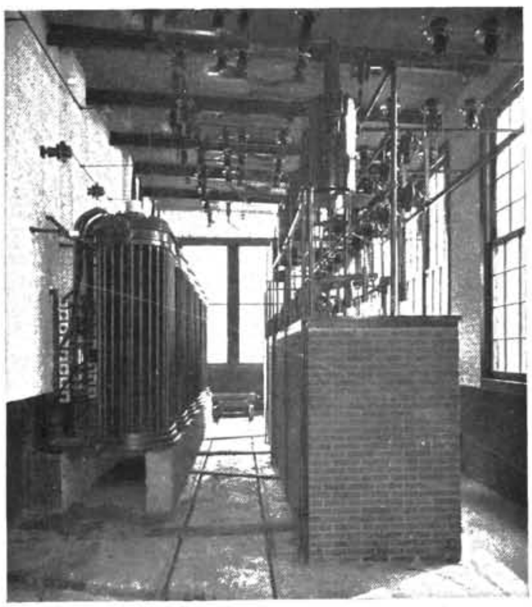

Fig. 6
HIGH TENSION COMPARTMENT, ARDMORE SUBSTATION

Ardmore Substation

The Ardmore substation is the only one which was built for the 1200 volt system, the single-phase substations in each of the other cases having been altered to suit the new conditions.

This substation is a red brick structure and is divided into a machine room and a high tension compartment, the former containing the rotary converters, reactances and switchboard, and the latter the transformers, oil switches, lightning arresters, etc. Figs. 5 and 6 are interior views, while Figs. 7 and 8 show respectively a section and plan of this substation.

Both of the 33,000 volt transmission lines are tapped into the Ardmore substation, and switching arrangements are provided to permit either of the lines being used. The potential is stepped down from 33,000 to 370 volts and fed to the rotary converters, whence it is fed in both directions to the trolleys and feeders at 1200 volts.

The more important items of the equipment are as follows:

Four TC-4-300-750-600/1200 volt compound wound rotary converters.
Four 45 kv-a. oil-cooled reactive coils.
Six H-25-160-19, 100/33,000 volt, "Y" 370/370 volt oil-cooled transformers.

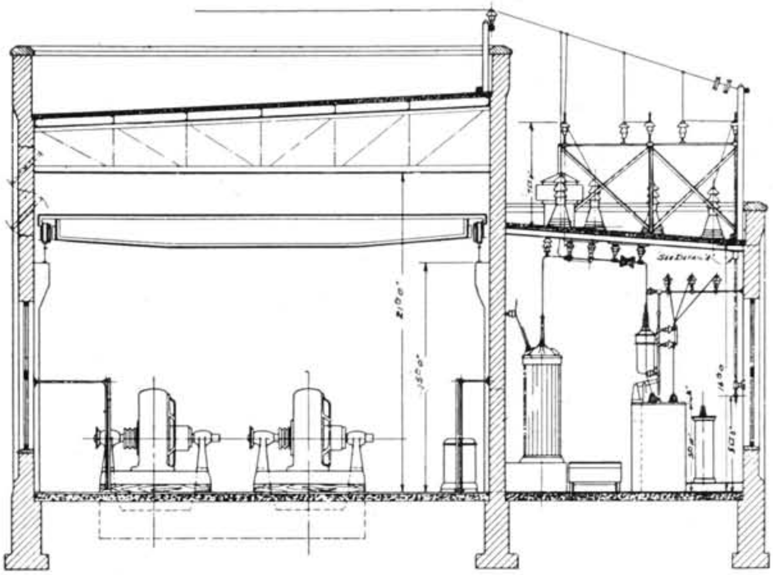

Fig. 7
TRANSVERSE SECTION, ARDMORE SUBSTATION

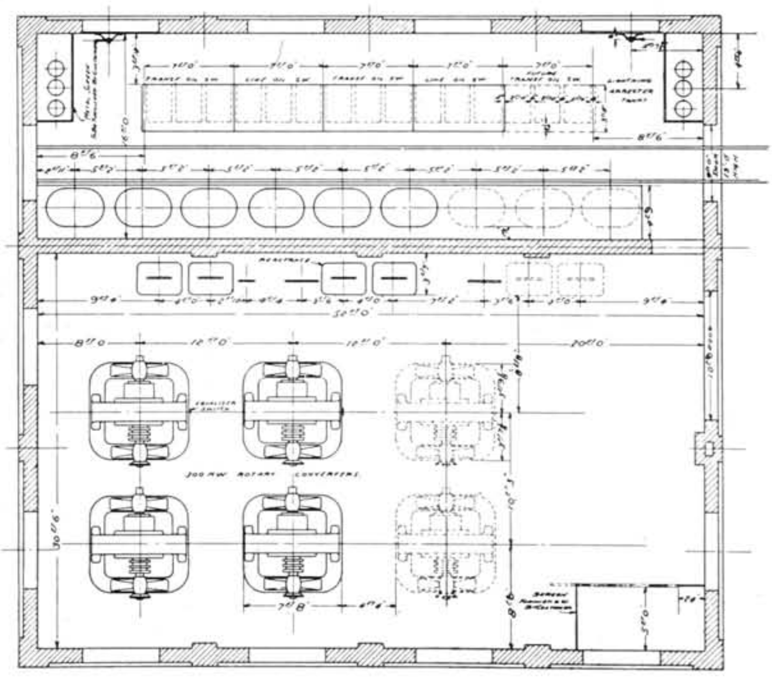

Fig. 8
PLAN, ARDMORE SUBSTATION

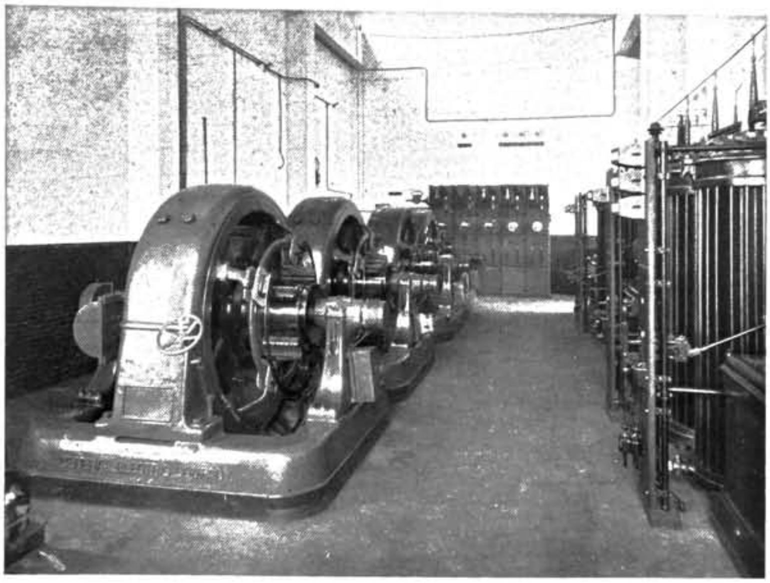

Fig. 9
MAIN SECTION, NAVAL ACADEMY STATION

it in the direction of Washington, Baltimore, Annapolis and Annapolis Junction.

Figs. 9 and 10 are interior views of the machine room and high tension compartment respectively. One of the rotary converters is not shown in Fig. 9. Fig. 11 is an exterior view of the substation, while Fig. 12 was taken on the roof to show the manner of carrying the leads from the transmission line vertically down to the transformers. It also shows the horn gaps used in conjunction with the electrolytic lightning arresters.

The more important items of equipment for this substation are:

Five TC-4-300-750-600/1200 volt compound wound rotary converters.
Four 45 kv-a. oil-cooled reactive coils.
Seven H-25-160-33,000 "Y" 370/370 volt oil-cooled transformers.

The switchboard consists of the following:

Two 33,000 volt incoming line panels.
One 33,000 volt, three-phase outgoing line panel.
Two 33,000 volt, 600 kw. a-c. rotary converter panels.
Three 33,000 volt aluminum cell lightning arresters.
Two 600 kw., 1200 volt d-c. rotary panels.
Three 1000 amp., 1200 volt d-c. feeder panels.
One 750/1200 volt D-2 voltmeter on swinging bracket.

Figs. 13 and 14 show a transverse section and a plan of this substation.

Baltimore Substation

The Baltimore substation is a brick structure and is situated at the outskirts of Baltimore near Scott street. The exterior of this building, and also a good view of the external high tension wiring, are shown in Fig. 16. The illustration, Fig. 15, gives an excellent idea of the switchboard which controls the output of the substation. This board consists of two rotary converter panels and two feeder panels, the high tension alternating current panel being located at the opposite side of the machine room and shown in Fig. 17.

The more important items of equipment are:

Four TC-4-300-750-600/1200 volt compound wound rotary converters.

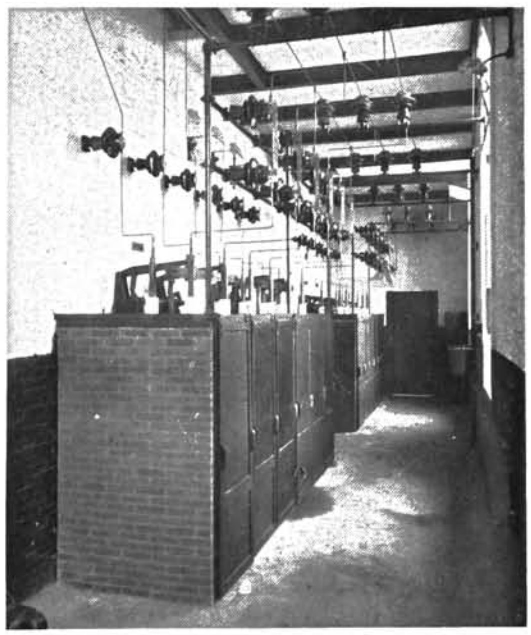

Fig. 10
HIGH TENSION COMPARTMENT, NAVAL ACADEMY SUBSTATION

Four 45 kv-a. oil-cooled reactive coils.
Six H-25-160-33,000 "Y" 370/370 volt oil-cooled transformers.

The switchboard consists of the following:

Two 33,000 volt incoming line panels.
Two 33,000 volt, 600 kw. a-c. rotary converter panels.
Two 3000 volt aluminum cell lightning arresters.
Two 600 kw., 1200 volt d-c. rotary panels.
Two 800 amp., 1200 volt d-c. feeder panels.
One 750/1500 volt D-2 voltmeter on swinging bracket.

Fig. 11
NAVAL ACADEMY SUBSTATION

Annapolis Substation

The Annapolis substation is in the center of Annapolis and includes under one roof substation, express depot, waiting room and ticket office. This substation contains two 300 kw. rotary converters and three 160 kw. transformers.

The functions of this substation are considerably simplified since the change from alternating current to direct current, owing to the fact that the City of Annapolis permits the use of the 1200 volt trolley.

Substation Apparatus

All of the electrical apparatus in the substations was designed, manufactured and ininstalled by the General Electric Company.

The following table gives the number of rotary converters and transformers installed in the various substations. It should be noted that provision is made for two additional rotary converters and transformers in both the Ardmore and Baltimore substations, while at Academy Junction one spare rotary converter is already installed and provision is made for the addition of a second.

Fig. 12
HIGH TENSION WIRING ON ROOF OF NAVAL ACADEMY SUBSTATION

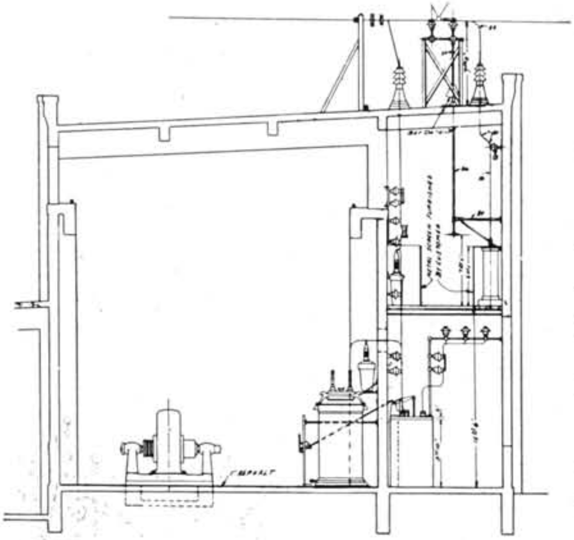

Fig. 13
TRANSVERSE SECTION, NAVAL ACADEMY JUNCTION SUBSTATION

These rotary converters are all three-phase four-pole, 300 kw. units running at 750 r.p.m. and designed for a full load direct current of 500 amps. They are, practically speaking, standard 600 volt rotary converters with additional insulation to permit their operation in series to give 1200 volts. They are compound wound with their shunt fields excited

SUBSTATION APPARATUS

	ROTARY CONVERTERS		TRANSFORMERS	
	Number	Capacity Kw.	Number	Capacity Kw.
Bennings	1 1	500* 1000*	7 1 1	800 1100* 550*
Ardmore	4	300	6	160
Academy Junction	5	300	7	160
Baltimore	4	300	6	160
Annapolis	2	300	3	160

* Units marked thus are for operating the District line.

from the individual machines and the series fields of each pair are connected in series on the grounded side. A speed limiting device and magnetic oscillator are provided on each machine, and the metallic graphite brushes employed on the alternating current side decrease the amount of dust and make lubricating unnecessary, at the same time eliminating the wear of the rings. The direct current brush rigging is supported directly on the magnetic frame, in order to remove as far as possible from the commutator all metal on which an arc would hold in case a flashover should occur at any time.

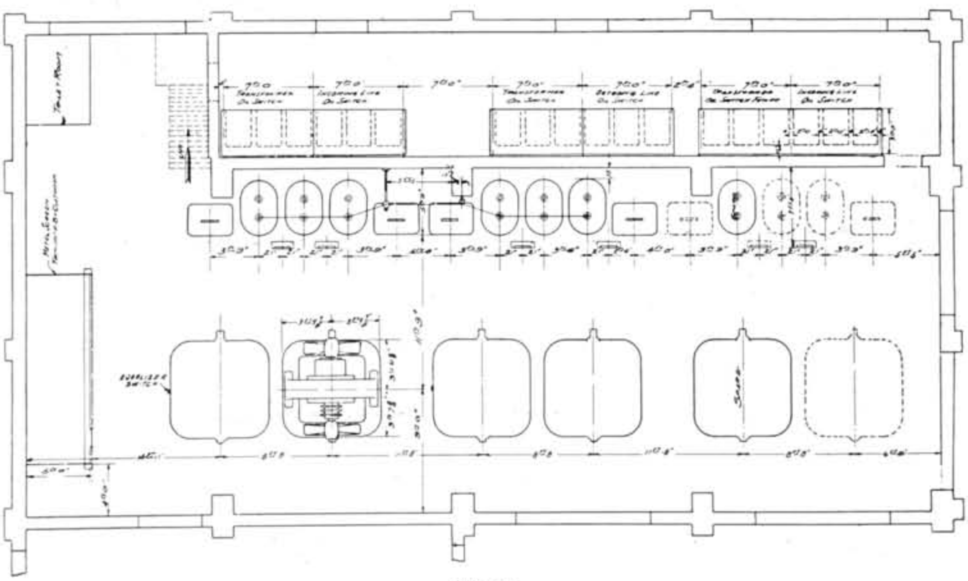

Fig. 14
PLAN, NAVAL ACADEMY JUNCTION SUBSTATION

These rotary converters have given the most excellent satisfaction in operation and no difficulty of any kind has been experienced with two machines operating in series.

Type H units, similar in design. They are wound for 33,000 volts on the high tension side and for 370 volts on the low tension side. The primaries are Y-connected and are provided with four 2½ per cent. taps, while the secondaries, which are double, are delta-connected and have 50 per cent. starting taps.

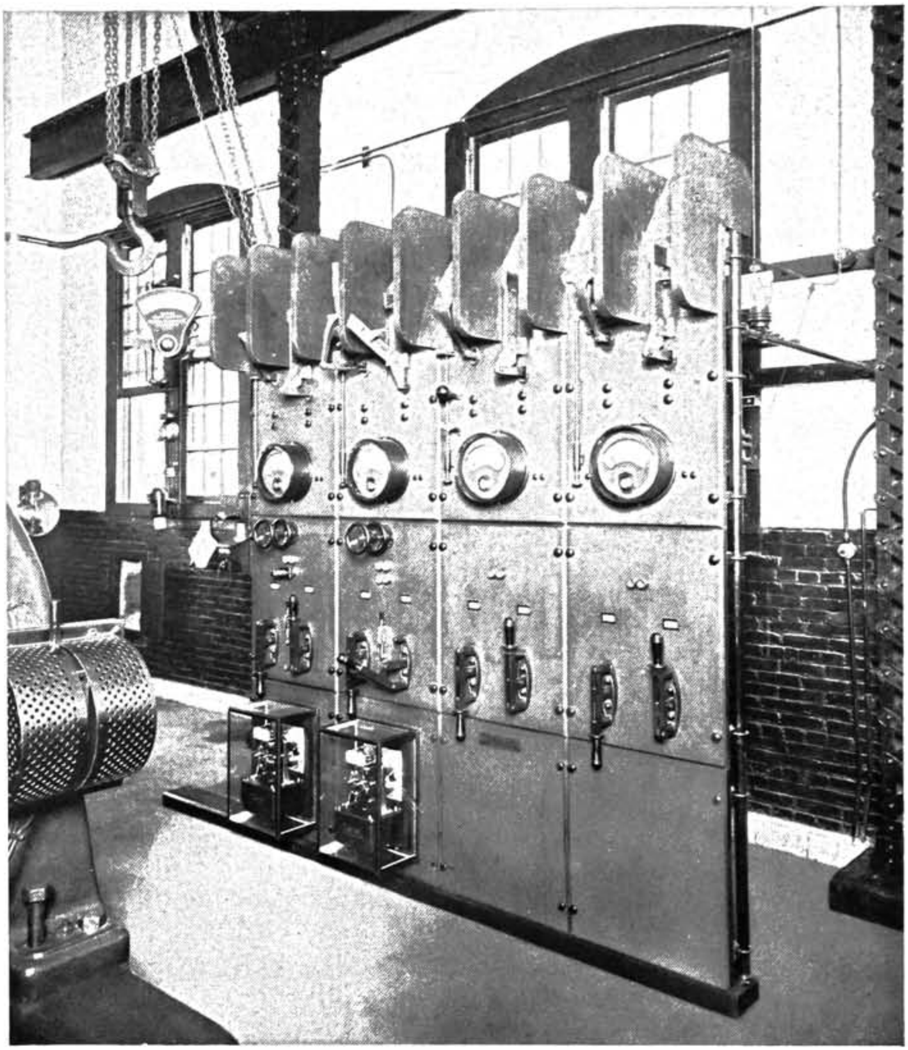

Fig. 15
1200 VOLT SWITCHBOARD IN THE BALTIMORE SUBSTATION

The reactive coils each have a capacity of 45 kv-a., are oil-cooled, and have standard starting switches with protecting covers mounted on the top.

All the transformers with the exception of those installed in the Bennings substation which are of 800 kw. capacity, are 160 kw.

The switching arrangements are of special interest, as the high tension direct current boards are of standard General Electric

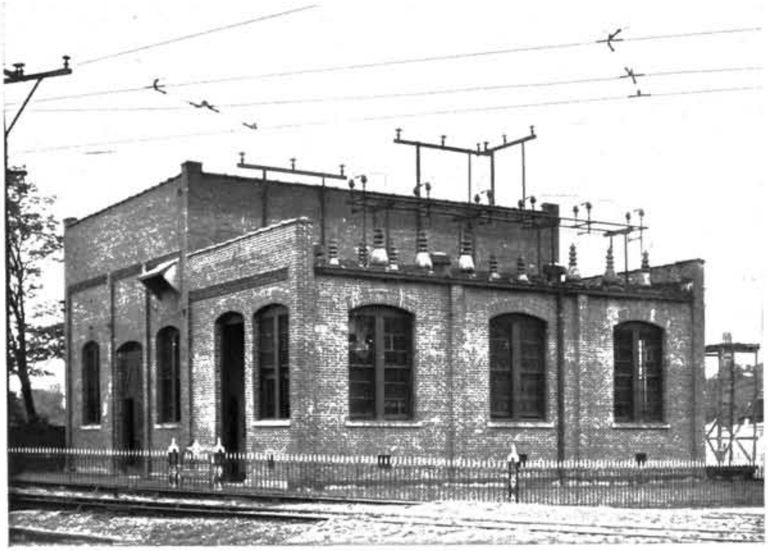

Fig. 16
BALTIMORE SUBSTATION

design, specifically made for 1200 volt work, with two machines in series.

The direct current switchboard of the Baltimore substation is illustrated in Fig. 15. This board consists of two machine panels and two feeder panels, each machine panel being for one pair of rotary converters.

The two 600 volt rotary converters are connected in series as previously stated, the series fields of both machines being connected between the armature of the low machine and ground. This arrangement makes necessary only one circuit breaker, one lever switch, and one ammeter and voltmeter on each panel. The lever switch is placed on the bus side of the circuit breaker so that when the switch is open it is possible to work on the circuit breaker without danger while the positive bus is alive.

The circuit breakers have standard contacts with an increased length of break for 1200 volts, while the lever switch is made of standard 600 volt parts. Both the circuit breaker and lever switch have the current carrying parts mounted at the top of the panel out of reach, while their operating handles are on the lower panel. The mechanical connection between the handle and switch is made by an insulating rod. Fireproof arc chutes are provided around the circuit breaker and lever switch at the top of the panel.

The circuit breaker is arranged so that the handle always returns to the inward position, while the handle of the lever switch alongside it stands out when the switch is open. In order to distinguish between the two handles, which are identical in appearance, that of the circuit breaker is mounted inverted so that its handle points downward. For tripping the circuit breaker by hand an insulated trip rod is arranged

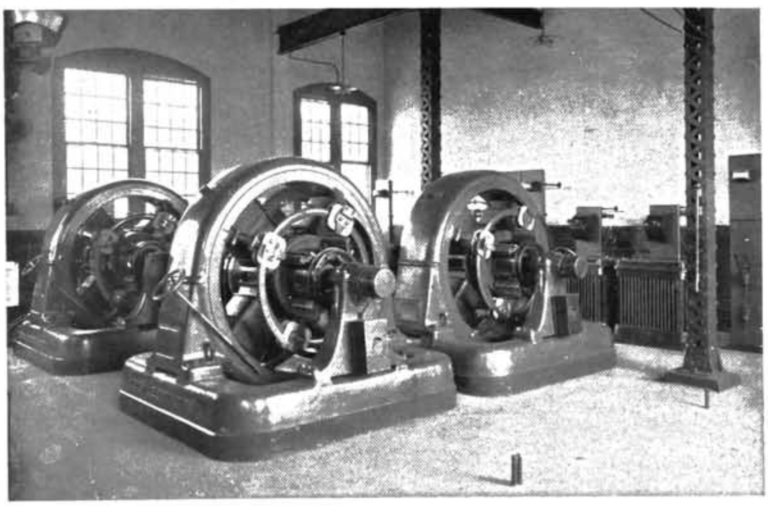

Fig. 17
INTERIOR OF BALTIMORE SUBSTATION

to operate on the tripping pin of the breaker.

The rheostats are operated from the front of the board by means of a handwheel which turns a mechanism designed in such a manner as to permit of the regulation of the machines individually or collectively at will. The ammeters are of the d'Arsonval type and provided with insulated covers; the wattmeters are also insulated to suit the higher voltage. The voltmeters are standard 600 volt instruments of the permanent magnet type with 1200 volt scales, potential receptacles being provided so that the voltage of each or both machines may be read. Multipliers are used in the plugs so that the 600 volt instruments give the correct readings for the higher potential on the 1200 volt scale.

The circuit breakers, lever switches and ammeters on the feeder panels are similar to those on the machine panels. The circuit breaker is connected to the bus and lever switch on the line side. One two-point 1200 volt potential receptacle on the line side of the lower switch allows reading the trolley voltage before the feeder is cut in.

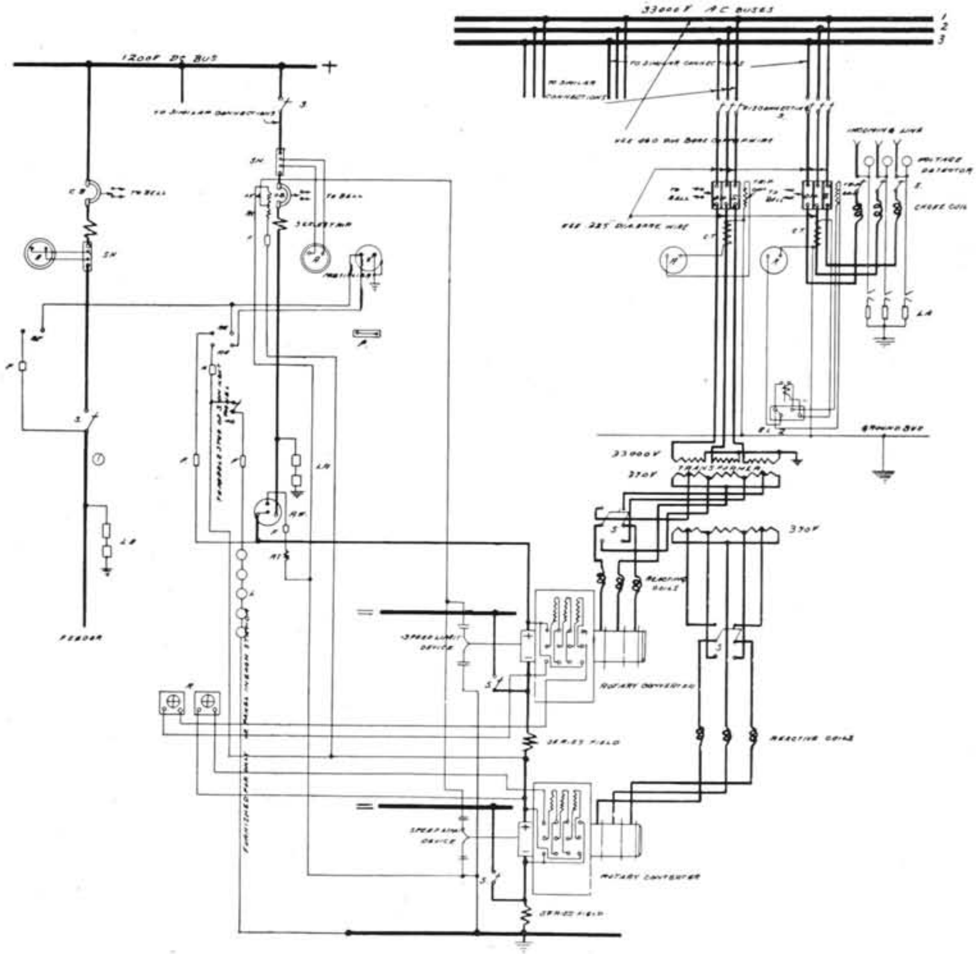

Fig. 18
SWITCHBOARD WIRING DIAGRAM BALTIMORE SUBSTATION

All the panels are made in three sections, 24 inches wide, the top section being 40 inches in height, the middle section 31 inches, and the bottom section 28 inches. All bolt heads on the front of the board are covered with insulating caps.

The rotary converters are started from the alternating current side, the starting switch being mounted on top of the reactance cover. Field break-up switches are mounted on the yokes of the rotary converters.

The switchboard wiring diagram shown in Fig. 18 gives full details of the manner in which the electrical connections are made.

Cars and Equipments

The rolling stock originally consisted of 17 straight passenger cars, 13 combination passenger and baggage cars, 1 express car and 3 freight cars or locomotives—34 equipments in all. Of these cars all were new when the 1200 volt system was installed, with the exception of three of the combination cars and two of the freight equipments, which were converted from single-phase to 1200 volt direct current equipments.

Ten new cars were put into service in April, 1911; nine of these cars were of the straight passenger type and one a private car, bringing the present equipments up to 44 electrically equipped units.

Passenger Equipments

The equipments on the 30 passenger cars are all identical, each comprising four 75 h.p. motors and a full complement of Type M control, designed to operate on both 600 and 1200 volts direct current. These motors are of the commutating pole type and have given most excellent results in service. The schedule which the cars have to handle in this particular instance is very severe, but the motors have shown a wonderful record, especially in the direction of brush wear.

The control is of the relay automatic type, as arranged for train operation, and is intended to give full speed on 1200 volts and half speed on 600 volts. The local conditions call for many special features in the control apparatus. The operation in the city of Baltimore calls for 600 and 1200 volt single trolley, and the interurban run from Baltimore to the District line for 1200 volt single trolley. From the District line to 15th and H streets in Washington there is a 600 volt double trolley, while from 15th and H streets to the Treasury building, 600 volt double conduit plows are used. Hence the equipment is arranged to operate on 600 and 1200 volt single trolley. and on double trolley and double conduit plows.

The transfer of circuits from single trolley to double trolley is accomplished by using the

Fig. 19
THREE CAR TRAIN

negative trolley pole and hooks for switches as well as current collectors, and when a change from single to double trolley is made, all that is necessary to be done is to put the negative pole in contact with the second trolley. The transfer of circuits from trolley to conduit plows is made by a double-pole double-throw switch operated either by hand or air. This switch is provided with a magnetic blowout so that it can be opened when alive. When operated by air it is so interlocked with the controller that the control handle must be in the "off position" before the switch can be operated.

Express and Freight Equipments

The service equipments comprise in general the same apparatus as the passenger cars, with the exception that the motors are of 125 h.p. each and the control is of the hand operated type. A very considerable business is being done in the handling of large freight trains. Fig. 21 shows a typical freight train on the road. The 1200 volt equipments have proved entirely satisfactory in every way for this class of service.

Car Bodies

All of the car bodies were built by the Niles Car & Manufacturing Company. The

Fig. 20
FIVE CAR TRAIN

The air compressors for the air brake equipments have a capacity of 25 cubic feet of free air per minute and are provided with the usual air compressor governors. These compressors are provided with motors wound for 1200 volts and are arranged to run at half speed on 600 volts.

The heaters and air compressors are operated directly from the trolley.

A dynamotor is provided for furnishing 600 volt current for the lighting circuits during 1200 volt operation, but on the 600 volt section of the road the lights are fed directly from the trolley. The transfer of these circuits is accomplished by a suitable relay directly under the control of the motorman.

straight passenger and combination passenger and baggage cars are similar in all important details, the only notable difference being that the smoking compartment in the combination cars is reduced in length to provide for a baggage compartment.

All the cars present a handsome appearance; they are painted a dark green and are double ended. The more important dimensions and weights are as follows:

Length over all	50 ft.
Length over body	40 ft.
Width over all	8 ft. 9 in.
Height from sills to top of roof	9 ft. 4½ in.
Height from track to top of roof	12 ft. 9½ in.
Weight of car body	28,500 lb.
Weight of trucks (each)	10,000 lb.
Weight complete ready for service	78,000 lb.

Type of truck	Baldwin class 78-25 A
Distance between truck centers	28 ft. 8 in.
Wheel base of truck	6 ft. 6 in.
Diameter of wheels	36 in.
Seating capacity	54

The following table will show the more important details of the service equipments for locomotives, the first column of figures referring to the two converted equipments and the second column to the new one.

Length over all	54 ft.	50 ft.
Height over all	14 ft. 1 in.	14 ft. 1 in.
Width over all	9 ft. 6 in.	8 ft. 8 in.
Weight of body	30,000 lb.	27,000 lb.
Weight of trucks-(each)	13,000 lb.	13,000 lb.
Weight complete	86,000 lb.	83,000 lb.
Distance between truck centers	33 ft.	26 ft.
Wheel base of trucks	7 ft. 6 in.	6 ft. 6 in.
Diameter of motor wheels	3 ft. 1 in.	3 ft. 1 in.

The standard spacing of the poles is 150 feet but the distance varies at curves and on other special work. The poles are 35 feet in length, with a diameter at the top of from 6 to 8 inches. They are buried for a depth of 6 feet in the ground and are set at a slight inclination to the track.

The trolley is suspended 19 feet from the rail level between Washington and Baltimore and 22 feet from the track on the Annapolis division. The distance between the two trolleys on double track work is 11 feet. The brackets, which are of a T section, are 10 feet 6 inches in length and are attached to the poles by a flange and two lag screws.

All of the messenger insulators, straight line insulators, steady braces and hangers are of the General Electric Company's standard pattern.

The messenger insulators are of interest inasmuch as they have grooved petticoats, the function of which is to prevent the insulation from breaking so as to ground the line. The theory which has been found to hold good in practice is that, should an insulator be damaged by gun shot or stone throwing, it would not break in such a manner as to destroy the insulation of the line, but would be fractured at one of the grooves and there would still remain sufficient insulation to prevent a short circuit.

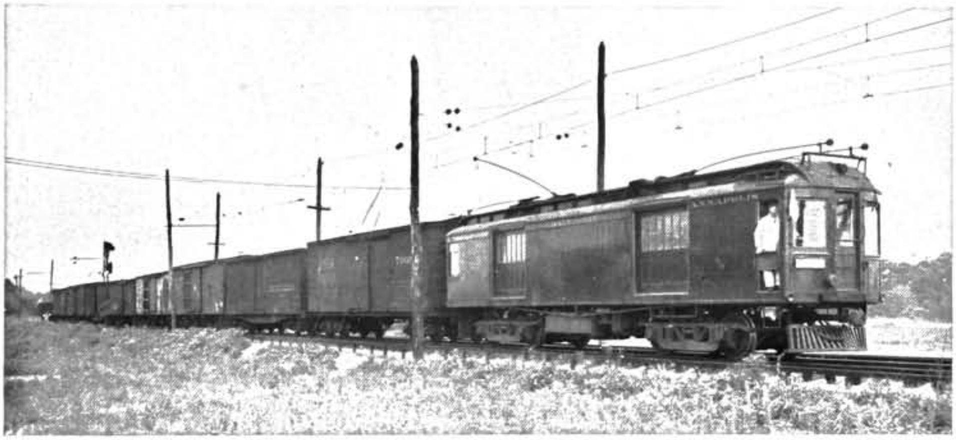

Fig. 21
EXPRESS CAR AND FREIGHT TRAIN

Figs. 19, 20 and 21 shows respectively a three car train, a five car train and a freight train.

Overhead Construction

The overhead construction throughout the interurban section of the line is of the catenary 9-point suspension type. A double bracket construction has been adopted on the main line between Washington and Baltimore and a single bracket construction on the line from Annapolis Junction to Annapolis. The trolley wire is of 0000 grooved copper, while the messenger, which is of special high strength steel, consists of seven strands and has a diameter of ⅜ inch.

In the tunnels near Westport the trolley wire is supported by cross wires thoroughly insulated with fish tail and hickory strain insulators. The cross suspended wires are fastened to U bolts built into the cement structure and supported in the center by other U bolts. The messenger is insulated and anchored at both ends of the tunnel.

Section insulators are used where the 1200 volt and 600 volt trolleys meet. The city of Baltimore now permits a 1200 volt trolley as far as Lombard and Green streets, and the city of Annapolis permits a 1200 volt trolley running entirely around the town.

The general appearance of the catenary construction will be seen in Fig. 22.

Protection against lightning is afforded by a wire strung along the top of the trolley poles and grounded every fifth pole. Both sets of poles are protected in this manner on double track road. The ground leads are carried under ground and connected to the running rails.

Transmission Line

The three-phase transmission line is in duplicate (six wires) between Bennings and Baltimore, and single (three wires) between Academy Junction and Annapolis. It consists of No. 2 aluminum wires strung on the same poles that carry the trolley. The potential is 33,000 volts at 25 cycles.

Telephone System

The road is equipped throughout with a duplicate telephone system, one line being used exclusively for giving train orders from the dispatcher's tower at Naval Academy Junction to cars at the terminal stations and to the different booths situated along the line. The telephone wires are carried on the same poles with the high tension transmission and trolley wires and are transposed every fifth pole.

The line from Washington to Baltimore is of double track throughout and is provided with crossovers at intervals of about three miles. A telephone booth is situated at each crossover. The distance from the Baltimore terminal to the Treasury station at Washington is 40.54 miles and the total mileage of the system on a single track basis amounts to 97.09 miles including sidings and yards.

The rails are of T section, weighing 80 pounds per yard and are laid in lengths of 33 feet. The gauge of the track is standard.

The Annapolis division, which is 20.05 miles long, is laid with similar rails for the major portion of the distance.

Fig. 22
VIEW ALONG RIGHT OF WAY

There is one curve of eight degrees under the B. & O. Railway but excluding this there are no curves of over four degrees. The entire interurban section has a private right of way; the track is well ballasted with gravel and in every respect is excellent for high speed travel. Standard rail joints are used, and the 0000 bonds employed are of the twin terminal type. Cross bonds are used for all special track work and at intervals of about half a mile.

A feature of special interest from a railroad point of view, and one that greatly conduces to the maintenance of a high speed schedule is that there are only two grade crossings on the entire road between Washington and Baltimore, all the roads and public highways having been raised across the railway at considerable expense.

Car Barns

The car barns are situated at Naval Academy Junction and are provided with every facility for the upkeep of the rolling stock. The building is constructed with a reinforced concrete frame filled with red brick panels. It is divided into a paint shop, washing and inspecting room, machine shop, carpenter shop, blacksmith shop, store room, locker room and offices. The machine shop is well equipped with lathes, drills, saws, etc., all of which are driven by General Electric direct current motors.

The heating system is very complete and the fire protection is exceptionally good; a pressure tower with a capacity of 50,000 gallons having been constructed for fire protection. The pits are heated to expedite the work of repairing and inspection during the winter months. A very efficient form of transfer table is used in the machine shop, with the aid of which a truck can be replaced in 28 minutes, this being a very creditable performance.

The potential used throughout the yards is 1200 volts and that in the car barns 600 volts.

It is perhaps worthy of note that a special oil house was built, since it was believed that a well equipped oil house is essential to high speed operation.

In addition to the above car barns a barn with a capacity of ten cars has been built at Lombard street, Baltimore, to facilitate the maintenance of the schedule by a local storage of cars.

Terminal Facilities

The terminal facilities of the Washington, Baltimore & Annapolis Railroad are admirably situated in their respective cities and are of such a nature as to provide for the comfort and convenience of the traveling public.

The station at Baltimore is a red brick building located between Park avenue and Liberty street, and has entrances on both streets. It is also bounded by Marion street. It consists of a waiting room and a ticket office with a track laid through one portion of the building. The administration offices of the company occupy the upper floor.

The Washington terminal is now near the Treasury building and thirteen ticket offices are provided in Washington between the old White House terminal and the Treasury. The White House depot, which was formerly used as a terminal for the Washington, Baltimore & Annapolis cars when a single-phase road, is now only used for the storage of cars.

At Annapolis the waiting room, ticket office and substation are all in the same building, known as West Street Station. There are also five additional ticket offices in Annapolis.

A waiting room is provided at Naval Academy Junction for the convenience of passengers changing cars at this point.

NOTES ON THE OPERATION OF THE WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILROAD AS A 1200 VOLT SYSTEM

Some of the ruling factors which led to changing the Washington, Baltimore & Annapolis Electric Railroad from 6600 volts alternating current to 1200 volts direct current operation should be cited before showing the economies secured by the change.

Many of the operating conditions were peculiar to the system. The run from the White House depot, on the outskirts of Washington, to the center of the city is over an underground conduit system, which, owing to its limited strength prohibited the use of of cars weighing more than 40 tons. This was lighter than single-phase cars, capable of performing the service, could be built. Formerly with alternating current operation, it was necessary for the passengers to change cars at the White House interurban depot, while now the 1200 volt interurban cars run right to the center of the city. Another reason for the change was that the curves in Baltimore around which it was desired to operate in trains demanded a shorter car than those used for the single-phase operation. The third reason was the high operating expenses, particularly the car barn expenses.

When the change was made the weight of cars was reduced from 59 tons to 39 tons and the seating capacity per car from 66 to 54 passengers.

From the following statements it will be noted that the change from alternating current to direct current operation has secured a saving of approximately 40 per cent. in the railway company's power bill. This wonderful showing is partly accounted for by the good inherent characteristics of the 1200 volt apparatus and partly by the peculiar conditions which existed before the change. With single-phase operation short stretches of track at Baltimore and at Annapolis were operated by 600 volt direct current, which was furnished by single-phase motor-generator sets taking power from the single-phase trolley. When the change was made to 1200 volt direct current operation these sections were tied directly to the interurban trolley.

To maintain the same time table with 1200 volts direct current as was formerly maintained by 6600 volts alternating current, a reduction in the maximum speed was found possible as the rate of acceleration was increased; this factor accounts for a saving in power as losses in the brake shoes are reduced.

It is interesting to note that the final substitution of 1200 volt apparatus for alternating current apparatus was made in a single night and that not one trip of the regular time table was missed on the first day of change.

The reduction of car barn expenses since the adoption of 1200 volt apparatus is perhaps one of the most significant advantages which have been derived from the change. The following figures speak for themselves.

	1909 A-C. Operation	1911 D-C. Operation
Number of cars	23	44
Car barn employees	63	27
Car barn expenses per car mile	3.72 cts.	1.37 cts.

A complete analysis of these expenses for direct-current operation is as follows:

	Operating Expenses	Cents per Car Mile
32	Passenger and combination cars	$0.37
33-a	Freight cars	.05
33-b	Express cars	.00
33-c	Mail cars	.00
34	Locomotives	.00
35	Service cars	.04
36	Electric equipment of cars	.21
37	Electric equipment of locomotives	.00
38	Shop machines and tools	.02
39	Shop expenses	.18
66	Car house employees	.50
67	Car house expenses	.00
	Total	$1.37

The above figures refer to a period of nine months ending December 31, 1911. These satisfactory figures are acccounted for by the excellent inherent characteristics of the 1200 volt apparatus which are further exemplified by the following statements:

The original carbon brushes furnished with the GE-205 motors have now run over 130,000 miles and show less than ⅛ in. wear; not one brush has been renewed.

The brushes on the CDM dynamotors have run over 130,000 miles; not one has been renewed.

The brushes on the CP-29 compressors have run over 130,000 miles; not one has been renewed.

The wear on all of the above brushes is so small that after over 130,000 miles of service there is not sufficient wear to enable any prediction as to their ultimate life.

All of the original armature bearings are still in service after having run over 130,000 miles.

The axle bearings average 40,000 miles before being re-babbitted. The journal bearings average 85,000 miles before re-babbitting.

The average wheel mileage per turning is 45,000 miles.

Owing to the thorough methods of inspection which are in vogue on the Washington, Baltimore & Annapolis Railroad, which call for an inspection after every 1500 miles of service and a general overhauling after every 45,000 miles of service, the above figures do not represent the life of bearings, etc., used up to their ultimate wearing life, but, rather show what the management consider a good policy as regards re-babbitting.

It is of special interest to note that the original car control contact burning tips furnished with the equipment are still in service and that not one burning tip has been renewed. No arc chutes have been replaced.

As a point of general interest it may be mentioned that the average cost per 1000 wheel miles for brake shoes is $0.0875 and that the wheel mileage per brake shoe amounts to 8838 miles; also, that the trolley wheels cost per 1000 car miles $0.2246 and that the average car miles per wheel is 3693.18 miles.

The record for the small double truck city car used in Annapolis which is equipped with two GE-217 motors and R-200-A control and has been in continuous service for seventeen months is of special interest as there have been no expenses of any kind for replacements on this equipment with the exception of the renewal of 15 resistance grids which were burnt out by coming into contact with very heavy snow. This happened in January, 1911, and no replacements of any sort or kind have been made on this car since that date.

Troubles on Car Equipment Caused by Lightning

During the year 1911 there was an unusual amount of damage done by lightning throughout the State of Maryland and District of Columbia, but the entire damage done to car equipments on the Washington, Baltimore & Annapolis Electric Railroad amounted to but $71.10. In each case the damage was quickly and cheaply repaired.

Notes on Substation Operation

Since the 1200 volt equipment has been installed, no new brushes have been put in on the direct current side of the rotary converters (the converter equipment of the whole road consists of fifteen units).

There have been no flashovers.

No commutators have been turned down.

No troubles with direct current circuit breakers.

No trouble with or repairs to switchboards since the road was started up.

The cost of substation maintenance has been practically nil.

Lightning

The alternating current side is protected by aluminum cell arresters on the 33,000 volt line and aluminum cell Type MD arresters are installed on the direct current side.

No trouble of any kind has been experienced from lightning in any substation since these arresters have been installed, which was considerably over a year ago.

As stated above, the change from 6600 volt operation to 1200 volt direct current operation was made on the night of February 14-15, 1910, and therefore the power record for the month of February is an excellent means of comparing the relative power consumption of the two systems.

POWER REPORT FOR FEBRUARY, 1910

	Feb. 1–14 A-C. Operation	Feb. 14 28 D-C. Operation
Kw-hr. consumption . .	374,880	231,895
Car miles (interurban) .	57,287	58,809
Kw-hr. per car mile . .	6.54	3.94
Peak load (average) . .	1491	1101
Cost per car mile . .	0.0617	0.0391

The most significant point in the above statement is that the kw-hr. consumption per car mile is just about one-half for the direct current operation as compared with alternating current operation and accordingly the cost for power per car mile has been cut almost in halves.

The following notes are from the Power Report for the entire year of 1910 and for nine months (April–December) 1911. The figures are in all cases the average per month.

	Average per Month 1910 D-C. Operation	Average per Month 1911 D-C. Operation
Kw-hr. consumption . .	555,000	512,500
Car miles (interurban) .	138,300	144,000
Kw-hr. per car mile . .	4.015	3.561
Peak load	1182	1195
Cost per car mile . .	0.0386	0.0352

The following detailed analysis of the operating expenses and the general statistical data show a most satisfactory condition of operation and should prove of use to all interested in interurban railway operation.

4950–20 Washington, Baltimore & Annapolis 1200 Volt Direct Current Railroad

DETAILED OPERATING EXPENSES FOR 9 MONTHS 1910 AND 1911

	Operating Expenses		9 mos. to Dec. 31 Cents per C.M. 1911	1910
	I. WAY AND STRUCTURES			
1	Superintendence of way and structures	*	0.55	0.60
2	Ballast	*	0.04	...
3	Ties	*	0.09	0.28
4	Rails	*	0.01	...
5	Rail fastenings and joints	*	0.01	0.04
6	Special work	*	0.03	0.02
7	Underground construction	*	...	...
8	Roadway and track labor	*	1.02	1.29
9	Paving	*	0.12	0.10
10	Miscellaneous roadway and track expenses	*	0.03	0.06
11	Cleaning and sanding tracks	*	0.08	0.07
12	Removal of snow, ice and sand	*	...	0.04
13	Tunnels	*	...	...
14	Elevated structures and foundations	*	...	...
15	Bridges, trestles and culverts	*	0.04	0.25
16	Crossings, fences, cattle guards and signs	*	0.02	0.02
17	Signal and interlocking systems	*	0.06	0.04
18	Telephone and telegraph systems	†	0.04	0.06
19	Other miscellaneous way expenses	*	...	0.01
20	Poles and fixtures	*	0.05	0.06
21	Underground conduits	*	...	...
22	Transmission system	†	0.05	0.03
23	Distribution system	*	0.25	0.39
24	Miscellaneous electric line express	*	...	...
25	Buildings and structures	*	0.21	0.11
26	Depreciation of way and structures	*	...	...
27	Other operations—Dr.	*	...	...
28	Other operations—Cr.	*	...	...
	TOTAL WAY AND STRUCTURES		2.70	3.47
	II. EQUIPMENT			
29	Superintendence of equipment	†	0.13	0.22
30	Power plant equipment	*	...	...
31	Substation equipment	†	...	0.01
32	Passenger and combination cars	†	0.37	0.29
33a	Freight cars	*	0.05	0.05
33b	Express cars	†	...	...
33c	Mail cars	†	...	...
34	Locomotives	†	...	...
35	Service cars	*	0.04	0.04
36	Electric equipment of cars	†	0.21	0.19
37	Electric equipment of locomotives	†	...	...
38	Shop machinery and tools	†	0.02	0.01
39	Shop expenses	†	0.18	0.10
40	Horses and vehicles	*	0.02	0.04
41	Other miscellaneous equipment expenses	†	...	0.01
42	Depreciation of equipment	†	...	...
43	Other operations—Dr.	*	..	...
44	Other operations—Cr.	*	..	...
	TOTAL EQUIPMENT		1.02	0.96
	III. TRAFFIC			
45	Superintendence and solicitation	†	0.31	0.40
46	Advertising	†	0.44	0.56
47	Miscellaneous traffic expenses	†	0.01	0.03
	TOTAL TRAFFIC		0.76	0.99

* Interurban. † Entire system.

DETAILED OPERATING EXPENSES FOR 9 MONTHS 1910 AND 1911—Continued

	Operating Expenses		9 Mos. to Dec. 31 Cents per C.M. 1911	1910
	IV. CONDUCTING TRANSPORTATION			
48	Superintendence of transportation	†	0.40	0.40
49	Power plant employees	*	...	...
50	Substation employees	†	0.34	0.32
51	Fuel for power	*	...	...
52	Water for power	*	...	...
53	Lubricants for power	*	...	...
54	Miscellaneous power plant supplies and expenses	*	...	...
55	Substation supplies and expenses	†	0.02	0.01
56	Power purchased	*	3.66	3.73
57	Power exchanged —balance	*	...	...
58	Other operations—Dr.	*	...	...
59	Other operations—Cr.	*	...	...
60a	Passenger conductors	†	1.50	1.37
60b	Passenger motormen	†	1.50	1.42
60c	Other passenger trainmen	†	0.01	0.01
61c	Freight and express conductors	†	0.14	0.11
61b	Freight and express motormen	†	0.14	0.12
61c	Other freight and express trainmen	†	0.20	0.20
62	Miscellaneous car service employees	†	0.18	0.14
63	Miscellaneous car service expenses	†	0.23	0.45
64	Station employees	†	0.90	0.86
65	Station expenses	†	0.33	0.34
66	Car house employees	†	0.50	0.50
67	Car house expenses	†	...	0.01
68	Operation of signals and interlocks	*	0.07	0.10
69	Operation of telephone and telegraph	†	0.04	0.03
70	Express and freight collections and deliveries	†	...	0.07
71	Loss and damage	†	0.01	0.02
72	Other transportation expenses	†	0.02	0.02
	TOTAL CONDUCTING TRANSPORTATION		10.19	10.23
	Items 73–88:			
	Total, general and miscellaneous	:	3.32	3.04
	TOTAL OPERATING EXPENSES		17.99	18.69

* Interurban. † Entire system.

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
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For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

SERIES INCANDESCENT
STREET LIGHTING
SYSTEM

GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK
SUPPLY DEPARTMENT

Series Incandescent Street Lighting System

General Electric Company

SCHENECTADY, N. Y.

SUPPLY DEPARTMENT

May, 1912

No. 4952

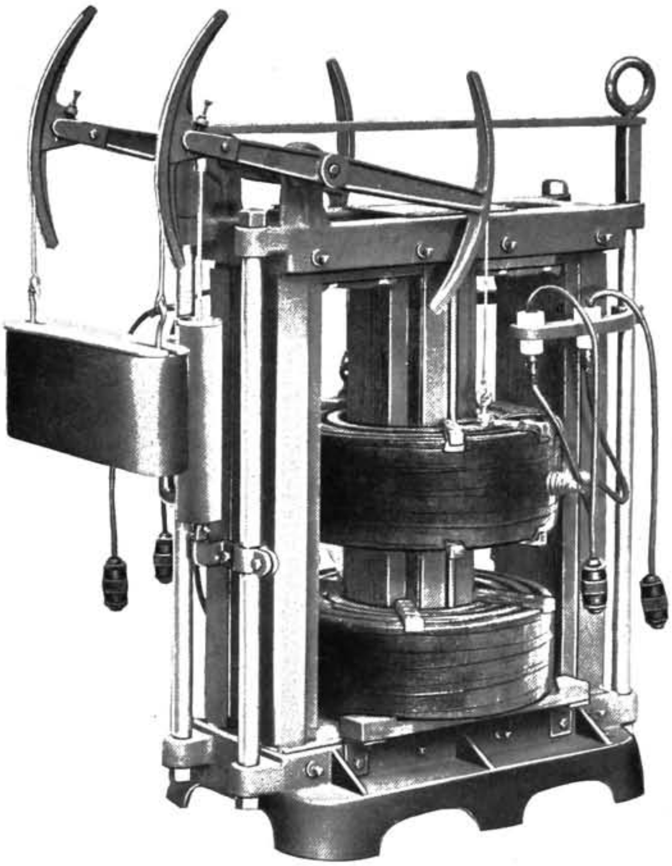
Supersedes in part No. 4718

General Electric Company
Schenectady, N.Y.

SUPPLY DEPARTMENT

May, 1912 | | * *Bulletin No. 4952*

SERIES INCANDESCENT STREET LIGHTING SYSTEM



60 CYCLE, 20 KW., 2200 VOLT, 5.5 AMP., CONSTANT CURRENT TRANSFORMER
CAT. NO. 119694

Good street lighting has come to be recognized as one of the necessary adjuncts of modern civilization. It makes night travel safe, stimulates business, and, not only adds to the attractiveness but reflects the progressiveness of a municipality.

The General Electric series incandescent system with its utilization of the series Mazda lamp and the constant current transformer has accomplished remarkable results by its economy and effectiveness in extending the benefits of street illumination

**Supersedes in part Bulletin No. 4718.*

to localities where efficient lighting otherwise, owing to the expense involved, would have been impossible.

Some of the places where this system is especially applicable are small villages, outlying districts where the street lighting appropriation is small, residential and suburban streets, narrow and crooked streets and alley-ways, also streets and roads where the foliage is dense. In all of these places the installation of high candle-power units is precluded and the series Mazda lamp is an ideal solution of the lighting problem.

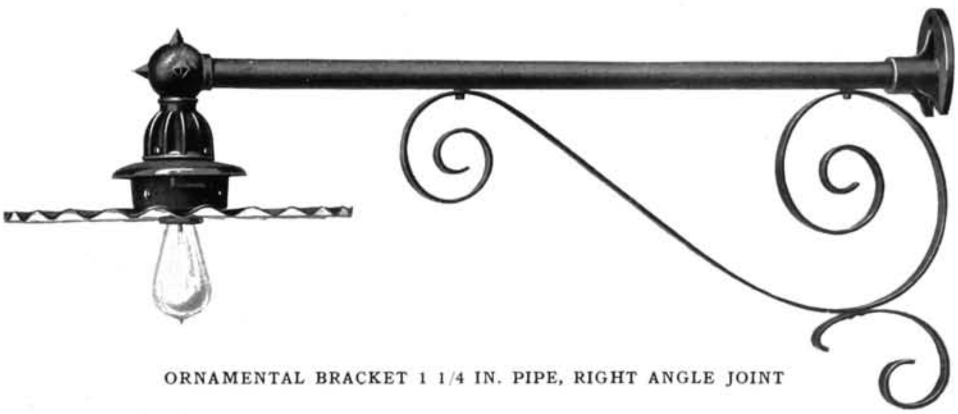
The station equipment of this system consists of a transformer to maintain the current constant, a switchboard for control of the circuits and a lightning arrester for protection. The constant current transformer is automatic in operation and keeps the lamps steady and free from pulsations. It is superior in every way to the old time method of regulating carbon lamps by the shunt box system.

For the light source the well known series Drawn Wire Mazda lamps are utilized. They are durable and long lived and can be furnished in candle-power sizes to meet all requirements. Radial wave reflectors are recommended owing to their superior distribution of light but deflectors can be furnished instead if, for any reason, they are desired.

The series sockets used with these lamps have short circuiting contacts which operate when a lamp burns out so that the remainder of the lamps in circuit will not be affected.

The brackets are made in a great variety of designs.

Where extra illumination is required, such as at dangerous street intersections, large diffusers equipped for holding either four or six lamps can be furnished.



ORNAMENTAL BRACKET 1 1/4 IN. PIPE, RIGHT ANGLE JOINT

In places where high voltage is objectionable, such as on bridges, in buildings, etc., SL transformers are available. When these transformers have the primaries placed in series with the incandescent system, a low voltage supply is furnished at the secondaries.

All of these parts of the General Electric system are described later in detail.

The foregoing brief description indicates the flexibility of the series incandescent system.

In many cases it is desired to use the series Mazda lamps in conjunction with arc lamps, under such conditions perfectly satisfactory operation is obtained, although it was not possible with the carbon series incandescent lamps. With this method it is possible to use arc lamps in the business districts where intense illumination is wanted and the series Mazda lamps where smaller units will be sufficient.

The quality of the service of a series incandescent system is largely dependent upon the auxiliary apparatus employed. The success that the General Electric series incandescent system has met with is due to the fact that this company manufactures the complete equipment from the generating and regulating units to the lamps themselves and the product represents long experience in this class of lighting.

The series Mazda lamps provide a means for illumination that is more economical and effective than any other small unit while the design, workmanship and quality of the material employed in the auxiliary apparatus combine to make the General Electric series incandescent system the most economical to install and maintain.

Installations of this system may be seen in all of the larger cities in this country, in addition to a large number of the small cities and towns.

BRACKETS

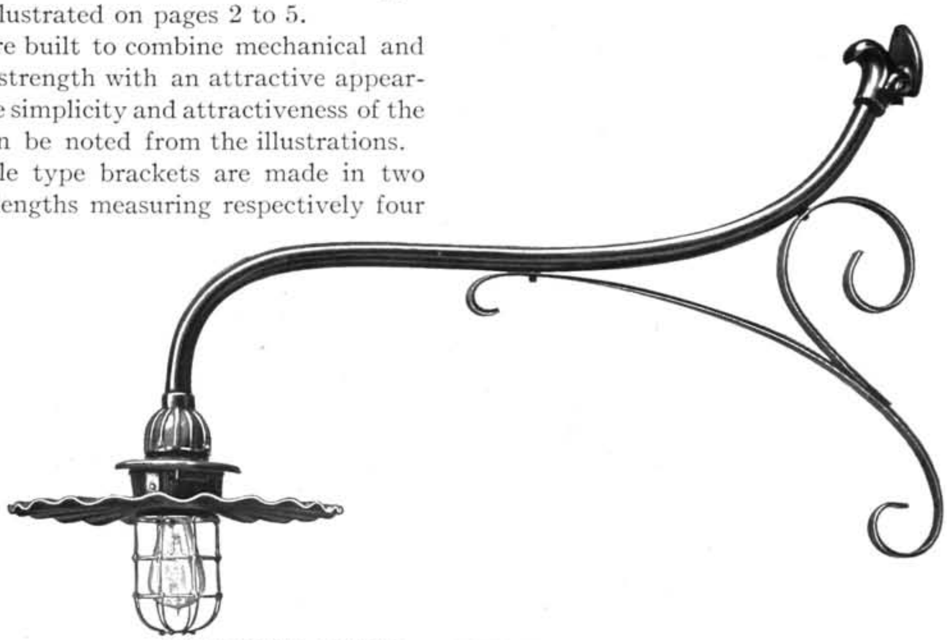
The line of brackets embraces those for pole and suspension mounting and equipped with radial wave reflectors or parabolic deflectors. The former are the latest type and are illustrated on pages 2 to 5.

They are built to combine mechanical and electrical strength with an attractive appearance. The simplicity and attractiveness of the design can be noted from the illustrations.

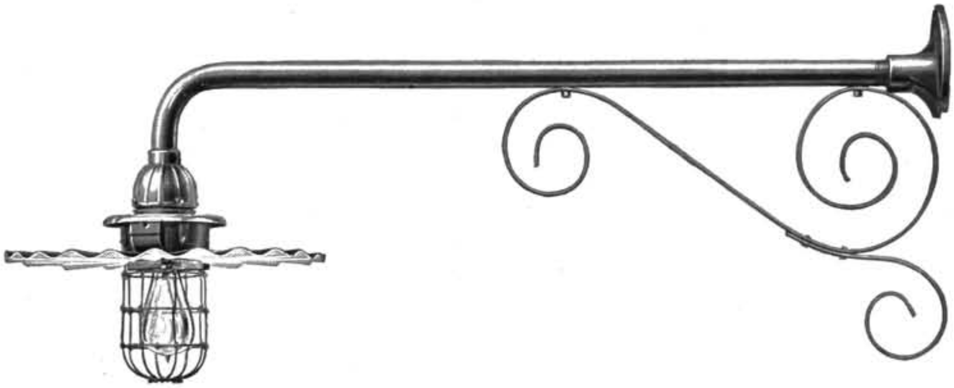
The pole type brackets are made in two different lengths measuring respectively four feet, and twenty inches from the face of the pole to the center of the lighting unit. The former is ordinarily used for street lighting, the latter being particularly adapted for use where space is limited, as in alleyways.

Several types are available: one, designed to be clamped to the supporting cable; another, for eye suspension with strain insulator, and another so that the reflector will always assume a level position regardless of the weight of the leads.

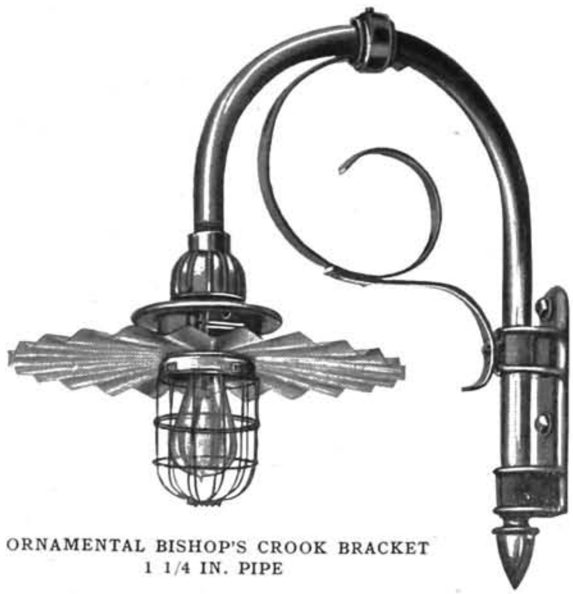
All brackets and suspension fixtures can be furnished for series or multiple service. The anchorage of the leads is a point of great importance, a feature to which in the brackets made by General Electric Company particular attention has been given. Two screws of adequate size are provided for each binding post. The line is insulated from the ground by the main insulator receptacle, which is capable of withstanding a potential test many times the voltage of the ordinary series circuit. It is provided with reinforced phosphor bronze slips for holding the series socket and for short circuiting the line connections when the socket is removed. It also supports the radial wave reflector by means of the holders or grinding plates and clamps which grip the reflector with screws placed radially, penetrating the porcelain wall and engaging threads there tapped.



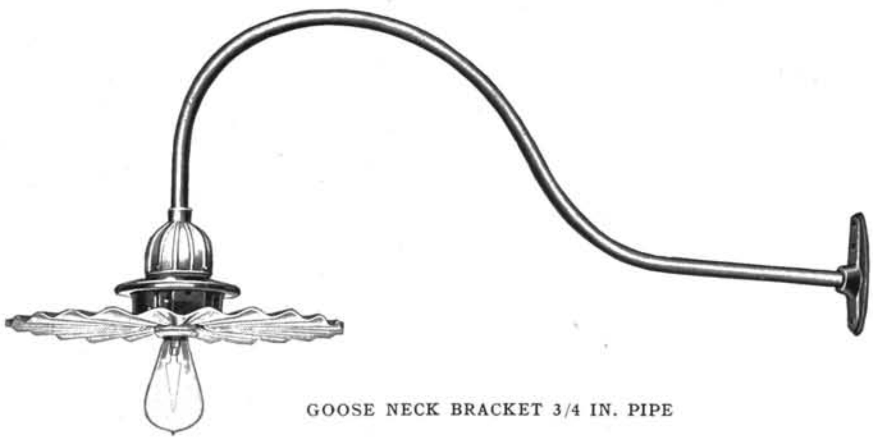
ORNAMENTAL BRACKET 1 1/4 IN. PIPE, DOUBLE BEND



ORNAMENTAL BRACKET 1 1/4 IN. PIPE, RIGHT ANGLE BEND



ORNAMENTAL BISHOP'S CROOK BRACKET
1 1/4 IN. PIPE

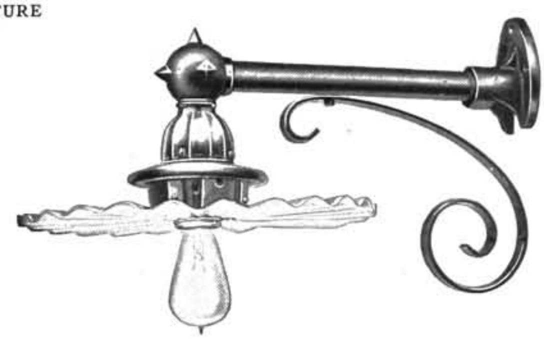


GOOSE NECK BRACKET 3/4 IN. PIPE

CENTER SPAN STRAIN INSULATOR SUSPENSION FIXTURE

The parabolic deflectors are less expensive than the radial wave reflectors but are not so durable or efficient.

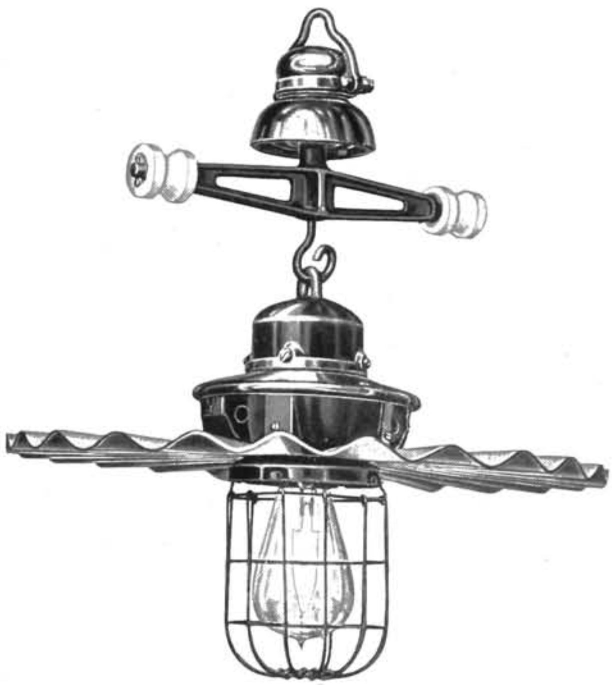
The 1¼ in. brackets are designed for either exterior or concealed wiring. The inside diameter of the pipe provides ample room for the interior wiring.



ORNAMENTAL BRACKET 1 1/4 IN. PIPE, RIGHT ANGLE JOINT 20 IN. EXTENSION

The radial wave reflectors give a very efficient light distribution. They are stamped from steel discs and the fluting or radial waves are not only beneficial for light distribution but give the reflector great mechanical strength. The under side is coated with white enamel to give reflection, while the upper side is coated with blue enamel.

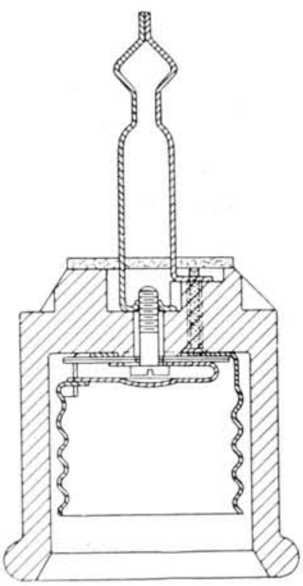
The reflectors are made in three sizes, 15, 20 and 24 inches. The two latter are the most popular, the 20 in. reflector being used with all sizes of street series lamps having the unskirted base and the 24 in. reflector with the lamp shaving the skirted base.



CENTER SPAN EYE SUSPENSION FIXTURE WITH CROSS ARM HIGH VOLTAGE INSULATOR HANGER

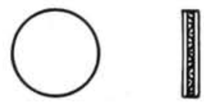
SOCKET, RECEPTACLE AND CUTOUT

It is essential that the socket be so constructed that it will automatically short circuit the lamp in case of an open circuit, and that the receptacle permits a ready removal of the lamp from the socket without opening the circuit. For this purpose there has been designed a socket and receptacle which not only have these characteristics,



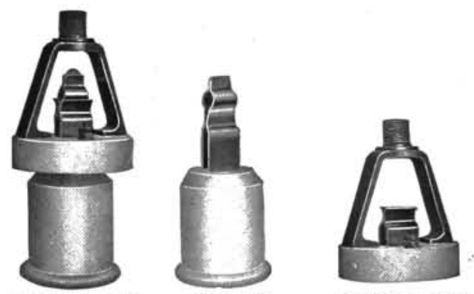
SERIES SOCKET

but in addition embody a feature long sought for by central stations consisting of a short circuiting spring contact, which, when the lamp is screwed into position, rests against the lamp base and prevents loosening by vibration. When the lamp is unscrewed the spring contact follows it in a downward direction until the free end engages the screw shell of the socket, making a continuous circuit. The advantage of this arrangement is obvious; in the case of a burned out or broken lamp it is necessary to remove the socket, in order to replace the film cutout, this being done, the socket may again be placed in the receptacle without puncturing the film cutout as the circuit is completed through the spring contact mentioned above. The new lamp is then screwed into position and the circuit is complete through the lamp, instead of through the spring contact. It will, therefore, be noted that it is not necessary to place the lamp in the socket before placing the latter in the receptacle, and that the jarring of the filament which usually attends the operation is eliminated.



FILM CUTOUT

A new aluminum disk film cutout has also been designed which will readily puncture between 150 and 200 volts and which effectually overcomes the trouble previously experienced with sockets burning out, caused by the failure of a mica or paper film to puncture when the lamp burns out or is broken.

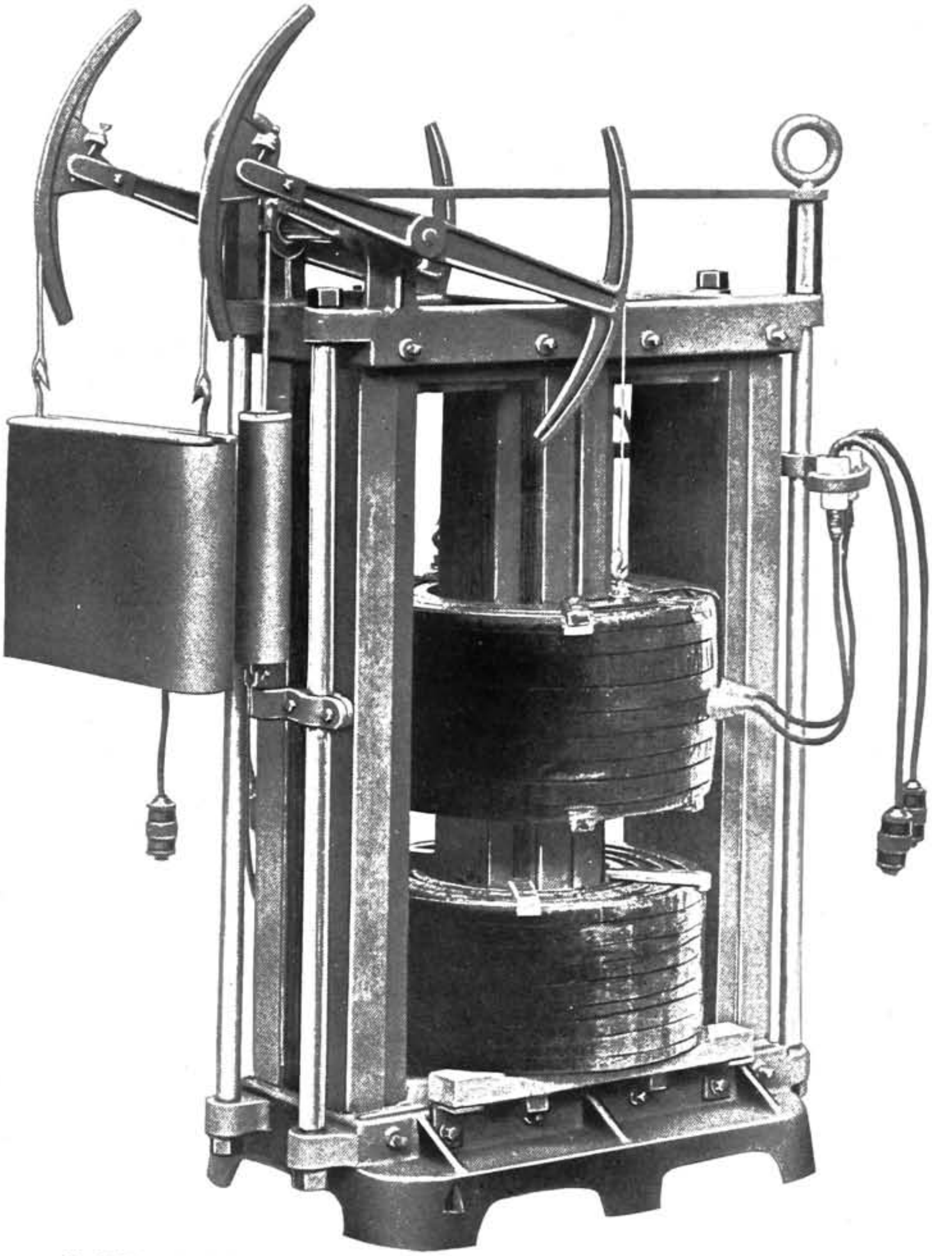


SOCKET AND RECEPTACLE — SOCKET — RECEPTACLE

This new cutout consists of two round aluminum plates $\frac{7}{16}$ inch in diameter and approximately $\frac{1}{32}$ inch thick insulated from each other by a piece of chiffon veiling and held together by varnish.

GENERAL ELECTRIC CONSTANT CURRENT TRANSFORMERS FOR SERIES INCANDESCENT SYSTEMS

The constant current transformers made by the General Electric Company are designed so that the coils will separate sufficiently to



25 CYCLE, 20 KW., 2200 VOLT, 5.5 AMP., CONSTANT CURRENT TRANSFORMER
CAT. NO. 119638

maintain constant current even when all of the lamps are cut out of the circuit; in other words, they regulate from full load to no load. The center of curvature of the weight sector arm is adjustable, as is also the amount of balancing weight, thus allowing the transformer to be adjusted for operation

at any current within 7½ per cent. of the normal rated value. They can also be operated on any primary voltage within 5 per cent. of the normal rated value. The regulation is guaranteed within 1/10 ampere either side of normal from full load to zero.

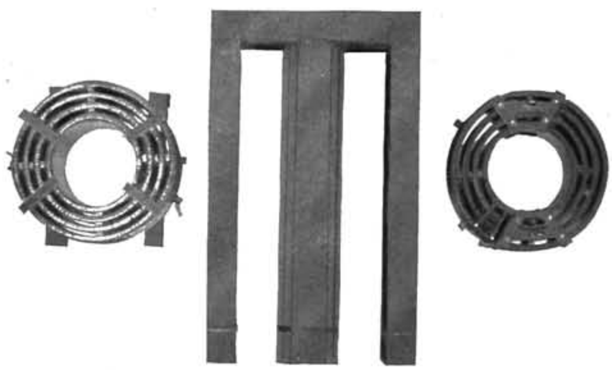
These transformers are subjected to an insulation test of 10,000 volts between secondary and primary; also between both coils and all parts. The duration of this test is 60 seconds. If the primary or open circuit voltage is above 5000 the test given is twice normal voltage.

The introduction of the new type with edgewise wound concentric coils with their numerous points of superiority marks an epoch in constant current transformer design. The term "edgewise wound" is applied to the transformers because of the fact that both primary and secondary consist of four concentric coils of rectangular wire wound on edge. There are numerous advantages resulting from this construction. The possibility of an internal short circuit is practically eliminated as the voltage between any two adjacent conductors consists of only the volts per turn of the transformer, which is never above ten. The four sections constituting each complete coil are assembled together concentrically with spacing strips to maintain at all points a sufficient air duct. Two surfaces of each conductor are therefore exposed to the currents of air passing through the air ducts, thereby increasing the effective radiating surface of each coil about threefold. The floor space and weight of these new transformers is only about ¾ of that of the old type pancake coil transformers.

The core is built up of thin laminations of sheet steel and has a center leg of cruciform shape. This construction requires only a thin angle for securely clamping the laminations thus decreasing the eddy currents in the clamp. It also gives the most economical flux path and permits a smaller diameter coil.

Construction

Every transformer is carefully constructed and all have the same degree of high grade workmanship. The extremely simple construction makes it possible for a man of ordinary mechanical ability to assemble



and disassemble them. A neat cast iron base is used and the finished transformers, by their general strength, simplicity and compactness, give a most pleasing appearance.

Rating

Standard transformers are made in 3-5-10-15-20-25 kilowatt sizes for 1100 or 2200 volt primary, 4-5.5-6.6 and 7.5 amperes secondary. The rating of these transformers is determined by multiplying the secondary load volt by the rated current. This rating assumes a load of unity power-factor.

Efficiencies and Power-Factor

The kilowatt output of the transformers is based on actual secondary load voltage which they will carry with a load of unity power-factor and rated secondary current. No allowance is made for line loss.

When transformers are permanently used on higher frequencies than they are designed for, a tap can be put on the primary winding at a slight extra cost which gives the rated output at the higher frequency. This is made possible by the fact that the series Mazda lamps are unaffected by changes in frequency and are interchangeable for direct or alternating current circuits.

The characteristics of the constant current transformers especially adapt it for controlling series incandescent circuits, since the life of the lamps depends largely on the ability of the controlling apparatus to maintain a normal current. The close regulation of this transformer makes it ideal. Besides acting as a controlling device it insulates the generating system from the incandescent circuit, thereby preventing a ground on the former in case of ground on the lamps' circuit. It combines in one unit a regulating device and step up transformer and reduces the floor space required to a minimum.

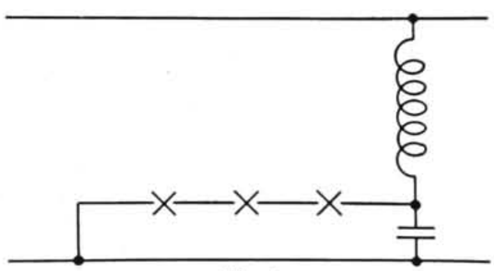


Fig. 1

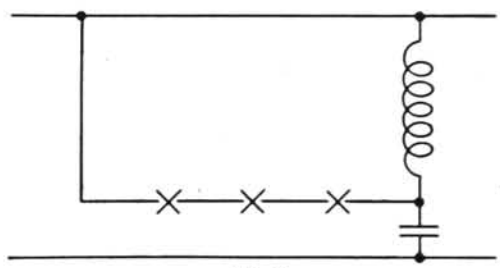


Fig. 2

COMPARISON OF VARIOUS METHODS FOR OBTAINING CONSTANT CURRENT

Alternating current is generally supplied at constant potential, consequently, when lamps or other apparatus requiring constant current are used, it is necessary to equip the circuit with some means of transforming from the constant voltage supply to constant current. This transformation is usually accomplished by means of inductive reactances or combinations of inductive and condensive reactances. For instance:

(1) A constant inductive reactance inserted in series with an alternating current, non-inductive circuit maintains approximately constant current so long as the resistance of the circuit is small compared with the series reactance.

(2) A constant condensive and an equal constant inductive reactance connected in series across a constant potential supply will maintain constant current in any circuit connected to the common point between the reactances. The other end of this circuit may be connected to either of the constant potential lines, in one case shunting the condensive reactance (Fig. 1) and causing the main current to lead; in the other, shunting the inductive reactance (Fig. 2) causing the main current to lag; or it may be connected to any point of a compensator bridging the constant potential circuit (Fig. 3).

(3) The "T-connection" or "resonating circuit" consisting of two equal inductive reactances connected in series in the constant potential circuit with a condensive reactance

equal to the two inductive reactances connected from the middle point of these across the constant potential circuit gives constant current in a circuit shunting the condensive

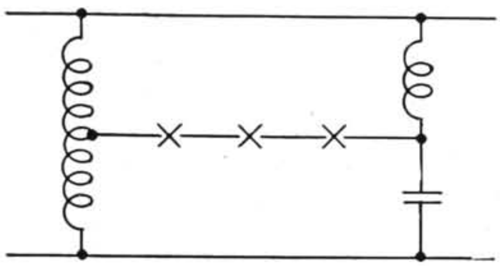


Fig. 3

reactance and one of the inductive reactances (Fig. 4).

(4) The "monocyclic square" consisting of two inductive and two condensive reactances connected in series-multiple across the constant potential circuit, the two similar reactances being opposite each other, gives constant current in any circuit connected to the diagonal of the square opposite the points of connection to the constant potential circuit (Fig. 5).

All of the above methods are unsatisfactory for the operation of incandescent lamps on series circuits for several reasons.

In the case of the constant inductive reactance the current is maintained constant

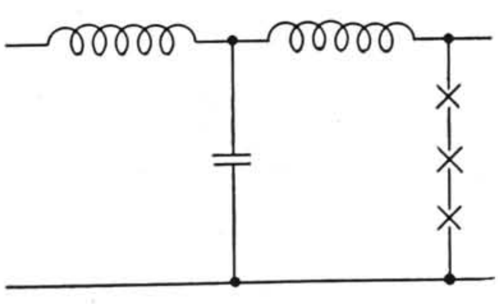


Fig. 4

only at a great sacrifice of power-factor. As seen from the low power-factor the impressed voltage must be extremely high compared with the load voltage.

One great disadvantage of all of the above systems is their lack of flexibility, the maximum voltage on the constant current circuit being fixed by that of the constant potential supply. Perhaps the prohibitive feature in the last three at least is the high cost of condensive reactance and its great weight.

The most efficient method of producing constant current from constant potential supply and at the same time maintaining a respectable value of power-factor and allowing flexibility in secondary voltage is by means of a series reactance which changes with the load in such a manner as to keep the current constant. This variable reactance is obtained in the constant current transformer by means of two coils, movable with respect to each other. In the General

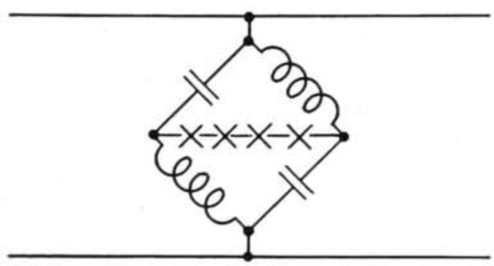


Fig. 5

Electric constant current transformers for series incandescent street lighting, one coil is stationary, while the other is suspended from a rocker arm to the other end of which weights are attached. These weights together with the magnetic repulsion between the coils counterbalance the weight of the movable coil. At full load the coils should be from one to two inches apart and as the load falls off the tendency for the current to rise, due to the decreased resistance of the secondary circuit, is offset by the separation of the coils. The separation is caused by the greater repulsion of the increased magnetic flux, due to the momentarily increased current in the secondary coil. With the coils farther apart more of the magnetic lines of force from the primary coil go out between the coils as leakage flux and the e.m.f. induced in the secondary is decreased in proportion to the fall in the secondary load, thus maintaining the current at a constant value. The series inductive reactance which varies with the load is independent of frequency, impressed voltage and character of load.

FIRE ALARM BOX IN ROCHESTER, N. Y., LIGHTED FROM SL TRANSFORMER

TYPE SL SERIES TRANSFORMERS

For Operating Series Incandescent Lamps at Low Voltage on 60 Cycle Series Arc or Incandescent Circuits

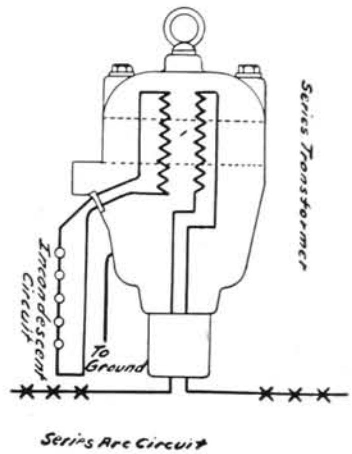
Certain classes of lighting require lower potential than that obtainable from series arc or incandescent circuits, and to provide for this lighting companies are often compelled to run multiple circuits from the central station at a considerable expense.

By using a Type SL (series lighting) series transformer a low voltage circuit may be taken directly from the series circuits when required, thus obviating a large item of expense and providing a very flexible system of distribution.

Some of the places where these transformers can be used to advantage are given below:

1. Isolated side streets or alleys where it is desired to install series incandescent lamps and where the only available circuit is a series arc circuit.

2. In places where a series system is desirable and high potential is impracticable,



as, for example, where it is desired to place the line upon telephone poles, or where customer wishes a few small units in a building and multiple circuits are not available.

3. On bridges where it is necessary to eliminate high potential.

4. For underground circuits leading to ornamental poles.

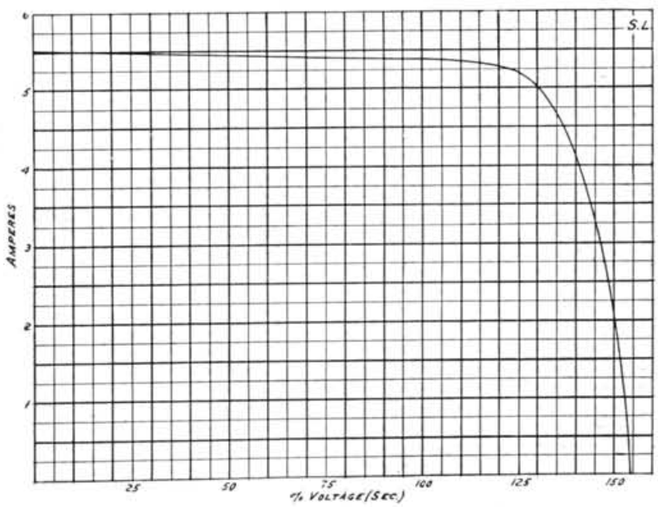
5. Lighting of fire alarm boxes, police boxes or letter boxes. This system has already been installed with great success in one of the largest and most enterprising cities in the country.

The SL transformers supersede the Type H Form S and are designed for mounting on poles or in subways.

As the name implies, the subway transformers are for underground use and are quite similar to the pole type except that the leads are separated and brought to a cap or metal bushing, to which may be attached the lead sheath of the underground

VIEW OF PARTIALLY ASSEMBLED SL TRANSFORMER

cable. This cap or bushing is designed so that after the soldered joint between the conductor is made and insulated it can be filled with a hot insulating compound.



The SL transformers range in capacity from 40 watts to 2000 watts, and the standard ampere ratings are 4, 5.5, 6.6 and 7.5.

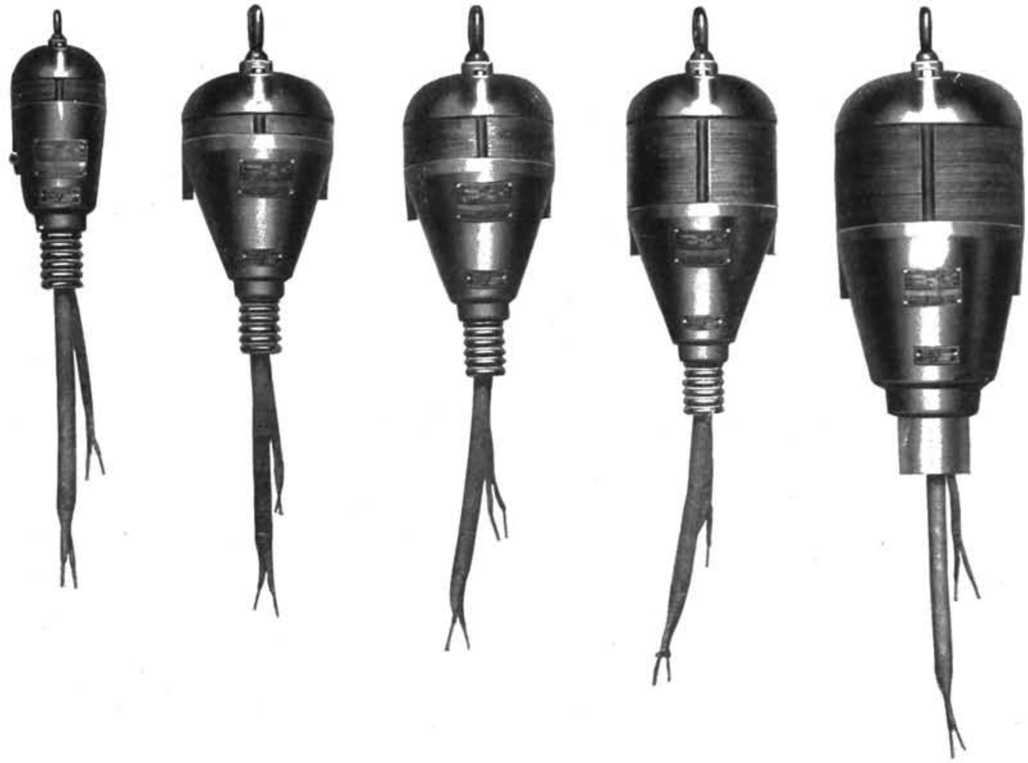
In general appearance and construction they resemble the telephone line insulating transformer.

SL TRANSFORMER ARRANGED FOR SUBWAY SERVICE

The core is shell type, built up of circular punchings with two symmetrical pieces in each layer. On the center leg or tongue of this core are assembled the form wound coils. The primary coil fits snugly over the secondary coil but is so insulated that it will withstand a breakdown test of 20,000 volts to the secondary coil and also to the core.

The casing for the transformer consists of a cast iron box, forming the lower part, and a cover or cap of the same material which forms the top. The case is conical in shape, being drawn in at the lower end to receive the large porcelain bushing through which pass the primary leads consisting of double-conductor rubber insulated cable. The secondary leads enter the case through a small porcelain bushing beneath the bracket near which is placed a grounding terminal. The core rests upon the upper edge of the case and upon the core rests the cover, modified slightly from the shape of a half sphere. Small studs through the cover and core bind these parts firmly together. The case has extension brackets for bolting the transformers to the cross arm of a pole or to the side of a building.

Because of the low capacity, and consequently small losses in the transformers, it was not found necessary to use oil as a cooling medium between the windings and the case.



.04 Kw. .250 Kw. .500 Kw. 1.0 Kw. 2.0 Kw.

TYPE SL-40, 250, 500, 1000, 2000 WATT SERIES TRANSFORMERS

Operation

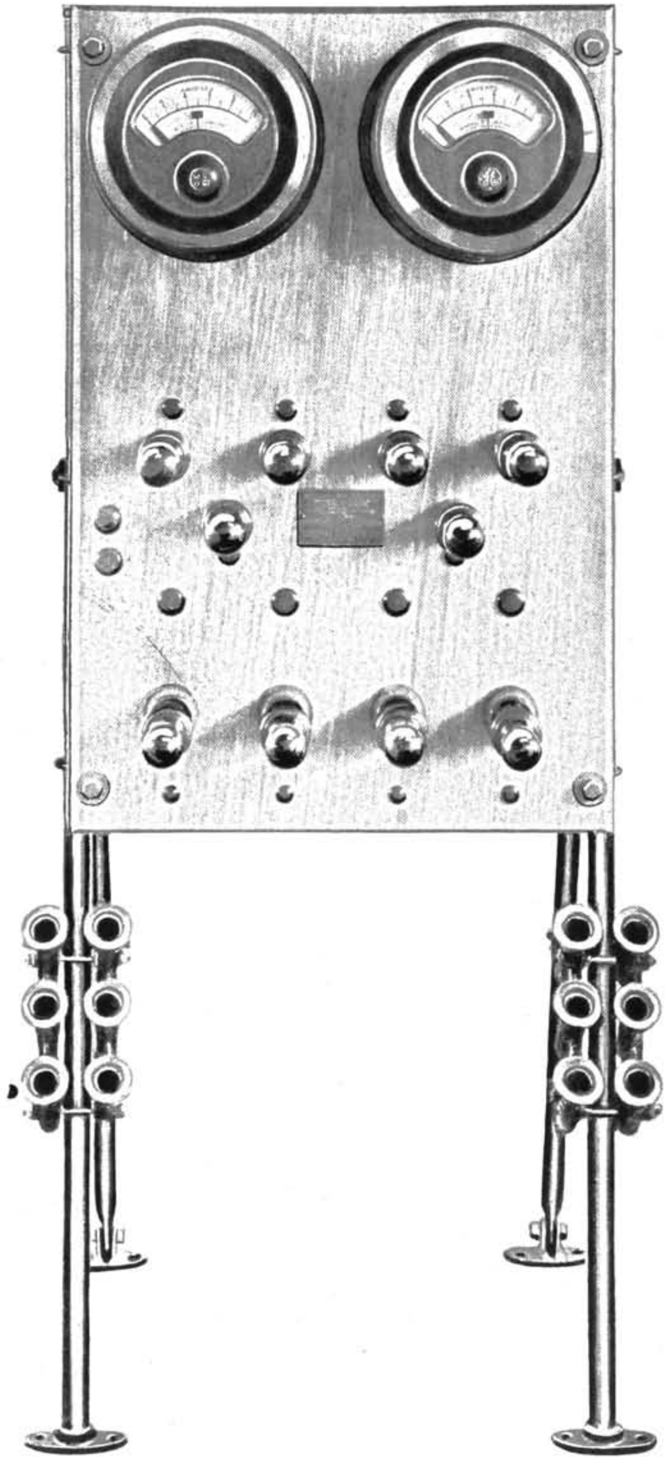
The primary winding is connected in series with the series arc or incandescent circuits so that under all conditions of load on the secondary the primary winding carries the full current of the arc circuit which is maintained at its normal value by a constant current transformer.

For satisfactory operation of the incandescent lamps it is desirable to obtain as near constant current as possible in the secondary winding. It is, of course, impossible to obtain such current regulations under abnormal conditions of load, but with the open circuit voltage on the secondary not exceeding 150 per cent. of the full load voltage and the current at 1, ¾ and ½ load not varying more than 2 per cent. the operation of the transformer and lamps on the secondary has been found to be satisfactory.

The drooping characteristic in the secondary voltage of the transformer is for the purpose of limiting the open circuit voltage on the secondary and has been obtained by so proportioning the magnetic circuit that the section is contracted in several parts to permit saturation of the iron with no current in the secondary.

Primary windings are designed for the usual arc currents, that is, 4, 5.5, 6.6 and 7.5 amperes. The ratio of transformation generally has been 1.1, but there is no difficulty in winding either primary or secondary for any reasonable current.

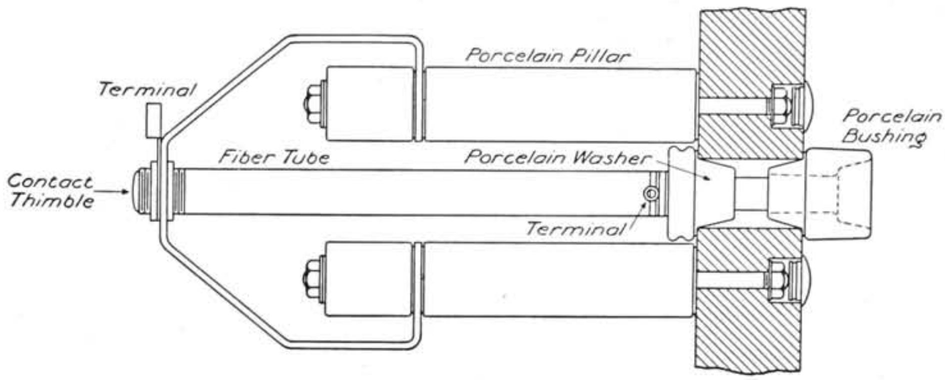
The core radiates its heat directly to the atmosphere through the edges of the exposed punchings.



PANEL FOR THE CONTROL OF TWO TRANSFORMERS WITH SINGLE CIRCUIT SECONDARIES

PANELS FOR SERIES INCANDESCENT CIRCUITS

For the control of General Electric series incandescent systems, small panels mounted on pipe supports for installations immediately in front of the transformer are generally used as they provide a compact, simple and inexpensive arrangement for transformer control. The high tension leads are somewhat shortened by the use of these panels since it is unnecessary to run them from the transformer to the main switchboard. The standard panels are made of polished blue Vermont marble $1\frac{1}{2}$ in. thick mounted on two pipe supports 64 in. long and are braced from the floor by pipes which are furnished with the panel. At the end of the pipe braces are pivoted flanges so they may be braced from the wall instead of the floor, if desired.



Primary Plug Switches

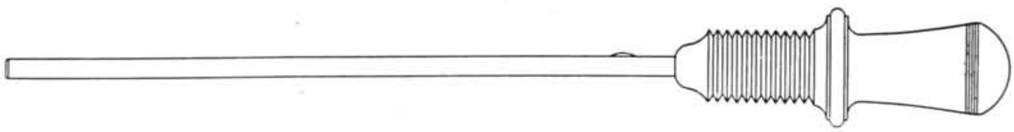
Each panel is equipped with two primary plug switches unless the primary voltage exceeds 2500 volts in which case a special panel equipped with oil switches must be furnished. These plug switches are capable of carrying 100 amperes continuously without undue heating. This type of switch when used on these isolated panels has the tube fuse clips attached.

Secondary Plug Switches

The duties of the plug tube switches in the secondary side of the transformer are somewhat different from those in the primary side, and while they are obliged to stand in some cases 8500 volts, the current carrying capacity is comparatively very small. For this reason they are made of brass and are well insulated from the panel, making it unnecessary to depend on the insulating qualities of the marble.

Secondary plug switches comprise OPEN CIRCUITING PLUG SWITCHES AND SHORT CIRCUITING PLUG SWITCHES.

Open circuiting plug switches are provided on all panels and are used to disconnect the line from the secondary of the transformer when testing for ground or open circuit. They also answer the purpose of disconnecting one of the circuits of a multi-circuit transformer for repair without interrupting the other circuit.

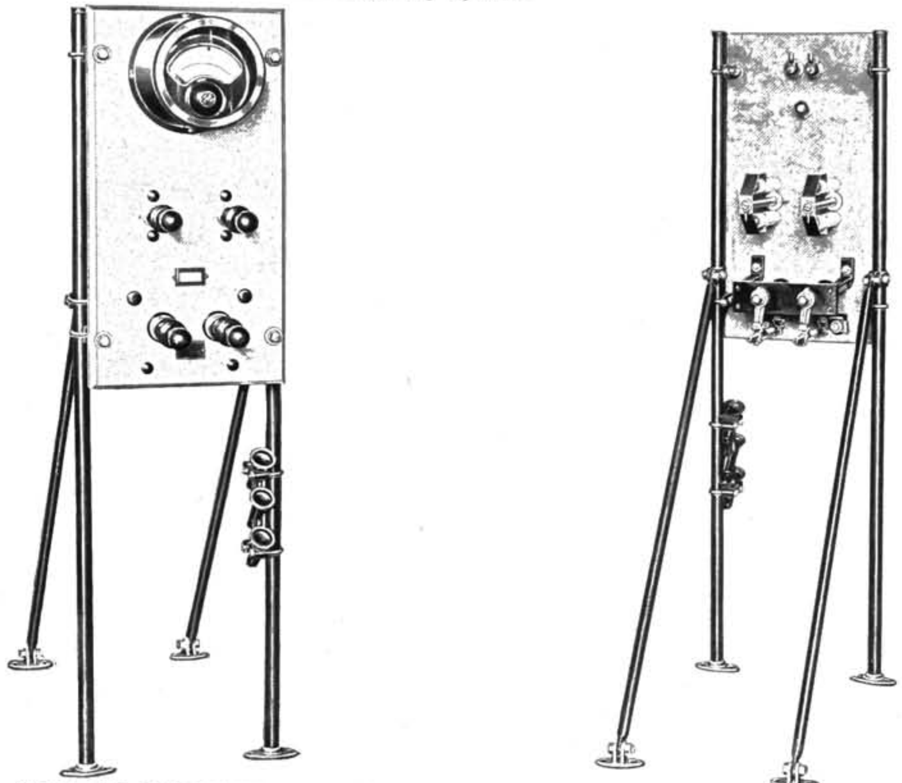


Short circuiting plug switches are only included in the equipment of multi-circuit transformer panels, and serve the purpose of connecting both secondary coils in series on one lamp circuit when desired.

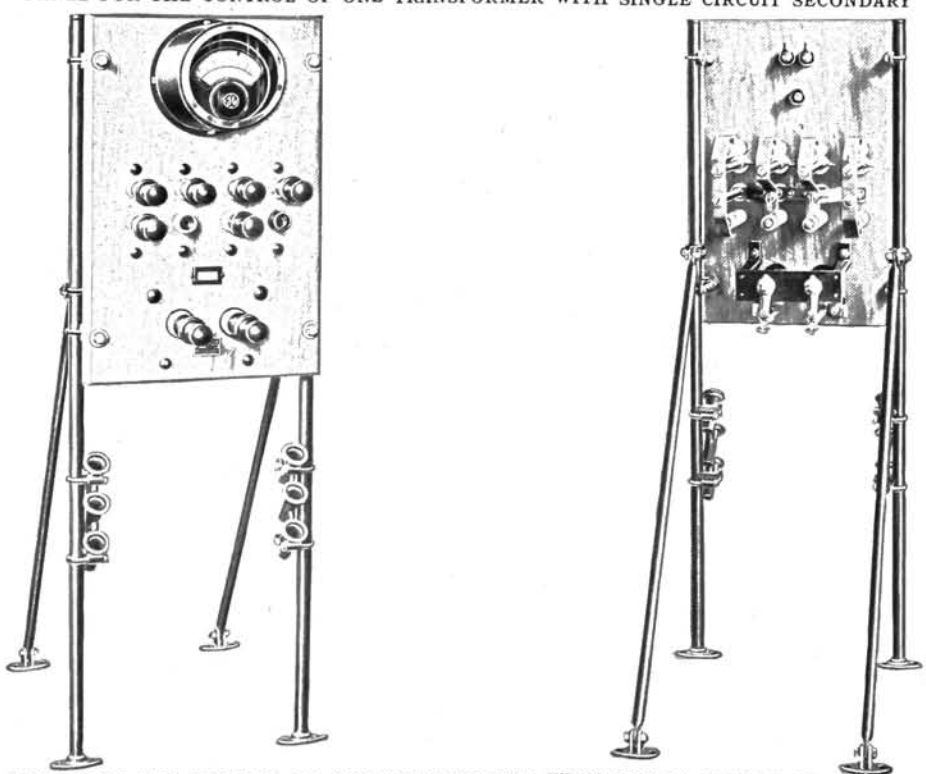
Fuses

All of the primaries of constant current transformers are provided with fuses to

4952–16 Series Incandescent Street Lighting System



PANEL FOR THE CONTROL OF ONE TRANSFORMER WITH SINGLE CIRCUIT SECONDARY



PANEL FOR THE CONTROL OF ONE TRANSFORMER WITH DOUBLE CIRCUIT SECONDARY protect the windings of the transformers. These fuses are made part of the primary switch and are mounted on the back of the panel. They are of the tube expulsion type and are very effective.

Plug Racks

Plug racks for the reception of plugs when not in use are provided with all panels. These racks are shown attached to the panels in the various illustrations. To cover special cases where more plugs are used, a plug stand as illustrated can be supplied.

Instruments

One Type R-2 round pattern ammeter is furnished for each transformer controlled and is permanently connected in the secondary circuit.

The Type R instruments are particularly adapted to this service as they are small, of neat appearance, accurate and substantial. They are practically dead beat, but will respond to a minute change in current value. Furthermore, they are free from frequency, wave form and heating errors, and are shielded from external magnetic influences as the entire electrical portions are completely surrounded by a laminated iron shield.

Five or ten ampere instruments are furnished depending upon the ampere capacity of the lamps, and in each case the ammeters

are provided with markers which may be set at the requisite current value. With the markers properly set any deviation of the current may be readily detected. It may be noted from the illustration that the scale is very open in the center, permitting the instruments to be read with great precision. When the voltage exceeds 2300 volts an insulating cover is provided for this ammeter.

RECORDING WATTHOUR METERS

The Thomson high torque induction meter IS-2 is standard for this class of panels. This meter is made back connected and is

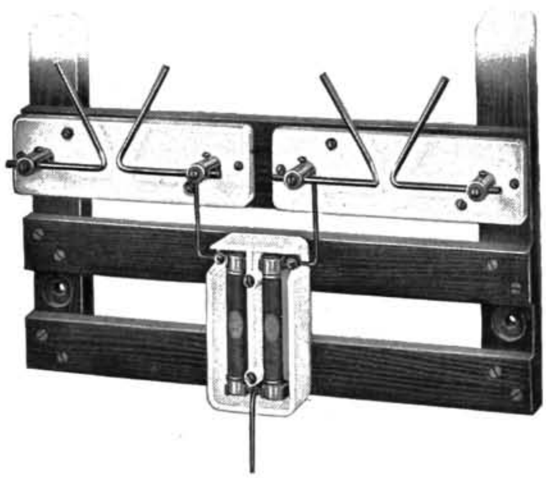
THOMSON HIGH TORQUE WATTHOUR METER

mounted on the front of the subbase. It is provided with a metal case, finished to correspond with other instruments on the panel. The Type IS-2 meter is designed with particular reference to switchboard requirements, and not only does it possess high initial accuracy under the most adverse conditions, but because of its high torque it will retain this accuracy over long periods of service.

Being small and compact, it adds to the appearance of the board. A full description of this meter is given in the bulletin on the Thomson high torque induction meter.

LIGHTNING ARRESTERS

The proper selection and installation of the lightning arrester equipment is an important feature of any series incandescent installation.



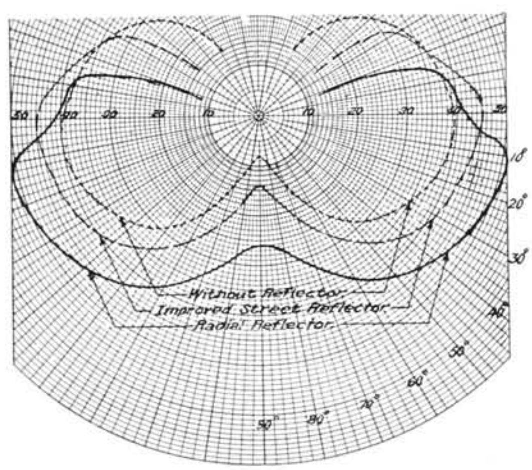
CAT. NO. 47563—1500 VOLTS

As many central stations suffer enormous losses each year resulting from lightning, we recommend for the protection of the series circuits our horn type arresters, with series resistances. Lighting circuits are usually confined to city limits, consequently the principal sources of trouble are not the high frequency disturbances but low frequency surges set up by sudden opening of the loaded circuits. These disturbances are specially severe when circuits are accidentally grounded due to contact of the wires where they pass through the tops of trees or become crossed with other circuits.

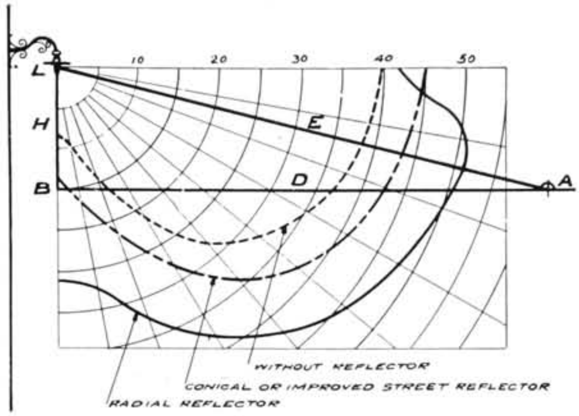
The horn type arrester is most satisfactory for this service as the surge set up by the sudden opening of the circuit is dissipated by the arrester before the arc is interrupted. The arc usually lasts for several cycles as the operation of the arrester depends upon the lengthening of the arc, limited by the series resistance. The resistance aids the horns in extinguishing the arc, limits the size of the arc and prevents short circuits occurring during the period of discharge.

It is recommended that these arresters be installed in the station on each outgoing line and that particular attention be given to connections, especially those to ground.

The most satisfactory method of making the ground connections is to drive a number of one inch iron pipes into the earth to a depth of six or eight feet at several points near the station, connecting all of these pipes together by means of copper wire or copper strips. A quantity of salt should be placed around each pipe on the surface and the ground thoroughly moistened with water.



If the lightning disturbances are of frequent occurrence it is advisable to occasionally examine the ground connections to see that they are in proper condition, as the failure of any lightning arrester is in many instances due to poor ground connections.



CALCULATION OF ILLUMINATION

The intensity of illumination furnished by a lamp to any point in the street is usually expressed in foot candles on a surface normal to the rays of light at that point. Otherwise expressed, assuming that there is a stone or other object at the point in question, the illumination is expressed in terms of foot candles, measuring the intensity received on the face of the object which is turned directly toward the light. If the candle-power of the lamp is known the illumination at any particular point can be calculated by the law of inverse squares, which is expressed in the following formula: $F = \frac{C}{E^2}$

Where F equals foot candles C equals candle-power in the direction of the point and E is the distance in a direct line from the lamp to the point.

In figuring the illumination for any such points it will be seen that there are two factors in the formula to be determined, namely, E^2 and C.

Candle-power varies for different angles of elevation, but can easily be read on the curves, if the angle of the ray directed toward the test point is known. This angle as well as the distance E can be determined either by calculation or by a graphical method.

The graphical method of determining the angle of elevation and direct distance from the lamp to the point in the street is illustrated in the accompanying figure. The photometric curve being superposed on a sketch drawn to the scale of one-eighth inch to the foot and showing the lamp twelve feet from the pavement.

To determine the illumination at any point such as A, 48 feet from the point B directly beneath the lamp, the line E is drawn from L to A.

Assuming that H is the equivalent of 12 feet and D the equivalent of 48 feet.

E is found to be 49½ feet.

We further find that the line E cuts through the photometric curves at 14 degrees below the horizontal and at this point the candle-power, as read from the curve, is 39 for the 40 candle-power lamp without reflector, 43 with conical reflector and 51 with radial reflector.

The illumination at A can then be calculated as follows:

No reflector $-F = \frac{39}{49.5^2} = \frac{39}{2450}$

$= 0.016$ foot candles.

Conical reflector $-F = \frac{43}{49.5^2} = \frac{43}{2450}$

$= 0.0176$ foot candles.

Radial reflector $-F = \frac{51}{49.5^2} = \frac{51}{2450}$

$= 0.208$ foot candles.

In a similar manner, illumination can be calculated for points nearer or farther from the lamp by simply indicating the point at its proportional distance along the ground line and measuring the line drawn from the lamp to the point. It can also be applied for different heights of lamps by drawing ground lines parallel to the one in the sketch and located above or below it so as to give H its proportional value. For the 60 and 80 candle-power lamps the illumination is practically proportional, and can be figured from the same curve.

GENERAL ELECTRIC COMPANY

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Bul. no. 4953

June 1912

POWER TRANSFORMERS

GENERAL ELECTRIC COMPANY

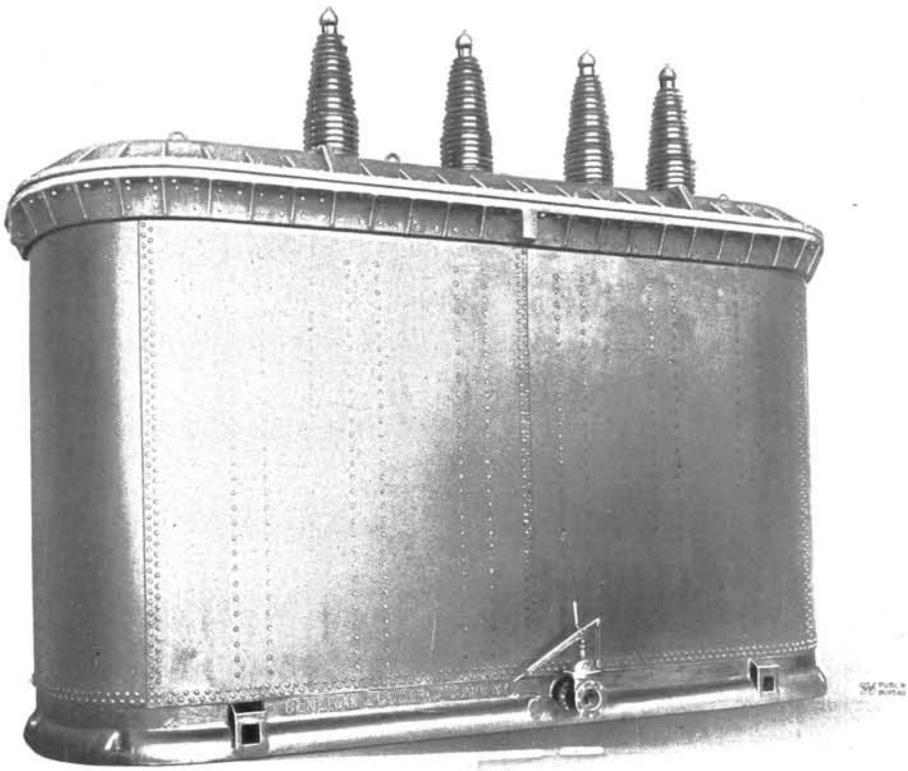
General Electric Company
Schenectady, N.Y.

June, 1912 | | **Bulletin No. 4953*

LARGE SHELL TYPE TRANSFORMERS

The developments in the field of electrical engineering which have rendered feasible the transmission of high potential currents over long distances, together with the reliability and efficiency of modern generating units, have resulted in notable economies in the generation and distribution of electric current. This has been accomplished largely by the use of distant water power or the centralization of the generating plants of a large territory in a single power station.

The transformer is one of the essential factors in effecting the economical distribution of electric energy. The object of this bulletin is to place before those interested some of the more important points regarding the relative merits of the different types of large transformers manufactured by the General Electric Co.



14,000 KV-A., 100,000 VOLT SHELL TYPE TRANSFORMER
This is the Largest Transformer Ever Built

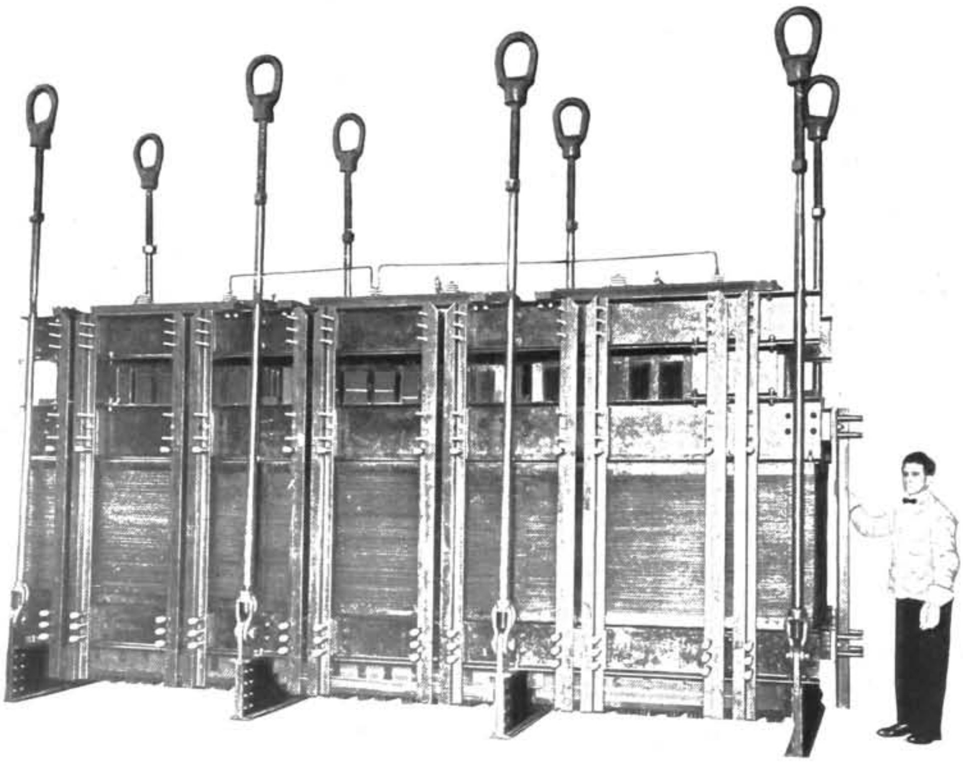
**Supersedes No. 4640*

The method of cooling used naturally divides such transformers into three classes, as follows: Oil-cooled (Type OC), water-cooled (Type WC) and air-blast (Type AB).

COOLING

In all transformers the first step in the dissipation of the heat generated by the losses is its conduction from the interior of the core and coils to the surface exposed to the cooling medium. In the oil-cooled types the next step in the process is the establishment of convection currents in the oil. The oil heated by contact with the exposed surfaces of the core and coils rises to the surface, flows outward and descends along the sides of the transformer case from the outer surface of which the heat is radiated into the air. In the water-cooled type the same general process takes place, with the exception that the bulk of the heat is carried away by water forced through a coil of pipe so placed that the heat is taken from the hottest oil at the top of the transformer. The circulation of the oil is completed after its descent along the sides of the case by again rising around the transformer core and windings and passing through ducts arranged for that purpose.

In the air-blast type, cooling is effected by a forced draft of air, which is directed through spaces provided between coils and in the core structure.



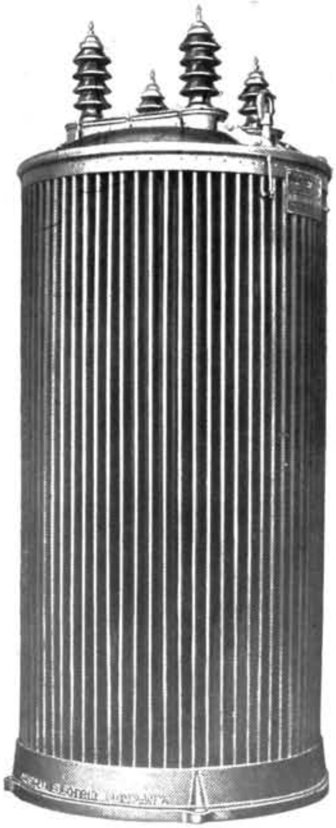
INTERIOR OF THREE-PHASE 14,000 KV-A. TRANSFORMER

A condensed description of each of the three types is given below:

Oil-Cooled

These transformers can be built for any voltage and almost any size, although the economical maximum limit in capacity is much lower than in water-cooled designs.

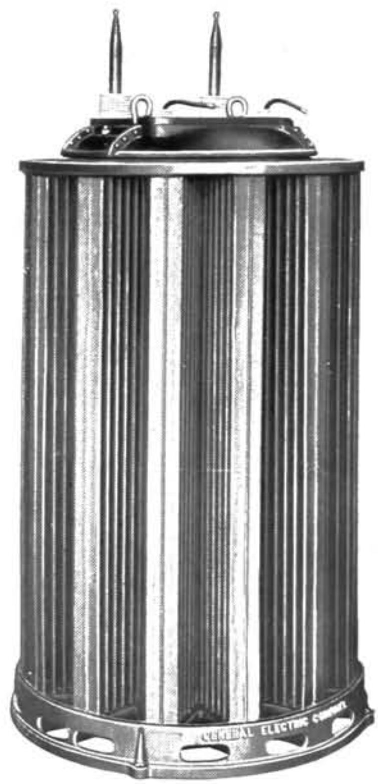
An idea of the limitations in this direction can be best obtained by making a rough comparison of two transformers of widely different capacities. Assume for the small unit a 100 kv-a. transformer and for the large unit a 3000 kv-a. transformer. If the same densities in copper and iron were used, or, in other words, if the large transformer had



OIL-COOLED TRANSFORMER SHOWING SIMPLE CORRUGATED TANK

losses proportional to the increase in output, the losses would be increased thirty times while the surface, or area, of radiation would only be increased about ten times. It would then be necessary in order to keep the heating within proper limits to considerably increase the size of transformer, resulting in a cost very much greater than that of a transformer having auxiliary means of cooling. For this reason oil-cooled transformers are in general not manufactured in sizes larger than 2000 kv-a.

Transformers of this type are placed in substantial fluted steel tanks, which are practically a one-piece structure, the base being cast directly to the formed body. The seams in the tank are made by a special process of welding which requires no flux. The tanks are, therefore, made oil-tight without the use of solder. In addition to the advantages in neatness, weight and construction, this tank has another advantage as compared with the cast iron tank, in that the sides of the tank are thin enough to allow a rapid conduction of the heat from the oil to the outside radiating surface.



OIL-COOLED TRANSFORMER SHOWING COMPOUND CORRUGATED TANK

For sizes up to about 500 kv-a. the tank is simple corrugated and above this size compound corrugations are used to obtain the necessary radiating surface. The general character of these tanks is clearly shown by the accompanying illustrations.

For very high voltages, where a great deal of height is required, a tank is used made of heavy boiler plate and provided with steel tubes to obtain the necessary radiating surface. These tubes are placed vertically around the outside of the body of the tank,

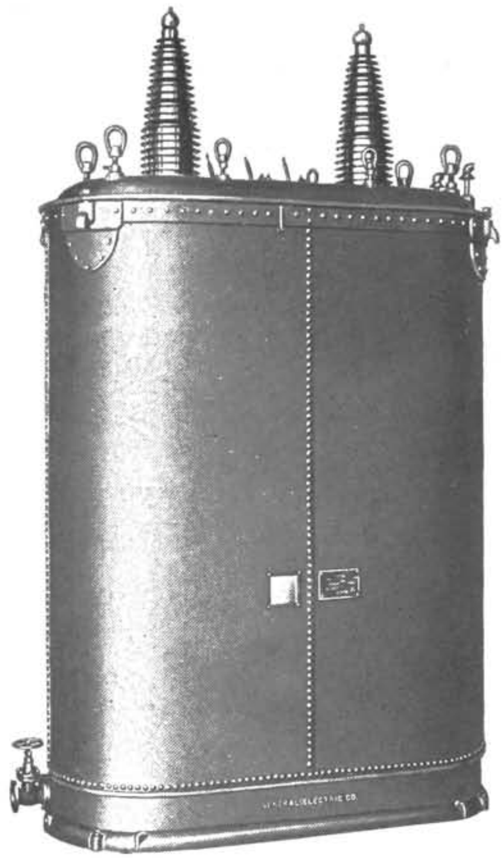
OIL-COOLED TRANSFORMER SHOWING ARRANGEMENT OF EXTERNAL STEEL TUBES

and are connected to it at top and bottom by welding.

Water-Cooled

The construction of water-cooled transformers is, in mechanical and electrical detail, entirely similar to the oil-cooled design, the only difference being in the tank. In water-cooled transformers the tank is built up of heavy boiler plate iron, riveted to a cast iron base. All joints in the tanks are absolutely oil-tight. The bottom of the tank is so made that the outlet pipe is at the lowest level, allowing the transformer to be thoroughly drained at any time. Hand holes are cast in each corner of the base to permit the use of jacks for raising or lowering the transformer when it is not convenient to use a crane.

In these transformers the heat generated by losses is disposed of by means of the circulation of water through coils of pipe placed in the hottest part of the oil. This arrangement is so effective that but very little heat is dissipated from the tank and



WATER-COOLED 3000 KV-A. 140,000 VOLT TRANSFORMER WITH OVAL TANK

there is, therefore, ordinarily no advantage in corrugations.

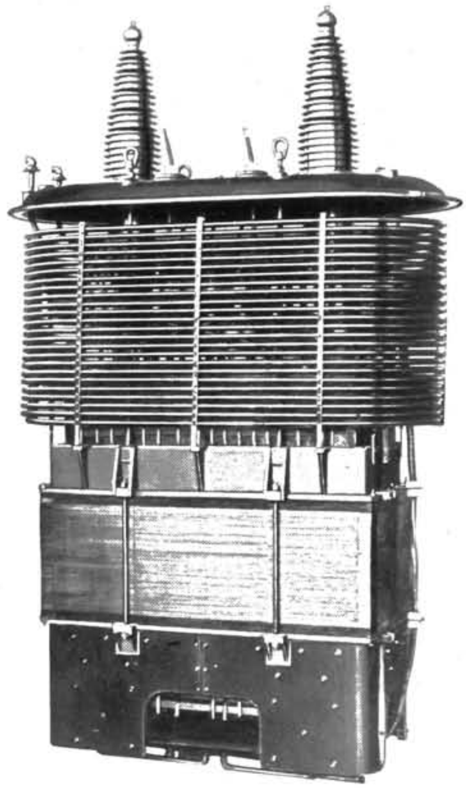
Under special circumstances, as in installations where a satisfactory supply of cooling water is not available at all periods, or, in cases where the meter rate of cooling water is excessive, a water-cooled design with corrugated tank is available. This arrangement provides approximately 70 per cent. of total capacity without cooling water and costs, in general, about 10 to 15 per cent. more than standard boiler iron tank design. This type has also been used to advantage in northern installations with heavy summer loads, where freezing difficulties have been completely eliminated, by draining the cooling coils during the winter low load period.

WATER-COOLED 3000 KV-A. 88,000 VOLT TRANSFORMER WITH ROUND TANK

Both Oil-cooled and Water-cooled transformers are so assembled that the complete core and coils, with the cover and leads, can be lifted from the tank as a unit. Eye bolts are provided for this purpose, and also for lifting the entire transformer filled with oil.

Some of the advantages of this type of construction are the following:

1. All terminals in this type are brought out through the cover, making it unnecessary to disturb them in any way when removing the transformer from its tank. In other



INTERIOR OF WATER-COOLED 140,000 VOLT TRANSFORMER SHOWING LOCATION OF COOLING COIL

types all leads must be either disconnected from the coils or terminal board, or else slipped through the bushings in the cover, which is liable to cause undue strain and injury to the windings, if proper care is not used.

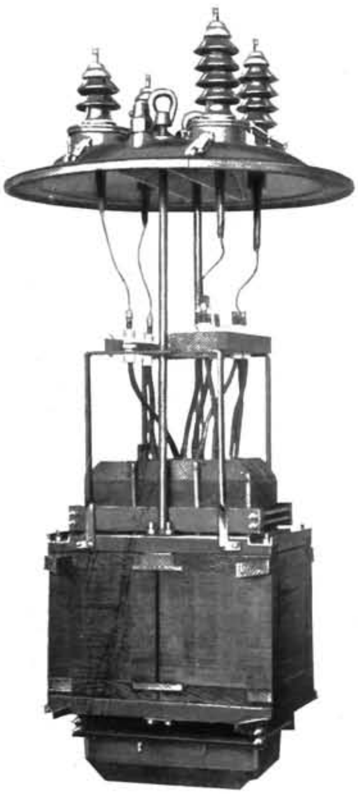
2. By aid of the openings in the cover, easy access may be had to the terminal board. Changes in connections can be made without drawing off any oil by merely raising the transformer a few feet out of the tank.

3. All connections may be rigidly locked in the proper position on the terminal board,

as this can be done while the transformer is out of the tank and in full view.

4. There are few bolts to loosen to remove the transformer from the tank.

5. This type of construction eliminates the need of lowering crane hooks, chains or ropes into the tank, thus avoiding breakage of the insulators, or injury to the insulation of coils. It is not necessary to remove any



INTERIOR OF OIL-COOLED 500 KV-A. 33,000 VOLT OUTDOOR TRANSFORMER SHOWING LIFTING ARRANGEMENT

oil as is generally the case in other types in order to locate hooks on the core clamps.

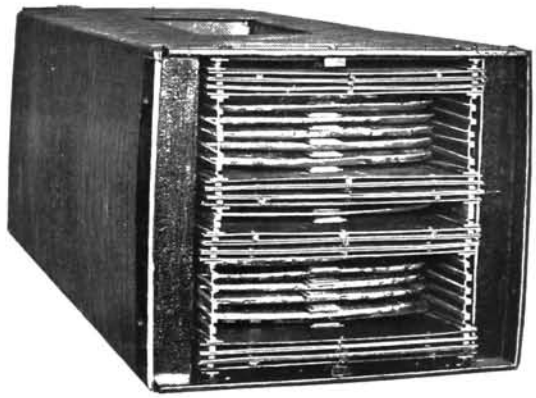
6. Minute inspection of any part of the transformer may readily be made with but a few minutes delay necessary in raising the transformer proper from the tank.

ELECTRICAL CONSTRUCTION

As in all General Electric transformers, most careful attention is paid to the details of electrical construction. The General Electric Company spends much time and money in the development of improvements in sheet steel, and the best material obtainable is used. As a result, these transformers have always been in the lead in this respect, as well as in others. Particular attention is paid to annealing and insulating the sheets and in assembling the cores. All joints are lapped, as this construction has proved greatly superior to butt joints, even when the latter have been most carefully made.

Coils

Only the highest grade of copper is used in coil making and the insulation is applied in



ASSEMBLED COILS OF WATER-COOLED 500 KV-A. 66,000 VOLT TRANSFORMER

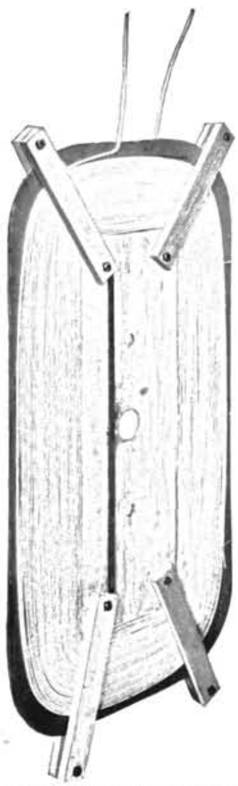
the General Electric Company's factory, thus giving the company a great advantage over other transformer manufacturers, as this practice insures the detection and elimination of defects, or bad spots in the wire itself, as well as in the cotton covering; such defects being very difficult to detect in the finished strip.

Insulation

The coils for shell type transformers are wound of flat copper strip with one turn per layer and are liberally insulated. Special insulating paper and mica are used between each turn.

After the coils are wound they are thoroughly baked to insure the complete elimination of moisture. Numerous treatments in carefully prepared insulating compounds are then applied, sealing up all interstices and cementing each coil into a solid structure. The coils are then subjected to further baking after which the proper number of tapings are applied, followed by the final series of treatments and bakings.

The insulating compounds used are made in the laboratories of the General Electric Company and are the results of exhaustive experiments covering a long period of years.



UNFINISHED SHELL TYPE COIL

In transformers for high voltages used for transmission work, the insulation of a considerable length of the conductor nearest the terminal leads is heavily reinforced. This practice, which is covered by patent, greatly increases the dielectric strength and acts as a safeguard against breakdowns which might otherwise occur, due to the excessive voltages and line surges inherent in transmission systems.

Taps

Placing taps in transformer coils always involves a complication of windings, especially if the taps are located at reinforced sections. In order to obviate this the taps are placed in the coils located in the central portions of the winding where potential strains are at a minimum. This is also an advantage to the customer as tap connections can be changed without disturbing the line leads.

Connection and Leads

The leads in water-cooled and oil-cooled transformers are brought out through porcelain bushings in the cover, suitable terminals being provided for connecting to the line. Where tap voltages are desired, all leads are

FINISHED SHELL TYPE COIL

brought up to a connection board, which is normally located under the oil. Usually only two high tension terminals are brought out, while sometimes four low tension terminals are supplied if a series multiple arrangement of coils is desired.

Filled Leads

For the primary terminals of all transformers for very high voltages the General Electric Company has adopted the use of sectional filled leads. As shown in the illustration, these are made up of a number of small annular sections, assembled with pressboard rings between them, which extend outward several inches from the lead proper, thus greatly increasing the leakage surface. A heavy metal rod, which serves as a terminal, passes through the center of the lead, binding tightly together the several sections and extending rings. The inside is divided into a number of sections by pressboard cylinders which are concentric with the lead.

An eye bolt is furnished with each bushing and is arranged to be screwed into the top of the terminal for convenience, when handling the leads. The completed lead is so designed as to be readily removed from the transformers, and for that reason is always shipped separately.

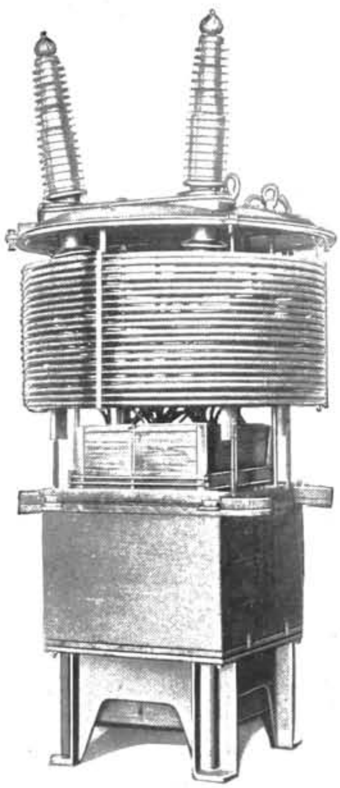
OIL-FILLED HIGH-TENSION LEAD, INDOOR TYPE

Shipment

Oil-cooled and water-cooled transformers are always shipped standing on their bases, and cannot be placed in a horizontal position. When necessary, transformers can be removed from the tanks and shipped separately boxed.

Cooling Coils

Cooling coils are generally made of extra heavy lap welded wrought iron pipe with electrically welded joints. These coils will withstand a hydraulic test of 1000 pounds per square inch.



INTERIOR OF WATER-COOLED 3000 KV-A. 88,000 VOLT TRANSFORMER

AIR-BLAST TRANSFORMER

There is practically no difference in the efficiency of coils made of iron, brass or copper. Either copper or brass pipe will generally not be guaranteed to test higher than 250 pounds per square inch, and in addition to this the joints are brazed.

In some rare cases the quality of water available for cooling purposes, may make it necessary to use either brass or copper pipe, in order to avoid corrosion which would prohibit the use of iron pipe.

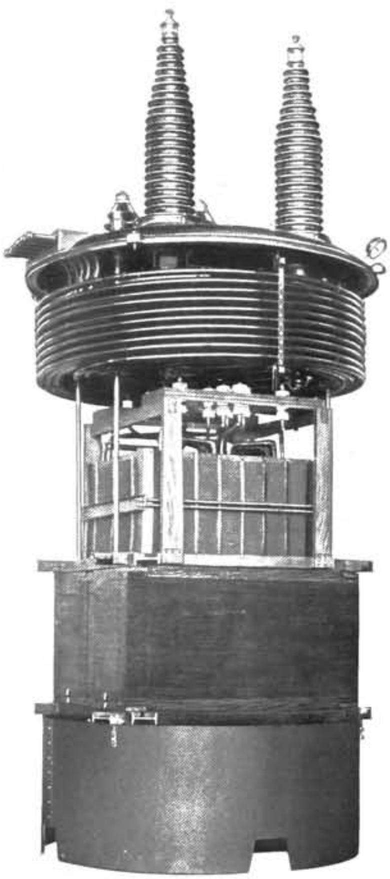
In new installations, it will be to customers' advantage to forward a one gallon sample of cooling water to the Pittsfield factory for careful chemical analysis.

OIL-FILLED PORCELAIN HIGH-TENSION LEAD OUTDOOR TYPE

AIR-BLAST TRANSFORMERS

As is indicated by the classification, this type transformer is cooled by forcing a current of air through ducts provided between the coils and between sectionalized portions of the core.

The base of the transformer is practically a cast iron shell, which is placed directly over the air chamber. The cold air is forced through the chamber by a motor-operated blower and then passes vertically through the coils and out through the top of the transformer. Part of the air is diverted horizontally through the ventilating ducts provided in the core and passes off at one side of the transformer. The amount of air going



INTERIOR OF WATER-COOLED 2750 KV-A. 100,000 VOLT TRANSFORMER FOR OUTDOOR SERVICE

AIR-BLAST SIX-PHASE 1100 KV-A. TRANSFORMER FOR USE WITH ROTARY CONVERTERS through the coils, or through the core, may be controlled independently by dampers which are placed in the passages.

The mechanical parts of these transformers are substantial and few in number. The cover is provided with lifting lugs, which afford an easy means of handling the transformer. The top and base castings are securely clamped together by heavy bolts and the sides of the casing are of heavy sheet metal with cast iron corner plates. The completed transformer has a very neat finish and appearance.

Blowers

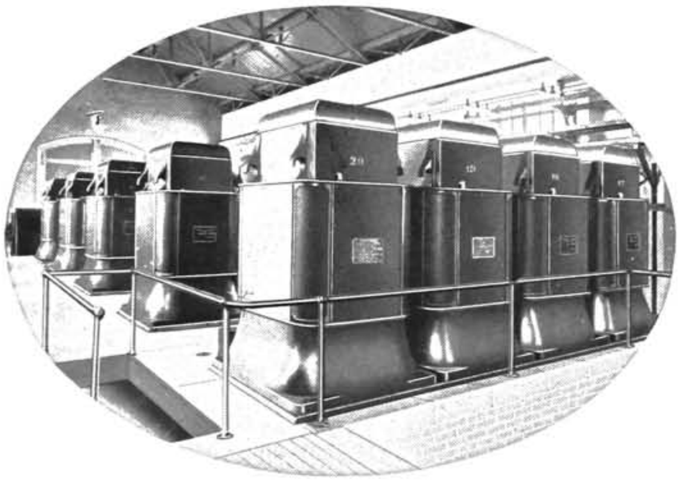
Air-blast transformers require a large volume of air at a comparatively low pressure. This varies from ½ to 1 ounce per square inch. The larger transformers require greater pressure to overcome the resistance of longer air-ducts. A table on page 15 gives the volume of air and the pressure necessary for a number of standard sizes of air-blast transformers, together with the size of blower and motors required in each case. From this table the volume of air required for any transformer can be approximated by allowing 150 cubic feet of air per minute for each kilowatt loss of the transformer. The necessary pressure is always stamped on the name plate of each transformer.

SINGLE-PHASE VS. THREE-PHASE TRANSFORMERS

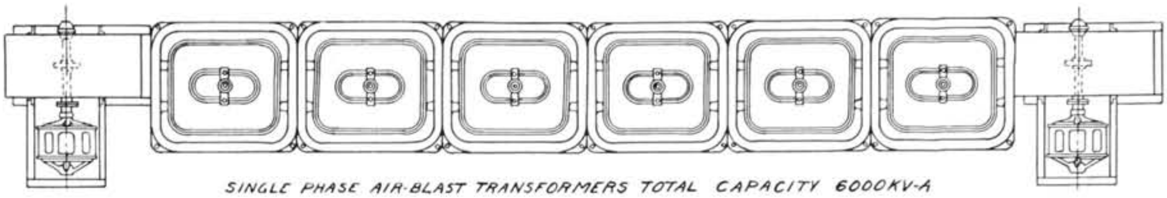
No specific rule can be given regarding the selection of single-phase or three-phase transformers since both designs are equally reliable; local conditions will generally determine which type is preferable. The following general remarks may, however, be helpful:

Single-phase transformers are preferable where only one transformer group is installed and where the expense of a spare transformer would not be warranted. In such installations the burnout of one phase of a three-phase unit would cause considerable inconvenience for the reason that the whole transformer would have to be disconnected from the circuit before repairs could be made. If single-phase transformers are used and connected in delta on both primary and secondary the damaged transformer can be cut out with a minimum amount of trouble and the other two transformers can be operated at normal temperature open delta at 58 per cent. of the normal capacity of the group of three transformers, until the third unit can be replaced.

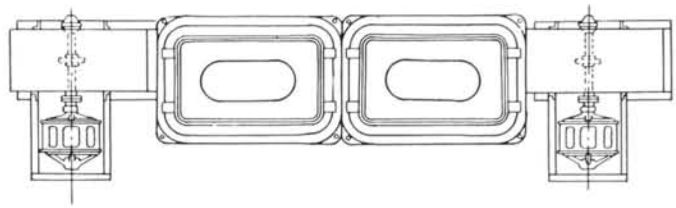
With a three-phase shell type transformer, if both the primary and secondary are delta connected, trouble in one phase will not



AIR-BLAST TRANSFORMER INSTALLATION



SINGLE PHASE AIR-BLAST TRANSFORMERS TOTAL CAPACITY 6000KV-A



THREE PHASE AIR-BLAST TRANSFORMERS TOTAL CAPACITY 6000 KV-A

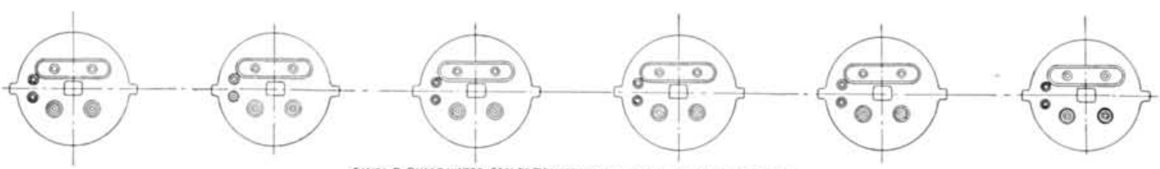
DIAGRAM SHOWING COMPARATIVE FLOOR SPACE REQUIRED FOR SINGLE-PHASE AND THREE-PHASE AIR-BLAST TRANSFORMERS

prevent the use of the other two phases in open delta. By short circuiting both primary and secondary of the defective phase, and cutting it out of circuit the magnetic flux in that section is entirely neutralized. This cannot be done, however, with any but delta connected shell type transformers.

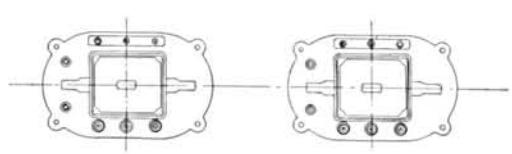
Where a large number of three-phase transformers can be used it is generally advisable to install three-phase units, the following advantages being in their favor compared with single-phase units:

1. Require less floor space than three single-phase units.
2. Weight less than three single-phase units.
3. Connections very much simplified, as only three primary and three secondary leads are generally brought out.
4. Transformer presents a symmetrical and compact appearance.

The construction of the three-phase transformer is practically similar to that of the single-phase, except that somewhat heavier and larger parts are required for the core structure.



SINGLE PHASE WATER-COOLED TRANSFORMERS TOTAL CAPACITY 6000 KV-A



THREE PHASE WATER-COOLED TRANSFORMERS TOTAL CAPACITY 6000KV-A

DIAGRAM SHOWING COMPARATIVE FLOOR SPACE REQUIRED FOR SINGLE-PHASE AND THREE-PHASE WATER-COOLED TRANSFORMERS

INFORMATION TO ASSIST CUSTOMER IN DETERMINING WHETHER AIR-BLAST, WATER-COOLED OR OIL-COOLED TRANSFORMERS WILL BE MORE SUITABLE FOR AN INSTALLATION

Type AB	Type WC	Type OC
	1. COST	
(*a*) *First Cost* Necessarily more expensive than the WC of similar rating.	Least expensive of all types.	Necessarily more expensive than the AB and WC of similar rating.
(*b*) The installation is extremely simple. Moisture that may have collected on the surfaces during transportation or storage should be thoroughly dried out.	Being heavier than Type AB, these transformers, as a rule, require heavier apparatus for installing. Both transformer and tank should be thoroughly dried out before being filled with oil. The oil is usually supplied in 50 gal. hermetically sealed steel barrels to minimize possibility of absorbing moisture during transportation.	Being heavier than Types AB and WC, these transformers require heavier apparatus for installing. Both transformer and tank should be thoroughly dried out before being filled with oil.
(*c*) *Auxiliary Apparatus* A duct, or chamber, of considerable size is required under the transformers in order to conduct the cooling air to them. A blower outfit for supplying air is required.	In most cases, cooling water may be obtained with sufficient natural head. However, there are frequent cases in which it can be obtained only by the use of pumps. A system of piping for the cooling water and oil drainage is required, the cost of which depends, of course, on the station layout.	Do not require cooling water or blower.
(*d*) *Maintenance* An occasional cleaning, for which a supply of compressed air at about 20 lb. pressure is recommended. The blower outfit requires no more care than any other similar apparatus.	A water pumping outfit would possibly require a trifle more attention than a blower outfit in which there are no valves or piping.	No air or water circulation to demand attention.
	2. FLOOR SPACE	
Always require space for cooling apparatus.	Extra space only required when auxiliary pumping apparatus is necessary.	Only require space for transformer as no extra apparatus is necessary.
	3. LOCATION	
As the transformers are open at the top they should not be located where there is much dust or dirt nor where water from any source is liable to fall on them. The blower should be so situated as to obtain clean dry air of a temperature not greater than 25 deg. C.	Transformers are completely enclosed but location should be such that no water will fall on leads or bushings. Location of auxiliary apparatus will depend on the station layout.	Transformers are completely enclosed but location should be such that no water will fall on leads or bushings. The building should be well ventilated. There is no auxiliary apparatus.

NOTE. No special foundations are necessary for any type of transformer other than a good, even floor, having sufficient strength to support the weight.

Type AB	Type WC	Type OC

4. GENERAL APPEARANCE

Type AB	Type WC	Type OC
Terminal leads may be located in the base and the air chamber may be used for conducting and distributing the connecting wiring. The absence of overhead wiring aids in simplifying the appearance of the station.	Leads are brought out of the top of the transformers. Water-cooling pipes are connected at the top in most cases.	Leads are brought out of the top of the transformers.

5. OPERATION

Equal reliability in all three types.

While full load efficiencies are practically equal in the three designs, it is necessary to change the proportion of iron and copper losses somewhat as the copper loss of the AB transformers is a smaller part of its total loss than of the WC and OC types. As a result, the regulation of the AB transformer is a trifle better.

6. GENERAL

The above information regarding selection of type is not applicable to air-blast transformers for circuits materially in excess of 33,000 volts.

On account of the great thickness of the solid insulation needed and the consequent difficulty in radiating heat from the copper, it is impracticable to design the AB type for more than this voltage. The oil immersed designs are therefore recommended for transformers above 33,000 volts.

Both oil-cooled and water-cooled types are available for all voltages, being restricted in this respect only by the limitations of transmission facilities.

Oil

A special grade of oil known as transil oil, which has been found by long experience to be best suited for the purpose, is furnished with all oil-insulated transformers. This is always shipped separately from the transformer and placed in sealed metal cans, barrels or tank cars in order to minimize the possibility of precipitating moisture in it. The oil will not absorb moisture from the atmosphere, even when directly exposed to it, but moisture may collect either in the interior portions of the tank not covered by oil, or on the upper surface of the oil if the tank is considerably below the temperature of the surrounding air. Such moisture may run into the oil and be held in suspension in sufficient quantities to impair its insulating qualities. No danger is apprehended from this cause in transformers in constant use as it is obvious that no condensation will occur where the temperature of the interior is kept above that of the surrounding air.

Transil oil furnished for General Electric transformers is always required to measure up to very rigid specifications. For high voltage transformers, the oil is specially treated to insure high breakdown strength.

Further description of oil and instructions as to the proper method of filling transformers can be found in Instruction Book dealing with the installation and operation of "High Voltage Transformers." All oil immersed transformers are provided with means for quickly emptying the tank of oil. On the larger sizes gate valves are furnished, while the smaller sizes are provided with hand-wheel operated globe valves, or service cocks.

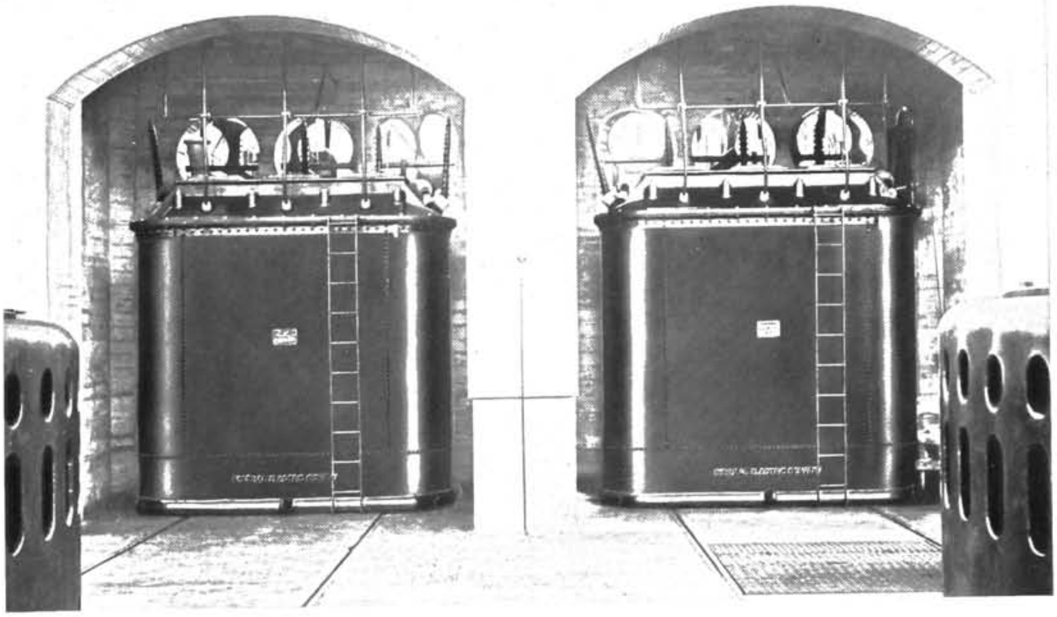
OUTDOOR SERVICE

Both water-cooled and oil-cooled transformers may be readily adapted to the conditions encountered in service out-of-doors. The types of tanks used are necessarily moisture proof and outdoor service requires simply the addition of gaskets between tank and cover together with special porcelain terminal leads.

The General Electric Company has furnished outdoor type oil-cooled, 1000 kv-a., units with high tension voltage of 110,000 and outdoor type, water-cooled, 2700 kv-a., units with 100,000 volts high tension.

VOLUME AND PRESSURE OF AIR REQUIRED FOR "AB" TRANSFORMERS

Total Trans. Kv-a.	Size Trans. Units Kv-a.	Cu. Ft. Air per Trans. per Min.	Cu. Ft. Air per Min. for All Trans.	Air Press. Ounces	Cu. Ft. Air Furnished by Std. Blower Set	Blower Set			H.P. Drive Full Volume and Pressure	Per Cent. of Total Output
						Frequency	Size Blow	Speed		
600	100	500	3000	½	3000	25 40 60	30 30 30	1500 1200 1200	2 1.5 1.5	0.25 0.19 0.19
1200	200	800	4800	⅝	6000	25 40 60	35 35 35	1500 1200 1200	5 4 5	0.31 0.25 0.31
1800	300	1100	6600	¾	8000	25 40 60	55 40 40	750 1200 1200	5 8 7.5	0.21 0.33 0.31
3000	500	1550	9300	⅞	10000	25 40 60	55 45 45	750 1200 1200	7.5 12 10	0.19 0.30 0.45
4500	750	2050	12300	1	14000	25 40 60	60 55 55	750 800 800	10 12 15	0.30 0.20 0.25
7500	1250	2850	17100	1	20000	25 40 60	70 70 60	750 800 900	20 20 20	0.20 0.20 0.20



INSTALLATION SHOWING TWO 7500 KV-A. FORCED-OIL TYPE TRANSFORMERS

GENERAL ELECTRIC COMPANY

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SUPPLY DEPARTMENT

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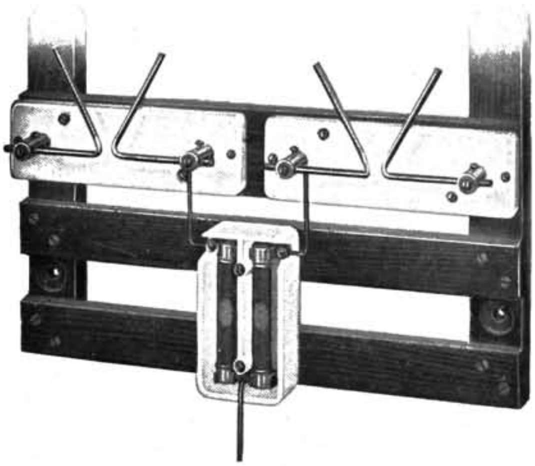
HORN TYPE LIGHTNING ARRESTERS FOR SERIES LIGHTING CIRCUITS

The necessity for continuity of service requires that series lighting systems be fully



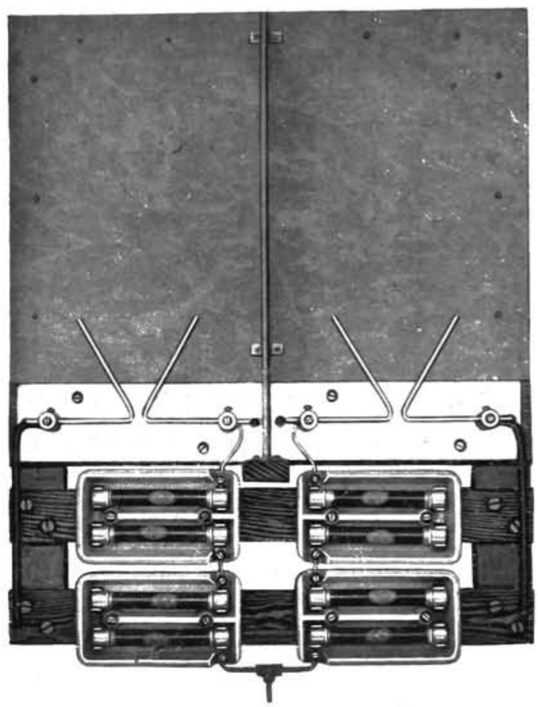
HORN LIGHTNING ARRESTER, MOUNTED FOR 15 LIGHT SERIES ARC CIRCUIT

equipped against damage by lightning and similar trouble.

The most common disturbances occurring on series circuits are the surges set up by the sudden opening of the loaded circuit. These disturbances are especially severe where circuits are accidentally grounded due to contact of the wires where they pass through the tops of trees or become crossed with other circuits. The horn type arrester recommended by the General Electric Company has been found very efficient in the protection of series transformers and rectifiers against this kind of disturbance.

The horn type of arrester consists of a horn gap with series resistance between each line and ground. The resistances and horn gaps are mounted on porcelain bases and the latter on insulating wooden supports. The supports of all arresters, except those for the lowest voltages, have asbestos barriers and backs to eliminate all liability of damage from the arc which forms in the horn gap at the time of discharge.

The spark gaps are adjusted to give a low spark potential relative to the voltage of the circuit. The number and ohmic value of the resistance rods used in the various arresters



HORN LIGHTNING ARRESTER FOR 50 LIGHT SERIES ARC CIRCUIT

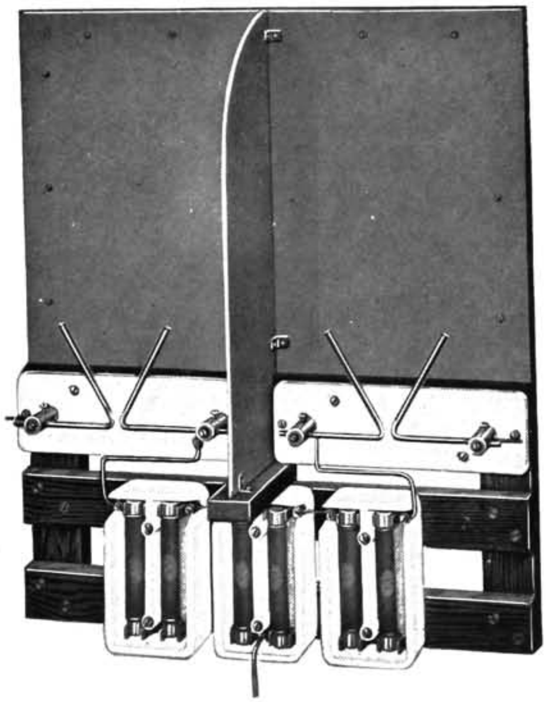
depend upon the voltage and current of the circuit. The resistance of the rods is unchanged with static dischargers and the rods have excellent heat dissipating qualities.

4954-2 Horn Type Lightning Arresters for Series Lighting Circuits

The horn type of arrester is particularly well suited to protect against the surges on series circuits, as the surges are damped out before the arc which forms across the horn gaps is interrupted.

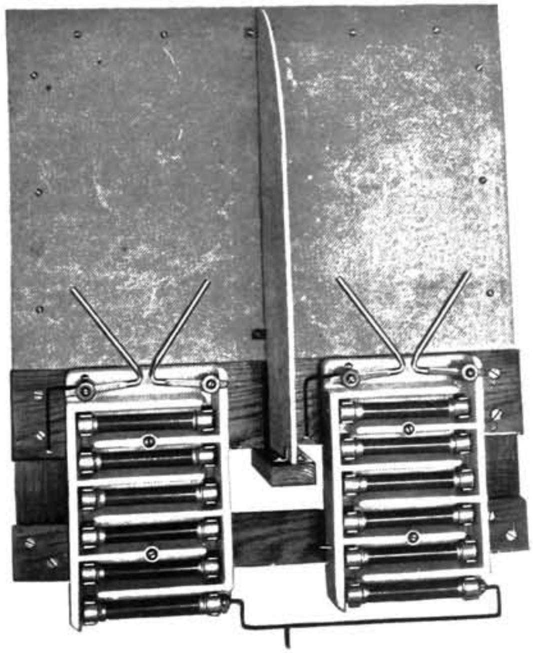
These arcs last for several cycles, since the length of the time of action of the arrester depends upon the lengthening of the arc between the horn gaps, limited by the series resistances.

Since practically all disturbances on lighting circuits are of low frequency, the series resistances can be used with good results. This resistance aids the horn in extinguishing the arc, limits the size of the arc and prevents short circuits from occurring during the period of discharge.



HORN LIGHTNING ARRESTER
FOR 35 LIGHT SERIES ARC CIRCUIT

The arrester is designed for mounting upon the wall of the station between the switchboard and line. If choke coils are used, lightning arresters should be connected between the lamp circuit and the choke coils. It is always advisable to connect the arresters to the line where it leaves the building, so as to completely isolate and protect the station apparatus from surges or disturbances.



HORN LIGHTNING ARRESTER
CAT. NO. 47561

PROTECTION OF CABLES

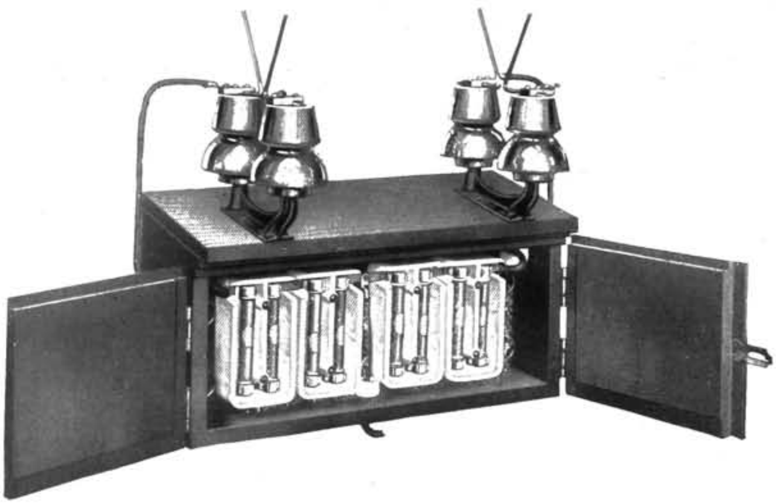
Quite frequently series circuits are run underground in cables for some distance from the generating station. In order to protect the cables it is advisable to place horn arresters at the points where the cable joins the overhead wires. These out-of-door arresters have the same essential parts as the station type of arrester previously described.

The resistance units are mounted in substantial wooden boxes on the roofs of which are placed the horn gaps. This design is used to economize space since if the horn gaps are placed in the boxes the latter would have to be made very large to accommodate the asbestos barriers and backs. In installing these arresters it is advisable to place them as near as possible to the top of the pole so that the arc may rise unobstructed and thus avoid the likelihood of live wires coming in contact with the horns which during the operation of the series current are alive.

GROUND CONNECTIONS

In all lightning arrester installations, the making of proper ground connections is of the utmost importance, as many lightning arrester troubles can be traced to bad grounds. It has been customary to ground a lightning arrester by means of a large metal plate buried in a bed of charcoal at a depth of six or eight feet in the earth.

A more satisfactory method of making a ground is to drive a number of 1-inch iron pipes six or eight feet into the earth surrounding the station, connecting all these pipes together by means of a copper wire or, preferably, by a thin copper strip. A quantity of salt should be placed around each pipe at the surface of the ground and the ground should be thoroughly moistened with water.



HORN ARRESTER FOR POLE INSTALLATION, CAT. No. 78259, BOX OPEN

It is advisable to connect these pipes to the iron framework of the station, and also to any water mains, metal flumes, or trolley rails which are available. For the usual-sized station the following recommendation is made: Place three pipes equally spaced near each outside wall, making twelve altogether, and place three extra pipes spaced about six feet apart at a point nearest the arrester.

HORN ARRESTER FOR POLE INSTALLATION
CAT. No. 78259, BOX CLOSED

Where plates are placed in streams of running water, they should be buried in the mud along the bank in preference to being laid in the stream. Streams with rocky bottoms are to be avoided.

Whenever plates are placed at any distance from the arrester, it is necessary also to drive a pipe into the earth directly beneath the arrester, thus making the ground connection as short as possible. Earth plates at a distance cannot be depended upon. Long ground wires in a station cannot be depended upon unless a lead is carried to the multiple grounding pipes installed as described above.

As it is advisable to examine the underground connections occasionally to see that they are in proper condition, it is well to keep on file exact plans of the location of ground plates, ground wire and pipes, with a brief description, so that the data can be readily referred to.

From time to time the resistance of these ground connections should be measured to determine their condition. The resistance of a single pipe ground in good condition has an average value of about 15 ohms. A simple and satisfactory method of keeping account of the condition of the earth connections is to divide the grounding pipes into two groups and connect each group to the 110 volt lighting circuit with an ammeter in series.

For grounding pole arresters, one or two 1 in. or 1¼ in. iron pipes should be driven into the ground at the base of the pole and connected to the arrester by means of a copper wire not less than No. 2. The ground wire should be protected for some distance up the pole to prevent its being injured. The pipes should be driven far enough from the pole so that movement of the pole will not loosen them.

LIGHTNING ARRESTERS FOR SERIES LIGHTING CIRCUITS
HORN TYPE LIGHTNING ARRESTERS

FOR ALTERNATING CURRENT SERIES ARC CIRCUITS

Lights	FOR STATION (INDOOR) USE Double-Pole Cat. No.	FOR POLE (OUTDOOR) USE Single-Pole Cat. No.	FOR POLE (OUTDOOR) USE Double-Pole Cat. No.
15	47563	78253	78252
25	47558	78253	78254
35	47559	78256	78255
50	47560	78260	78259
75	47561	78263	78261
100, single-circuit	78744	78263	78261
*100, multi-circuit	* 78743	78260	78259

* Two double-pole or four single-pole arresters required.

FOR SERIES RECTIFIER ARC CIRCUITS

Lights Rating of Rectifier Set	FOR STATION (INDOOR) USE Double-Pole Cat. No.	FOR POLE (OUTDOOR) USE Single-Pole Cat. No.	FOR POLE (OUTDOOR) USE Double-Pole Cat. No.
12	58959	79121	78251
25	79120	79121	79122
50	78766	78283	78282
75	78730	78264	78262
100	78730	78264	78262
* 100	* 78766	78283	78282

* Multi- or double-circuit, two double-pole or four single-pole arresters required.

FOR ALTERNATING CURRENT SERIES INCANDESCENT CIRCUITS

Kw. Output of Trans-former	Secondary Amperes	FOR STATION (INDOOR) USE Double-Pole Cat. No.	FOR POLE (OUTDOOR) USE Single-Pole Cat. No.	FOR POLE (OUTDOOR) USE Double-Pole Cat. No.
3	4.0	47563	78253	78252
3	5.5	47563	78253	78252
3	6.6	47563	78253	78252
3	7.5	47563	78253	78252
5	4.0	47563	78253	78252
5	5.5	47563	78253	78252
5	6.6	47563	78253	78252
5	7.5	47563	78253	78252
10	4.0	47558	78253	78254
10	5.5	47558	78253	78254
10	6.6	47563	78253	78252
10	7.5	47563	78253	78252
15	4.0	47560	78256	78259
15	5.5	47559	78256	78255
15	6.6	47558	78253	78254
15	7.5	47558	78253	78254
* 20	4.0	* 47558	78253	78254
* 20	5.5	* 47558	78253	78254
* 20	6.6	* 47563	78253	78252
* 20	7.5	* 47563	78253	78252
* 25	4.0	* 78743	78260	78259
* 25	5.5	* 47558	78253	78254
* 25	6.6	* 47558	78253	78254
* 25	7.5	* 47558	78253	78254

* Multi-circuit transformers—two double-pole or four single-pole arresters required.

FOR BRUSH ARC CIRCUITS

Single Circuit Voltage Rating of Machine	FOR STATION (INDOOR) USE Double-Pole Cat. No.	FOR POLE (OUTDOOR) USE Single-Pole Cat. No.	FOR POLE (OUTDOOR) USE Double-Pole Cat. No.
SINGLE CIRCUIT—One Double-Pole or Two Single-Pole Arresters Required			
3500	58960	78258	78257
4000– 5000	78766	78283	78282
6000– 6500	78730	78264	78262
8000– 8500	78730	78264	78262
9000–11000	78730	78264	78262
11250–15000	78730	78264	78262
TWO CIRCUITS—Two Double-Pole or Four Single-Pole Arresters Required			
3500	79120	79121	79122
4000– 5000	58960	78258	78257
6000– 6500	58960	78258	78257
8000– 8500	78767	78283	78282
9000–11000	78767	78283	78282
11250–15000	78730	78264	78262
THREE CIRCUITS—Three Double-Pole or Six Single-Pole Arresters Required			
3500	58959	79121	78251
4000– 5000	79120	79121	79122
6000– 6500	58960	78258	78257
8000– 8500	78767	78283	78282
9000–11000	78767	78283	78282
11250–15000	78767	78283	78282
FOUR CIRCUITS—Four Double-Pole or Eight Single-Pole Arresters Required			
3500	58959	79121	78251
4000– 5000	58959	79121	78251
6000– 6500	58960	78258	78257
8000– 8500	58960	78283	78282
9000–11000	78767	78283	78282
11250–15000	78767	78283	78282

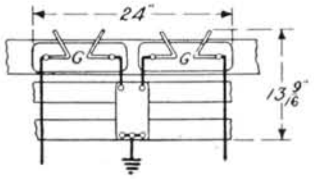
For shipping weights and dimensions, see page 6.

LIGHTNING ARRESTERS FOR SERIES LIGHTING CIRCUITS

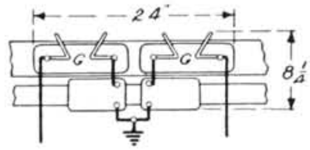
SHIPPING WEIGHTS AND DIMENSIONS OF HORN ARRESTERS

Cat. No.	Approx. Ship. Wt. in Lb.	Dimensions Fig. No.	Cat. No.	Approx. Ship. Wt. in Lb.	Dimensions Fig. No.
47558	35	2	78259	130	15
47559	100	3	78260	80	13
47560	150	4	78261	145	15
47561	130	5	78262	145	15
47563	30	1	78263	110	13
58959	30	8	78264	110	13
58960	100	9	78282	150	15
78251	80	16	78283	80	13
78252	80	16	78730	180	12
78253	50	14	78743	170	6
78254	90	16	78744	180	7
78255	110	15	78766	135	11
78256	70	13	78767	170	10
78257	110	15	79120	50	2
78258	70	13	79121	50	14
			79122	90	16

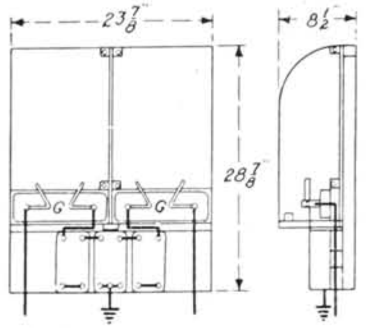
DIMENSIONS OF HORN ARRESTERS FOR SERIES LIGHTING CIRCUITS



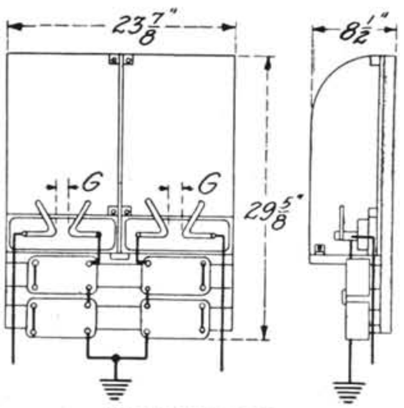
1500 VOLTS
CAT. NO. 47563, G = 1/8 IN.
Fig. 1



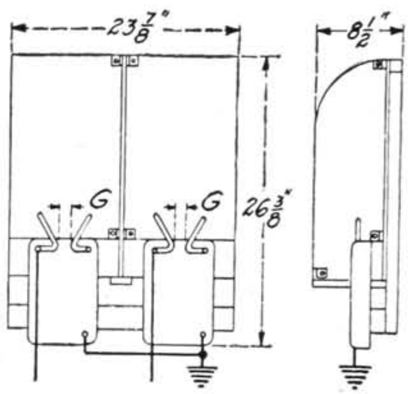
2300 VOLTS
CAT. NO. 47558, G = 1/8 IN.
CAT. NO. 79120, G = 1/8 IN.
Fig. 2



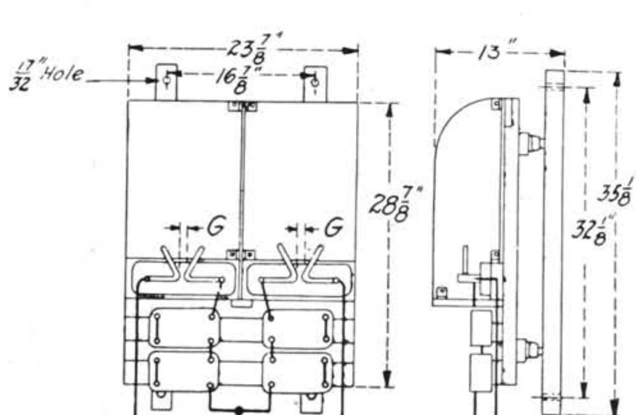
3200 VOLTS, CAT. NO. 47559, G = 3/16 IN
Fig. 3



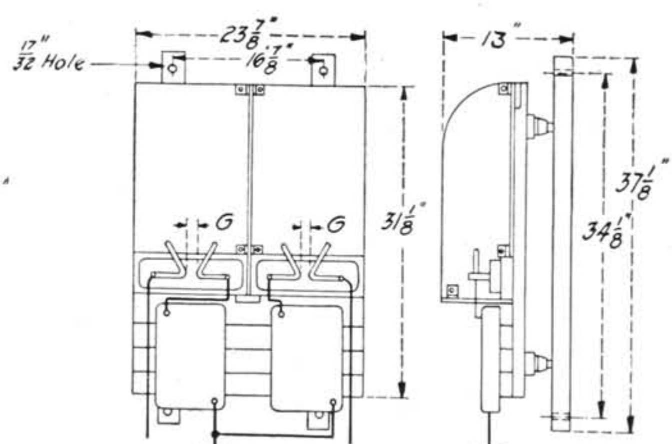
SINGLE CIRCUIT
4600 VOLTS, CAT. NO. 47560, G = 1/4 IN.
Fig. 4



6900 VOLTS, CAT. NO. 47561, G = 3/8 IN.
Fig. 5

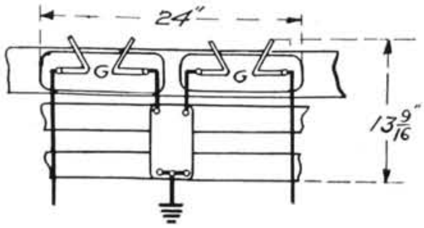


MULTI-CIRCUIT
4600 VOLTS, CAT. NO. 78743, G = 1/4 IN.
Fig. 6

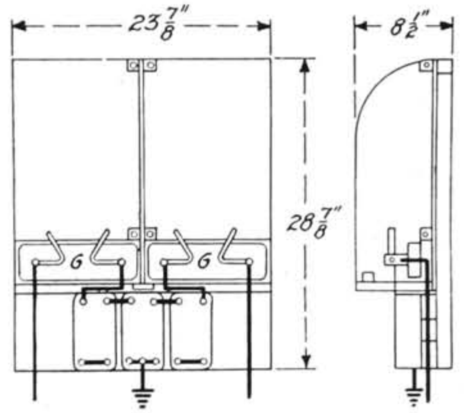


9200 VOLTS, CAT. NO. 78744, G = 1/2 IN.
Fig. 7

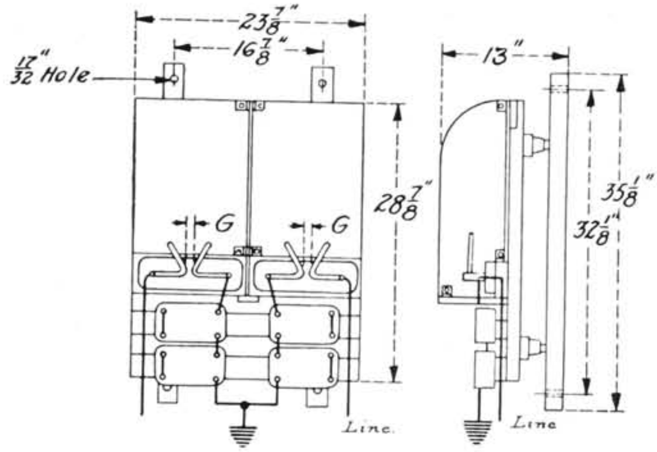
DIMENSIONS OF HORN ARRESTERS FOR SERIES LIGHTING CIRCUITS



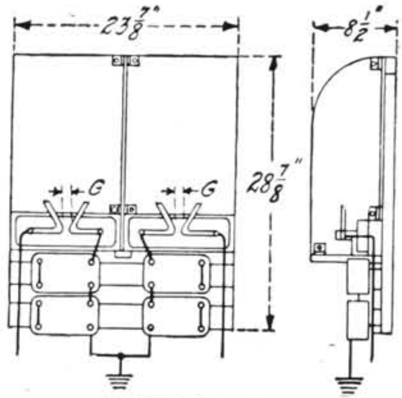
1100 VOLTS, CAT. NO. 58959, G = 1/8 IN.
Fig. 8



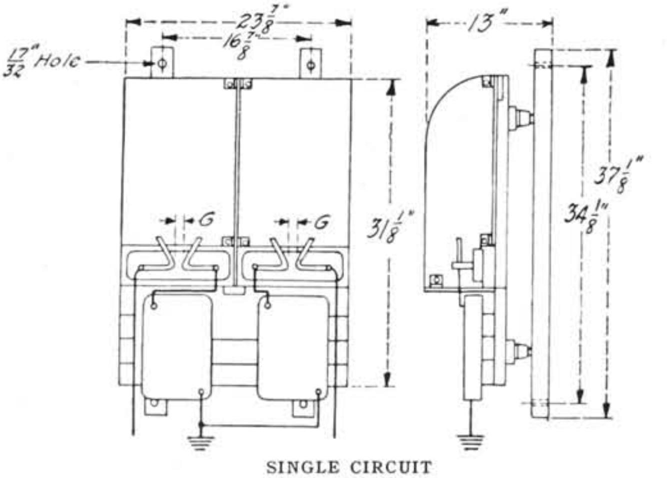
3200 VOLTS, CAT. NO. 58960, G = 3/16 IN.
Fig. 9



MULTI-CIRCUIT
4600 VOLTS, CAT. NO. 78767, G = 1/4 IN.
Fig. 10



SINGLE CIRCUIT
4600 VOLTS, CAT. NO. 78766, G = 1/4 IN.
Fig. 11



SINGLE CIRCUIT
9200 VOLTS, CAT. NO. 78730, G = 1/2 IN.
6900 VOLTS, CAT. NO. 78730, G = 3/8 IN.
Fig. 12

DIMENSIONS OF HORN ARRESTERS WITH SERIES RESISTANCE FOR CONSTANT CURRENT CIRCUITS ARRANGED FOR OUT-DOOR SERVICE

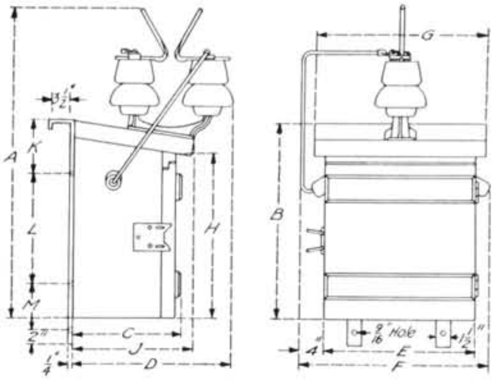


Fig. 13

SINGLE-POLE FOR ALTERNATING CURRENT ARC AND INCANDESCENT CIRCUITS														
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J	K	L	M
78256	3200	$\frac{3}{16}$	$24\frac{1}{4}$	14	$7\frac{1}{8}$	$12\frac{7}{8}$	$14\frac{3}{4}$	$19\frac{3}{8}$	$15\frac{3}{8}$	$10\frac{3}{4}$	$7\frac{3}{8}$	$6\frac{3}{4}$	$7\frac{1}{4}$	4
78260	4600	$\frac{1}{4}$	$24\frac{1}{2}$	$14\frac{1}{8}$	10	$13\frac{7}{8}$	$15\frac{3}{8}$	$20\frac{3}{8}$	$16\frac{3}{8}$	$10\frac{7}{16}$	$10\frac{1}{2}$	$6\frac{3}{4}$	$7\frac{1}{4}$	4
78263	9200	$\frac{1}{2}$	$27\frac{5}{8}$	19	$9\frac{5}{8}$	$12\frac{7}{8}$	$14\frac{7}{8}$	$19\frac{7}{8}$	$15\frac{7}{8}$	$14\frac{13}{16}$	$9\frac{1}{2}$	8	9	$4\frac{1}{2}$

SINGLE-POLE FOR RECTIFIER AND BRUSH ARC CIRCUITS														
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J	K	L	M
78258	3200	$\frac{3}{16}$	$27\frac{1}{4}$	14	$7\frac{1}{8}$	$10\frac{7}{8}$	$14\frac{3}{4}$	$19\frac{3}{8}$	$15\frac{3}{8}$	$10\frac{3}{4}$	$7\frac{3}{8}$	$6\frac{3}{4}$	$7\frac{1}{4}$	4
78264	9200	$\frac{1}{2}$	$27\frac{5}{8}$	19	$9\frac{5}{8}$	$12\frac{7}{8}$	$14\frac{7}{8}$	$19\frac{7}{8}$	$15\frac{7}{8}$	$14\frac{13}{16}$	$9\frac{1}{2}$	8	9	$4\frac{1}{2}$
78283	4600	$\frac{1}{4}$	$24\frac{1}{2}$	$14\frac{1}{8}$	10	$13\frac{7}{8}$	$15\frac{3}{8}$	$20\frac{3}{8}$	$16\frac{3}{8}$	$10\frac{7}{16}$	$10\frac{1}{2}$	$6\frac{3}{4}$	$7\frac{1}{4}$	4

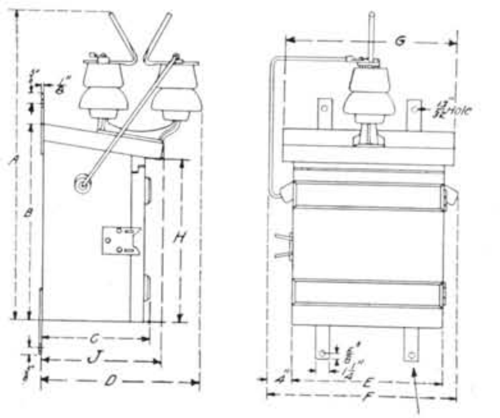


Fig 14.

SINGLE-POLE FOR ALTERNATING CURRENT ARC AND INCANDESCENT CIRCUITS												
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J
78253	2500	$\frac{1}{8}$	$24\frac{1}{4}$	14	$7\frac{1}{8}$	$10\frac{7}{8}$	$9\frac{3}{4}$	$14\frac{3}{4}$	$10\frac{3}{4}$	$10\frac{3}{8}$	$7\frac{3}{8}$

SINGLE-POLE FOR RECTIFIER AND BRUSH ARC CIRCUITS												
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J
79121	2500	$\frac{1}{8}$	$24\frac{1}{4}$	14	$7\frac{1}{8}$	$10\frac{7}{8}$	$9\frac{3}{4}$	$14\frac{3}{4}$	$10\frac{3}{4}$	$10\frac{3}{8}$	$7\frac{3}{8}$

4954–10 Horn Type Lightning Arresters for Series Lighting Circuits

DIMENSIONS OF HORN ARRESTERS WITH SERIES RESISTANCE FOR CONSTANT CURRENT CIRCUITS ARRANGED FOR OUT-DOOR SERVICE

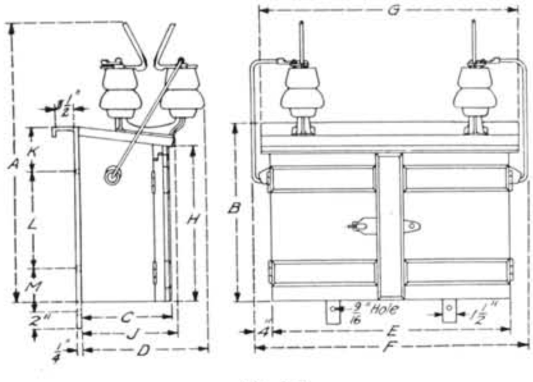


Fig. 15

DOUBLE-POLE FOR ALTERNATING CURRENT ARC AND INCANDESCENT CIRCUITS															
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J	K	L	M
78255	3200	3/16	24¼	14	7⅛	10¼	19	27	20	10⅞	7⅜	6¾	7¼	4
78259	4600	¼	24½	14⅞	10	13¾	24⅜	32⅜	25⅜	10 7/16	10½	6¾	7¼	4
78261	9200	½	27¾	19	9⅛	12⅞	25	33	26	14 13/16	9½	8	9	4½

DOUBLE-POLE FOR RECTIFIER AND BRUSH ARC CIRCUITS															
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J	K	L	M
78257	3200	3/16	24¼	14	7⅛	10¼	19	27	20	10⅞	7⅜	6¾	7¼	4
78262	9200	½	27¾	19	9⅛	12⅞	25	33	26	14 13/16	9½	8	9	4½
78282	4600	¼	24½	14⅞	10	13¾	24⅜	32⅜	25⅜	10 7/16	10½	6¾	7¼	4

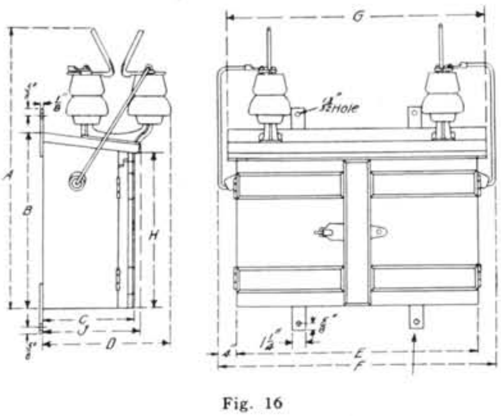
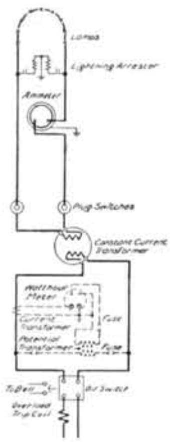


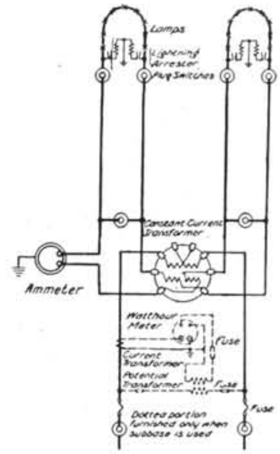
Fig. 16

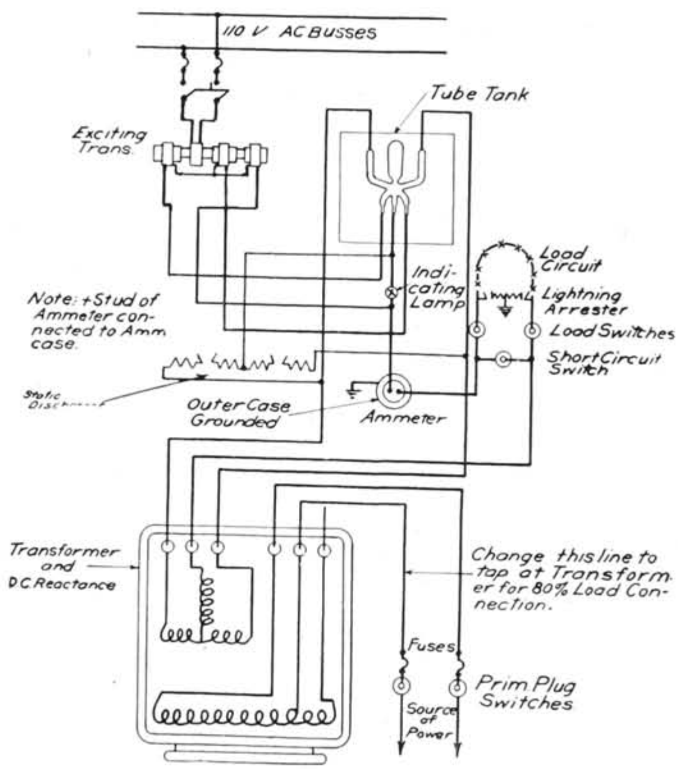
DOUBLE-POLE FOR ALTERNATING CURRENT ARC AND INCANDESCENT CIRCUITS												
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J
78252	1500	⅛	24¼	14	7⅛	10¼	9¾	17¾	14	10⅜	7⅜
78254	2500	⅛	24¼	14	7⅛	10¼	14⅜	22⅜	15⅜	10⅜	7⅜

DOUBLE-POLE FOR RECTIFIER AND BRUSH ARC CIRCUITS												
Cat. No.	Volts	Gap Setting	A	B	C	D	E	F	G	H	J
78251	1500	⅛	24¼	14	7⅛	10¼	9¾	17¾	14	10⅜	7⅜
79122	2500	⅛	24¼	14	7⅛	10¼	14⅜	22⅜	15⅜	10⅜	7⅜

CONNECTIONS OF HORN TYPE LIGHTNING ARRESTERS ON SERIES CIRCUITS







GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES
(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E. C., England, 83 Cannon St.

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

ORNAMENTAL LUMINOUS ARC·LAMPS

GENERAL·ELECTRIC·COMPANY

ORNAMENTAL LUMINOUS ARC·LAMPS

ORNAMENTAL POLE
NEW HAVEN TYPE

General Electric Company
Schenectady, N. Y.

Bulletin No. 4955

June, 1912

HLP

NIGHT VIEW OF CHURCH STREET, NEW HAVEN, CONN., ILLUMINATED WITH GENERAL ELECTRIC ORNAMENTAL LUMINOUS ARC LAMPS

IN all sections of this continent the people are awakening to the advantages of proper street illumination. Central stations, business men's associations, publicity clubs and the citizens at large are uniting in a common effort to boost their "home town" by the proper lighting of the streets.

This activity is not due to abstract theory, but is the result of the proven fact that good street lighting is as essential to the welfare of a municipality as are good roads, and the results are measured in direct financial returns. Real estate owners find that *proper street illumination causes property values to advance*, business men note increased activity in trade and the community finds that as a "city booster" it is the most effective way to advertise the progressiveness and public spirit of the municipality.

Referring to street illumination and its relation to police protection, one of the greatest authorities on criminology that this country has produced says that he would rather have plenty of electric lights and clean streets than all the law and order societies in existence.

Illumination of the streets at night was formerly considered the only function of lighting units, but, in this twentieth century spirit of progressiveness and economic management the tendency is to make the lighting units so attractive that they add to the appearance of a municipality by day as well as by night.

In keeping with these demands, the General Electric Company has recently placed on the market an illuminant which fulfills admirably all of these requirements. It not only furnishes a beautiful white illumination at night, with a high degree of efficiency and economy, but it is adapted for use on standards which lend themselves to highly artistic treatment.

These Ornamental Luminous Arc Lamps, as they are termed, have the same characteristics and embody the same principles

ORNAMENTAL POLE
DESIGN NUMBER 1

as the well known General Electric series luminous arc lamps, of which more than 80,000 are illuminating the principal cities and towns on this continent.

The placing of these new lamps into service on the evening of December 15th last in New Haven, Conn., where the initial installation was made, was the occasion of a great celebration. It was *a master stroke of advertising* by this most progressive city, for this rousing celebration came at the beginning of the Christmas holiday shopping, and the results demonstrated the sound business policy behind this "White Way" movement.

The initial cost of this display lighting was borne by the merchants; each merchant paying a certain amount per linear foot frontage. The cost of maintenance and operation is also levied upon them on this same basis.

Considering this installation first from the business standpoint, and omitting the feeling of civic pride involved, it was found that the holiday trade along the streets where this system was installed was exceptionally large and far exceeded the expectations of the merchants.

As an advertisement for New Haven, it is interesting to note that practically every trade and technical journal in the country, and many newspapers, have published descriptions of New Haven's "Great White Way" and have commented upon the progressiveness of the various civic bodies which instigated this very profitable movement.

Leading electrical men, illuminating engineers, and delegations sent by municipalities from all sections of the country visit this city for the purpose of inspecting the installation.

It is safe to say that the "White Way" in New Haven has achieved more publicity and caused more comment than any other lighting movement that has ever been attempted.

From an illuminating engineering standpoint this installation is remarkable. Not only is there an apparent uniform distribution of a brilliant white light over the street areas, but the building fronts, the façades and the cornices of the highest buildings (12 stories) are illuminated in all their details. All of

ORNAMENTAL POLE
DESIGN NUMBER 2

Ornamental Luminous
Arc Lamp

this has been accomplished, and is being maintained, on an exceedingly economical basis.

The benefits accruing to the central station from this excellent installation are obvious, as not only is there an increase of current consumption, but a high standard of illumination has been set which cannot help but raise the standard of illumination among the individual consumers.

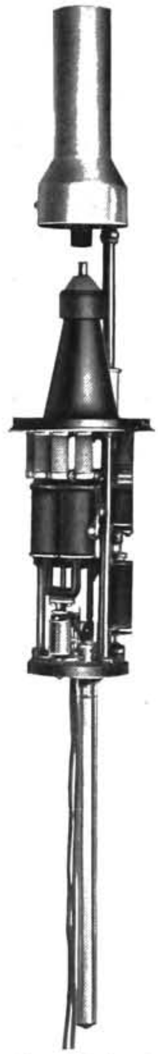
This installation is beautiful by day as well as by night, and forms the highest example of ornamental street lighting now in existence. It demonstrates beyond question the benefits to be derived from proper ornamental street illumination, and the adaptability of this lamp for such service.

In considering artificial illuminants it is desirable to regard the various advantages in the order of their relative importance. The logical point to be considered first is ILLUMINATION, as this is the function of the illuminant. Under this subject should be taken up distribution, quality, steadiness and elimination of shadows.

The DESIGN and RELIABILITY of the mechanism is next in importance to the illumination as it controls largely the "outages."

ORNAMENTAL POLE
DESIGN NUMBER 5

The third item of importance in the determination of an illuminant is COST OF OPERATION. This is affected by the efficiency, upkeep and depreciation.



Complete Mechanism Showing Tube for Lower Electrode

ILLUMINATION

Distribution

The distribution of light from the ornamental luminous arc lamp is ideal. The greatest intensity of light occurs approximately 10 to 30 deg. below the horizontal plane of the lamp, thereby giving a uniform illumination over the maximum street area, and, at the same time, sufficient light emanates above the horizontal plane to illuminate the adjacent buildings in all their details.

The photometric curve shown on page 7 indicates the excellent light distribution given with this new type of lamp while a graphic idea of this light distribution can be obtained by observing the illumination photographs.

Quality

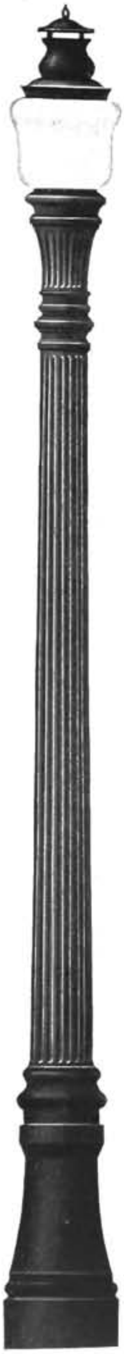
The streets illuminated with these lamps present a most attractive appearance due to the flood of pleasing white light upon roadway, sidewalks and buildings.

Steadiness

The design of the lamp is such that a steady arc of unvarying length is maintained and the amount of illumination is kept constant throughout the length of the trim.

Absence of Shadows

The complete elimination of shadows and the ideal distribution of light given by the ornamental luminous arc lamp are due in a large measure to the new design of globe which



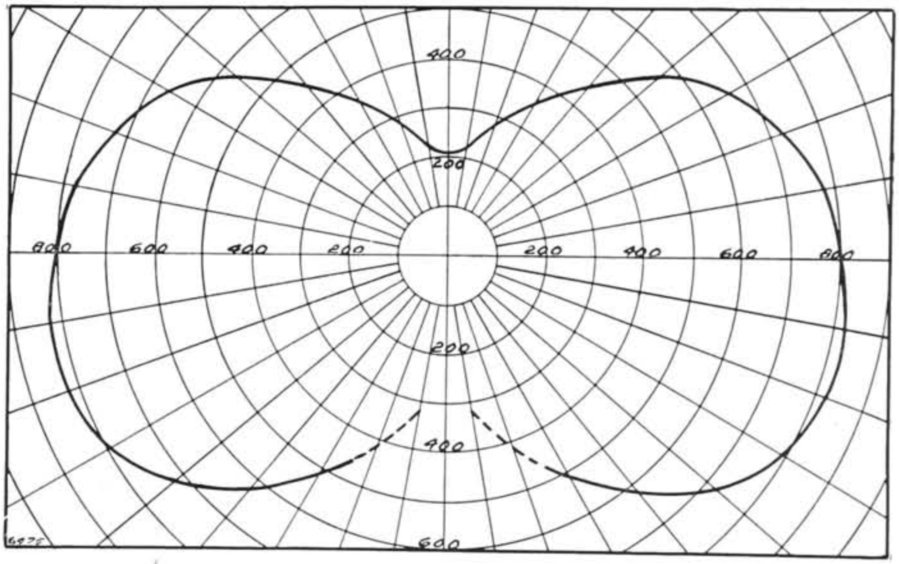
ORNAMENTAL POLE
DESIGN NUMBER 4

is not only distinctive and more attractive than those of the round type, but is so designed that it is completely filled with light and all shadows are eliminated.

By referring to Fig. 1, which illustrates the result of the use of round globes, it will be readily noted that an observer at "A" would see a shadow on that part of the globe which is above the line marked "B"; this shadow is caused by the fume box

PHOTOMETRIC TEST

Average Apparent Candle-Power in a Vertical Plane



Readings taken at 25 feet radius
Equipment: ALABASTER GLOBE

The intensity of the light varies according to the density of the globe used. The intensities given by the above curve may be increased at will by using globes of lighter density.

ORNAMENTAL POLE
DESIGN NUMBER 5

over the upper electrode. From Fig. 2, which illustrates the new design of globe, it will be seen that the shadow cast by the fume box will strike the globe along the line "B," thus an observer at "A" sees no shadow cast upon the globe as the shadow is covered by the top ornament. On account of the shape of the globe, the light is thrown upward and the top orna-

Globe used with Ornamental Luminous Arc Lamps

ment does not throw shadows upon the buildings. Light is also distributed downward in such a manner that no shadows are cast by the globe seat or the globe itself.

Another factor which prevents the lamp from throwing shadows on the surface of adjacent buildings or around the base is the density of the globe which is such that the globe forms a secondary source of illumination, the arc being invisible.

ORNAMENTAL POLE
DESIGN NUMBER 6

ORNAMENTAL LUMINOUS ARC LAMPS

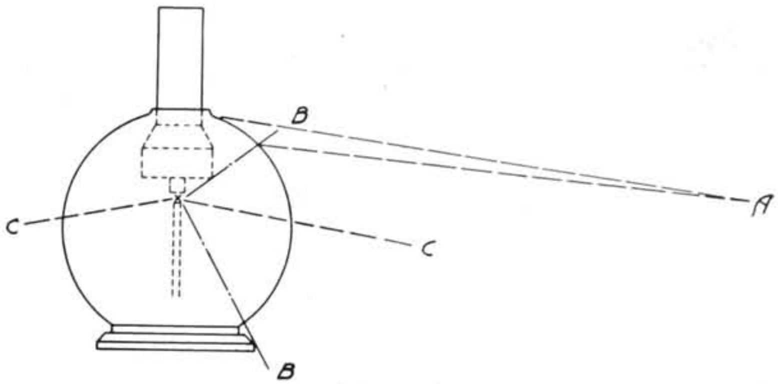


Fig. 1

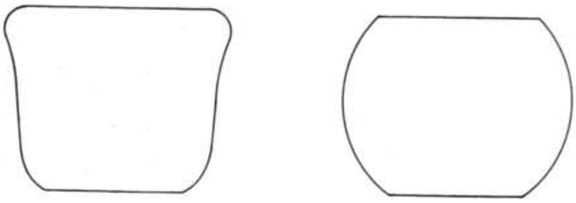


Fig. 2

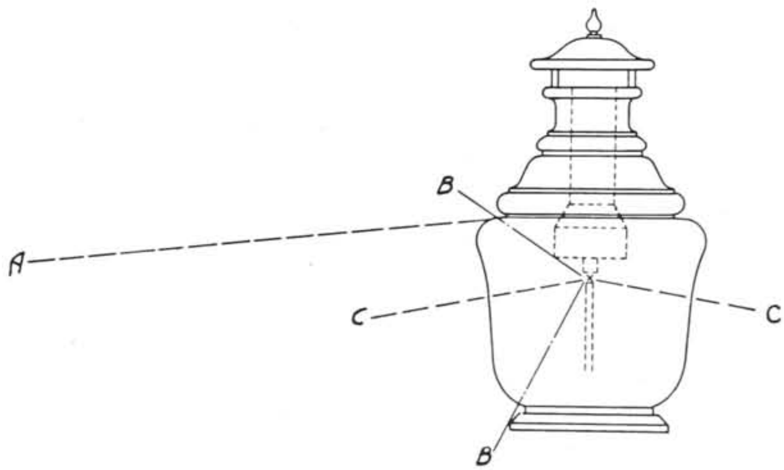


Fig. 3

ORNAMENTAL POLE
DESIGN NUMBER 7

DAY VIEW OF CHURCH STREET, NEW HAVEN, CONN., SHOWING INSTALLATION OF GENERAL ELECTRIC ORNAMENTAL LUMINOUS ARC LAMPS

MECHANISM

Mechanism

General

The mechanism is of the drop feed type and is, in operation and design, essentially the same as that of the standard mechanism of the direct current series luminous arc lamps. The arc is struck between a stationary copper upper electrode and a movable magnetite lower electrode and burns under normal updraft conditions. The lower electrode is carried on a rod actuated by the standard type of shoe clutch mechanism. The current is carried to the electrode by means of a flexible spiral connection contained in a tube which is telescoped by the electrode rod. This tube projects down inside of the pole for a distance of about 18 in. A single side rod, telescoping the supporting tube supports and carries the electrode, dome and chimney so that no shadows are visible when the lamp is properly placed, with the side rod toward the sidewalk.

As in the case of the regular series luminous arc lamps, the magnetite electrode is under the copper electrode, thus preventing hot particles of magnetite dropping on the copper electrode and welding.

Should any non-conducting slag form on the upper surface of the lower electrode, it would be effectually broken because two weld breaking devices are provided, namely, the hinged upper electrode, and the slot in the top of the dashpot stem. These extreme precautions, combined with the fact that the electrodes come together with a heavy blow, make outages resulting from welds or non-conducting slag practically impossible.

The armature is held away from the magnets by gravity.

ORNAMENTAL BRACKET
DESIGN NUMBER 8

If the voltage becomes excessive, or if, for any reason, the lamp should fail, it is immediately cut out of circuit by a cutout which is part of the lamp mechanism.

A long steady arc under all weather conditions is assured by means of a continuous updraft created by the tall chimney, liberal intake of air around the casing, and absolute air tight fitting of globe. The intake is directed by a long nozzle (see pages 4 and 13). This maintains a clear globe by removing the fumes through the chimney.

"The Door Gives Ready Access to the Mechanism"

The current-carrying parts are highly insulated from the frame and casing of the lamp, obviating the possibility of "grounds" and resultant outages.

The casing is furthermore insulated from the framework of the lamp as it rests on a porcelain insulator, and is guided by an insulating compound which forms the globe seat. These insulators have such a great dielectric strength that "grounds" are practically impossible under the severest weather conditions.

The casing which conceals the mechanism forms the capital of the standard or pole. A large door is provided which gives ready access to any part of the lamp mechanism as the casing can be revolved. The casing is held in position between the high voltage insulators and protects the mechanism perfectly from the weather.

ORNAMENTAL POLE
DESIGN NUMBER 9

The lamp complete is fastened by three recessed screws to the large porcelain strain insulator. This insulator is also secured to the top of the pole by three deeply recessed screws.

The material and workmanship used in the construction of this lamp are the very best obtainable.

These lamps are for direct current and when operating at standard adjustment 6.6 amperes, 75 to 80 volts at the arc the life of the lower magnetite electrode ($\frac{9}{16}$ in. by 15 in.) is from 100 to 125 hours, and that of the upper or copper electrode, approximately 3000 hours.

The composition of the lower magnetite electrodes is identical with those used in the regular General Electric series luminous arc lamps.

CYCLE OF OPERATION

The cycle of operation may be traced by referring to Fig. 4. The current enters terminal P, passing through the starting resistance, starting magnets and the cutout contacts to the negative terminal. The starting coils are thus energized and the lower electrode is brought into contact with the positive, estab-

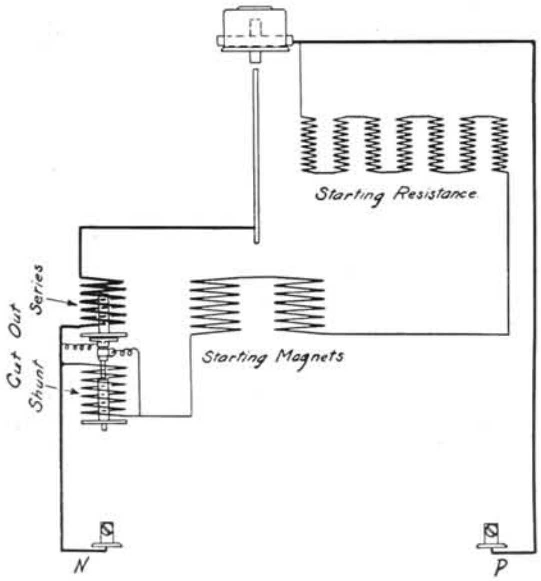


Fig. 4

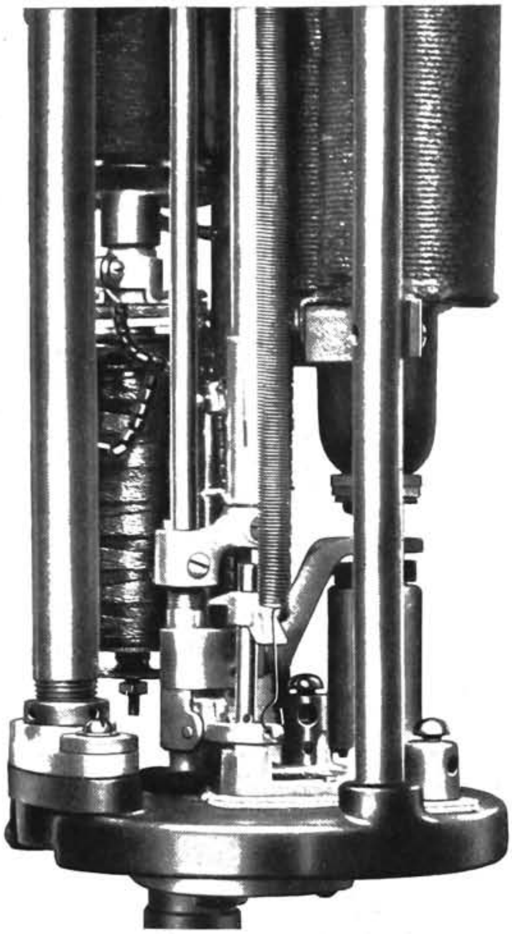
ORNAMENTAL POLE
DESIGN NUMBER 10

lishing the arc and the circuit through the series cutout coil. This coil, on becoming energized, separates the contacts and opens the circuit through the starting coils, thus allowing the lower electrode to fall back to its normal position, retarded by the dashpots. The electrodes remain in this position until for some reason the voltage at the arc momentarily reaches a point sufficiently high to actuate the shunt magnet, when the contacts are once more closed and the cycle of operation is repeated.

"The Trimming Operation
is Very Simple"

The lower electrode is $\frac{9}{16}$ in. in diameter and 15 in. long consisting of a thin sheet iron tube filled with a composition of magnetite. The composition of these electrodes is identical with that used in the regular series luminous arc lamps. The upper electrode is of the standard General Electric type supported in a cast metal electrode box, and connected thereto by a metal strip. An improved form of fastening the electrode to the fume box greatly facilitates its removal, which can be accomplished with ease at the point of installation. The fume box forms the lower part of the chimney which passes through a hole in the top of the globe and terminates in the ornamental wind shield.

ORNAMENTAL POLE
DESIGN NUMBER 11



Another View of Mechanism

OPERATING COSTS

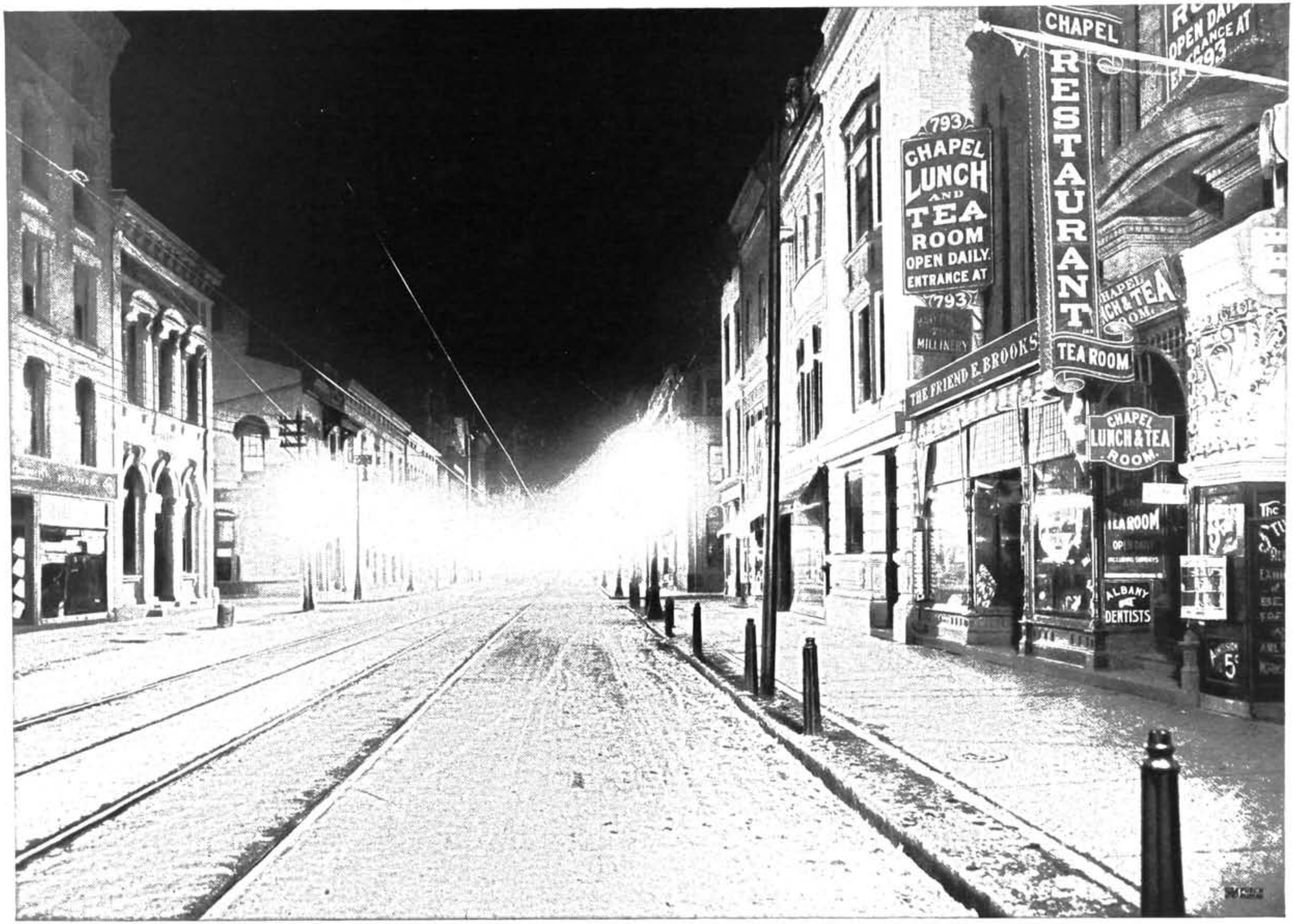
The lamp consumes approximately 510 watts, and a high efficiency of about 0.79 watts per mean spherical candle-power is attained.

The trimming operation is very simple and the removal of the globe is unnecessary. Only one electrode requires renewal at each trim. To trim the lamp the chimney with the top ornament is raised and swung to one side where it is held automatically by a bayonet lock. The new lower electrode is then pushed down through the top of the nozzle into position. The large opening in the top of the globe allows plenty of room for cleaning the globe on the inside and gives access to the removable ashpan which is at the bottom of the globe to catch all deposits. After trimming, the chimney is simply raised, and so released from the bayonet lock and swung back into position over the top of the globe.

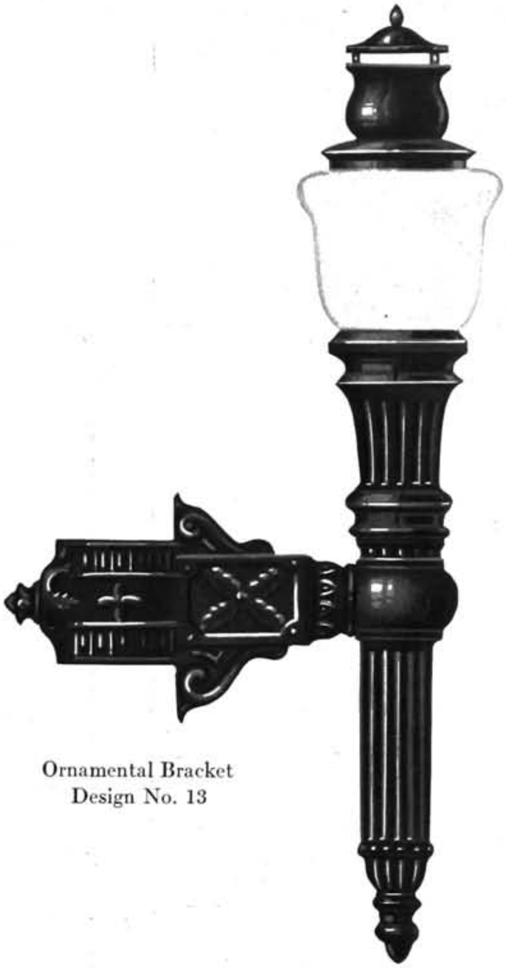
A cutout located in the base of the pole enables the trimmer to disconnect the lamp before beginning work upon it.

The changing of the lamps for any purpose is easily accomplished by removing three nuts; the studs project upward and are held in place ready for the installation of the new lamp.

ORNAMENTAL POLE
DESIGN NUMBER 12



THE ILLUMINATION OF CHAPEL STREET, NEW HAVEN, CONN., WITH GENERAL ELECTRIC LUMINOUS ARC LAMPS



Ornamental Bracket Design No. 13

One Type of Bracket for Mounting on Trolley Pole

Globe breakage is reduced to a minimum due to the following facts: The globe is large and away from the arc, its removal for cleaning is unnecessary, and hot particles cannot drop on it.

The simplicity and durability of the lamp assure reliability and economy of maintenance.

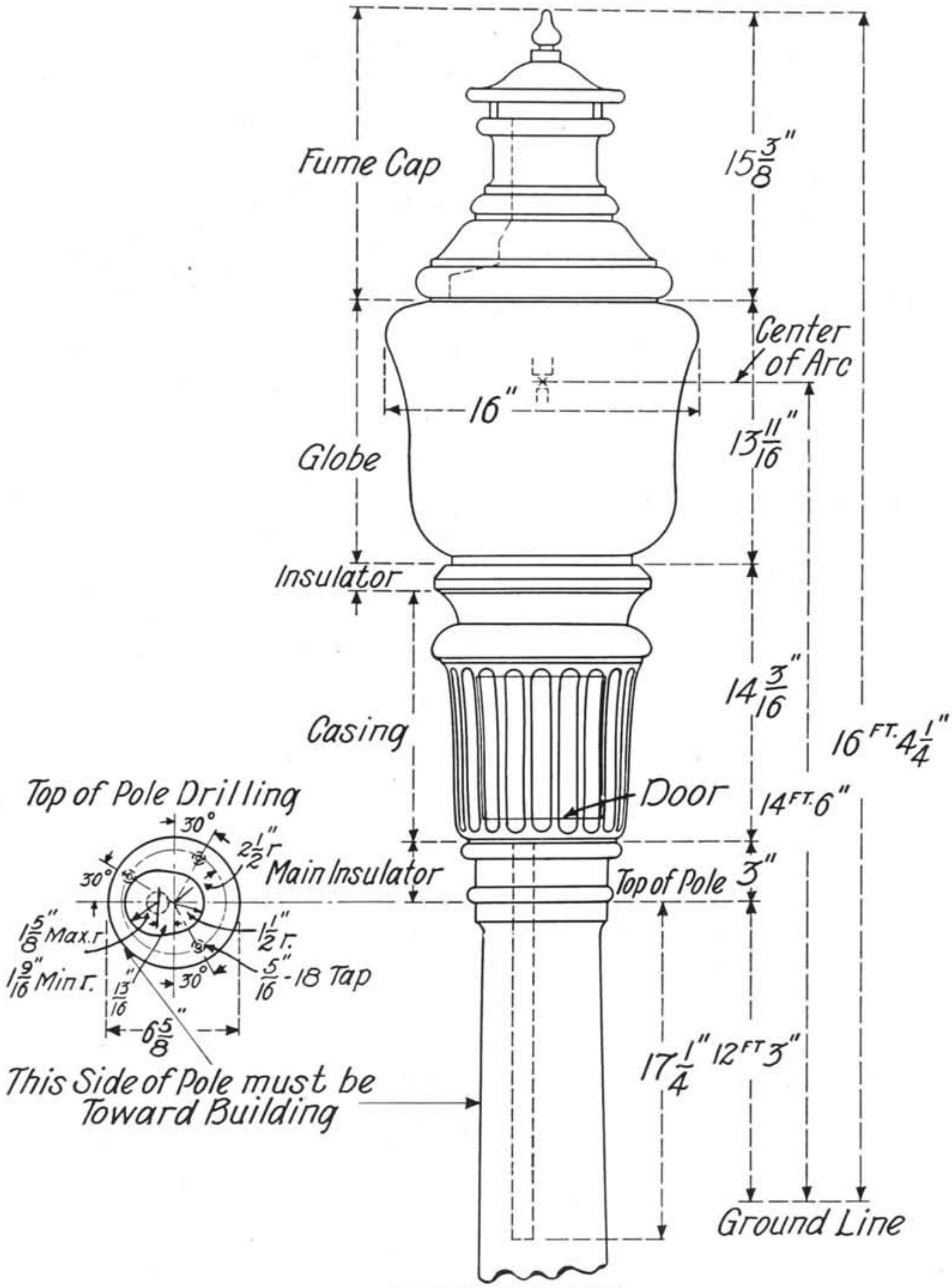
The large amount of illumination from these lamps renders possible their installation with a spacing of two or three times the distance maintained in connection with any other system of ornamental street lighting.

The poles are easily installed as they have a minimum number of pieces to assemble, all goosenecks, mast arms, cross arms, etc., being eliminated. By using a rectifier system the line loss is greatly reduced; for example, if alternating current is used the watts loss per 1000 ft. of single conductor cable will be about double the loss with direct current of the same amperage.

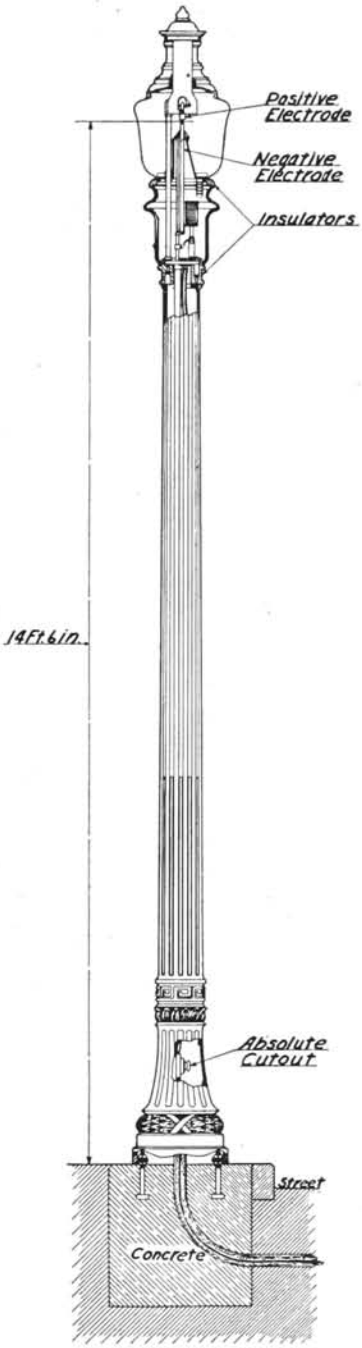
ORNAMENTAL POLE DESIGN NUMBER 14

ORNAMENTAL
LUMINOUS
ARC LAMPS

ORNAMENTAL POLE
DESIGN NUMBER 15

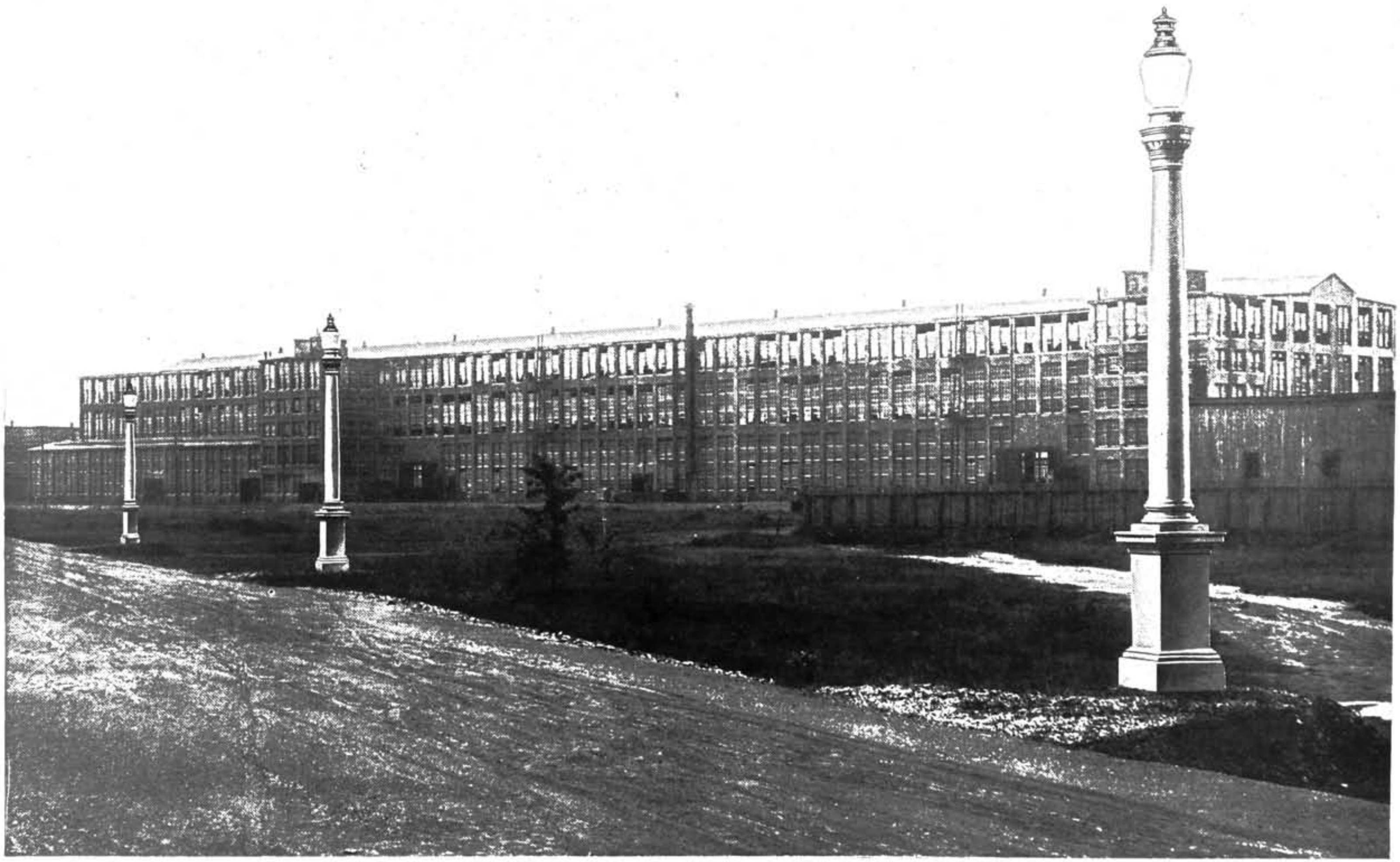


DIMENSION DIAGRAM
(Subject to change without notice)



Method of Mounting and Wiring
Pole and Lamp

ORNAMENTAL POLE
DESIGN NUMBER 16



EXTERIOR OF BUILDING AT THE LYNN WORKS DEVOTED TO ARC LAMP MANUFACTURE

General View of Arc Lamp Assembly Department and Machine Shop

THE building in which the ornamental luminous arc lamp is manufactured is shown in the accompanying illustrations which give in a small measure an idea of the immensity of the arc lamp department, at the Lynn Works. Every appliance, machine and method which will add to the betterment of the product is found there.

A corps of trained specialists with vast laboratories and resources at its command is continually working on the design and improvement of the arc lamps, while skilled workmen who have made a life specialty of manufacturing arc lamps, are employed.

The constant advance in design, and the care in manufacture, are factors which have largely contributed toward making the General Electric Company the largest manufacturer of arc lamps in the world, and the enthusiasm with which the ornamental luminous arc lamp is being received bids fair to still further enlarge this enormous organization.

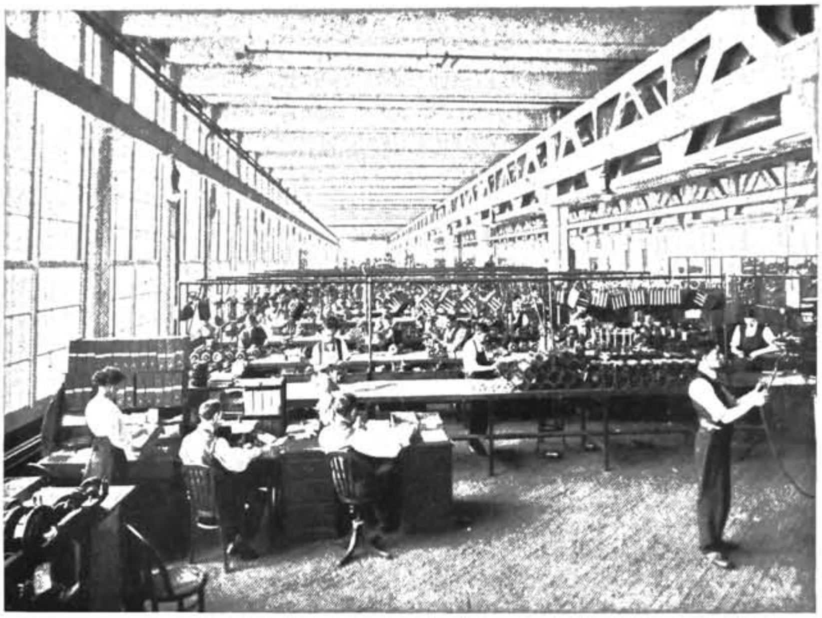
ORNAMENTAL POLE
DESIGN NUMBER 17

ORNAMENTAL
LUMINOUS
ARC LAMPS

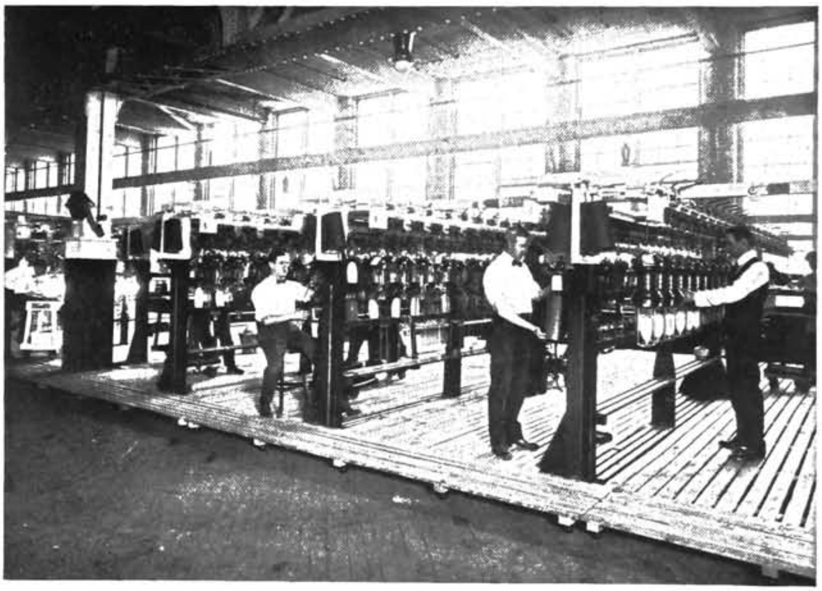
Arc Lamp Winding Department

Arc Lamp Casing Assembly Department

ORNAMENTAL POLE
DESIGN NUMBER 18



Arc Lamp Assembly Department



Part of the Arc Lamp Testing Department

ORNAMENTAL POLE
DESIGN NUMBER 19

CHAPEL STREET, NEW HAVEN, CONN.

THE LUMINOUS ARCWAY is the title that Baltimore is to give the more than two and one-half miles of business streets comprising nearly fifty blocks which are to be illuminated with the ornamental luminous arc lamp.

The regard in which business men hold ornamental street lighting is therefore again demonstrated as the merchants along the lighted streets there are to bear the entire cost of the installation and their intention is to turn it over to the lighting company when completed.

The order they have placed with the General Electric Company for nearly four hundred of these new ornamental luminous arc lamps is a flattering testimonial to the adaptability of this new illuminant for the highest type of ornamental street lighting.

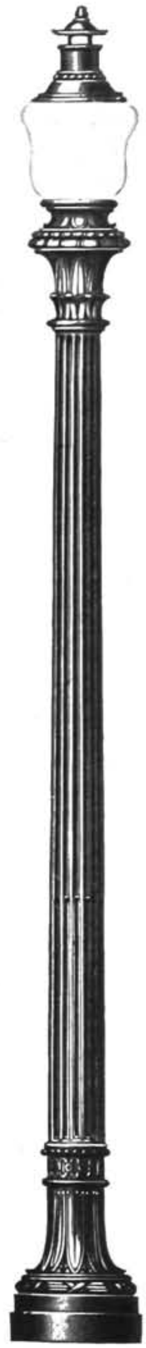
The pole to be used is highly ornate and was designed by the Baltimore Art Commission, and many authorities have declared this standard the most beautiful that has ever been designed for street lighting. It is an adaptation in design of the slender supports which the ancients utilized to hold a torch or "flambeau" for the lighting of their streets.

The placing of these lamps in service will be the occasion of a great celebration which will further advertise the city as one of the most progressive in the country.

In the campaign for obtaining the contracts from the property owners and merchants, the merchants and manufacturers' associations and the advertising clubs have been conspicuous for their industry.

The mayor of Baltimore has remarked that he will consider the installation of this Luminous Arcway as one of the great achievements of his administration.

Rochester, N. Y., realizing the benefits to be derived from a "white way" after very exhaustive tests has decided upon these new lamps and placed an initial order for one hundred.



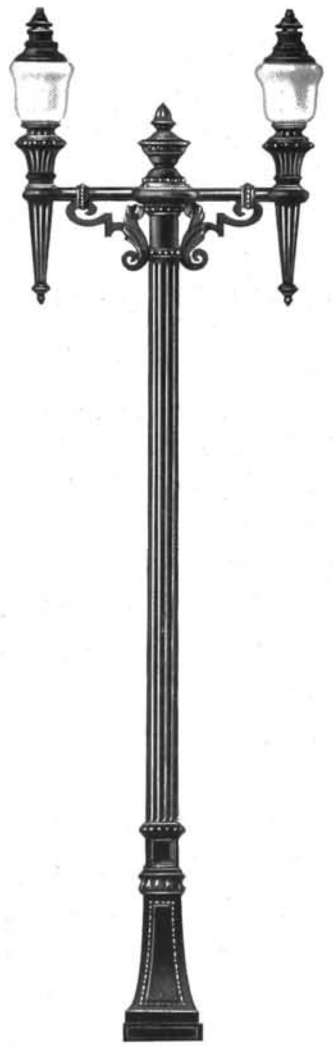
ORNAMENTAL POLE
BALTIMORE TYPE

ORNAMENTAL LUMINOUS ARC LAMPS

Although these ornamental luminous arc lamps have been upon the market but a short time, cities and towns in all sections of the continent, and even in Europe, are considering adopting them.

The enthusiasm which this illuminant has created in the lighting field is due to its manifold advantages, and it is universally conceded to be the greatest advance in ornamental street lighting ever made.

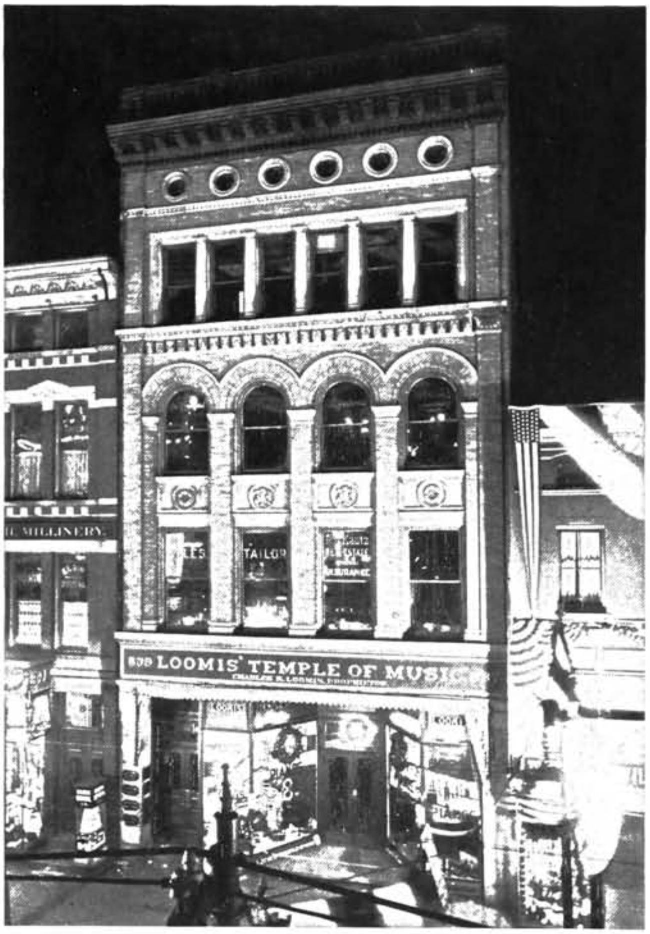
ORNAMENTAL POLE DESIGN NUMBER 20



Ornamental Pole Design No. 21

THE number of persons passing along a street is what determines its value for business purposes.

At night, the traffic upon a street is dependent entirely upon the street illumination, for when the sun sets the crowd unerringly seeks the streets which are brilliantly illuminated. This is a fact proven many times and has led to the true saying "Business follows the light."



Illumination of Building with Ornamental Luminous Arc Lamps on Street. The benefits of this lighting are not confined to the merchants on the first floor

ORNAMENTAL POLE
DESIGN NUMBER 24

CHAPEL STREET (Opposite "The Green"), NEW HAVEN, CONN.

As an important factor in municipal progress, street lighting enjoys an undisputed prestige, furnishing as it does the best auxiliary for police protection, while, as a method of advertising a city it is concrete evidence that cannot be disputed.

The ornamental luminous arc lamp is the latest development in the science of street illumination. The light given is powerful, of high efficiency and low intrinsic brilliancy and has a most pleasing appearance, being absolutely free from glare. The installation and maintenance of this lamp are economical.

"Buildings are Illuminated from Sidewalk to Cornice by this System of Street Lighting"

ORNAMENTAL POLE
DESIGN NUMBER 23

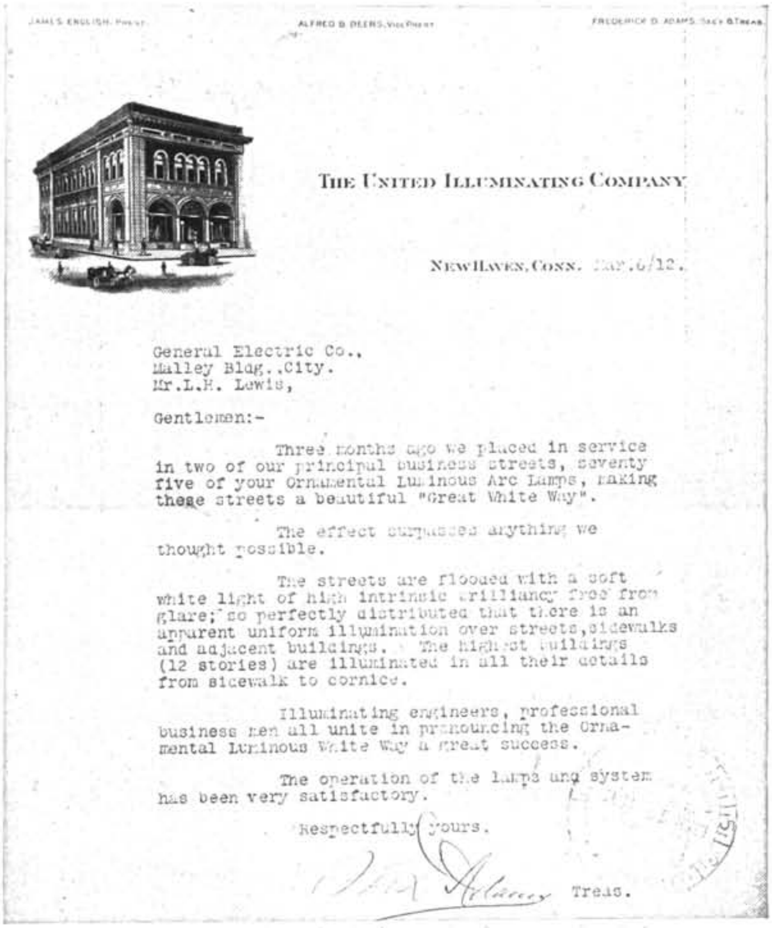
ORNAMENTAL
LUMINOUS
ARC LAMPS

The lighting units are ornamental and dignified and enhance the appearance of a street not only at night but by day.

Make *your* town "bigger, brighter and busier" by flooding the streets at night with the soft white light given by this remarkable illuminant.

In every large city you will find an office of the General Electric Company ready to furnish complete information in regard to the ornamental luminous arc lamp.

ORNAMENTAL BRACKET
DESIGN NUMBER 24



JAMES ENGLISH, PRES'T. ALFRED B. BEERS, VICE PRES'T FREDERICK D. ADAMS, SEC'Y & TREAS.

THE UNITED ILLUMINATING COMPANY

NEW HAVEN, CONN. Mar.6/12.

General Electric Co.,
Malley Bldg.,City.
Mr.L.H. Lewis,

Gentlemen:-

Three months ago we placed in service in two of our principal business streets, seventy five of your Ornamental Luminous Arc Lamps, making these streets a beautiful "Great White Way".

The effect surpasses anything we thought possible.

The streets are flooded with a soft white light of high intrinsic brilliancy free from glare; so perfectly distributed that there is an apparent uniform illumination over streets, sidewalks and adjacent buildings. The highest buildings (12 stories) are illuminated in all their details from sidewalk to cornice.

Illuminating engineers, professional business men all unite in pronouncing the Ornamental Luminous White Way a great success.

The operation of the lamps and system has been very satisfactory.

Respectfully yours,

F. D. Adams Treas.

A Proof of Reliability

Extract from an Editorial captioned "Ornamental Street Lighting," Electrical World, January 20th, 1912.

"Finally, the modern arc lamp is coming into use for this purpose with admirable effect. It has been tried in a simple form for several years past and in divers cities, but owing to the very general use of lamps with clear globes for this purpose the result has usually been somewhat glaring. The recent installation in New Haven puts an entirely different face on the matter, for here one has a powerful and properly shaded lamp borne on a post of very pleasing appearance and giving a wonderfully uniform and brilliant illumination not only on the street but on the façades of neighboring buildings. Altogether, display street lighting is showing most gratifying signs of improvement all along the line, and the recognition of its value gives promise not only of its rapid increase but of a higher type of municipal lighting in the future."

ORNAMENTAL BRACKET
DESIGN NUMBER 25

MORE THAN FIFTY OFFICES WANT TO TALK TO YOU ABOUT THIS LAMP

(Address the nearest)

GENERAL ELECTRIC COMPANY

Largest Arc Lamp Manufacturer in the World

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

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General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
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General Electric Company

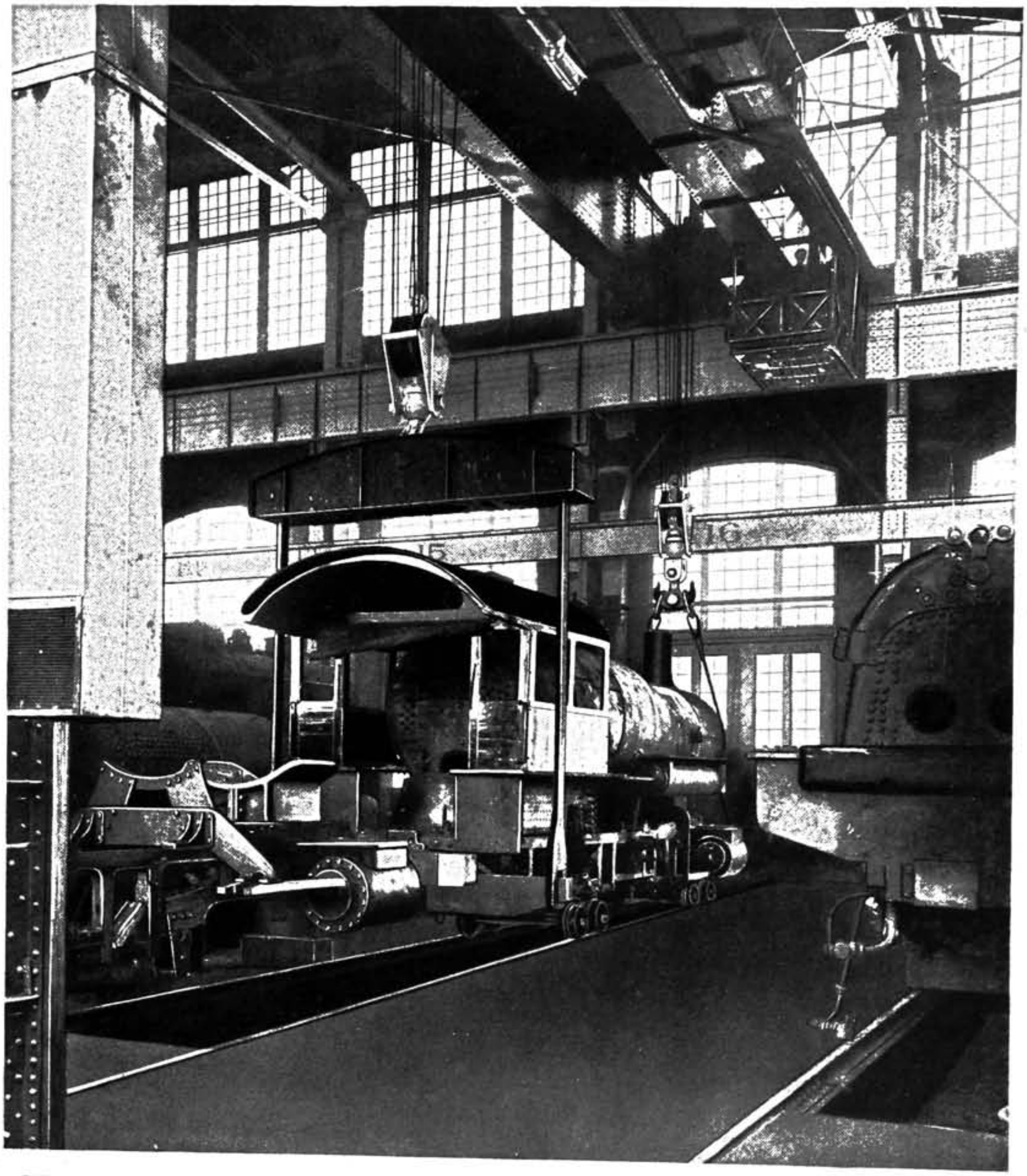
Schenectady, N.Y.

POWER AND MINING DEPARTMENT

June, 1912 **Bulletin No. 4959*

4.40

THE ELECTRICAL OPERATION OF RAILROAD SHOPS



LIFTING LOCOMOTIVE WITH 120-TON CRANE OPERATED BY G.E., TYPE ITC, INDUCTION MOTORS
NEW YORK CENTRAL RAILROAD SHOPS, WEST ALBANY, NEW YORK

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* *Supersedes Bulletin No. 4649.*

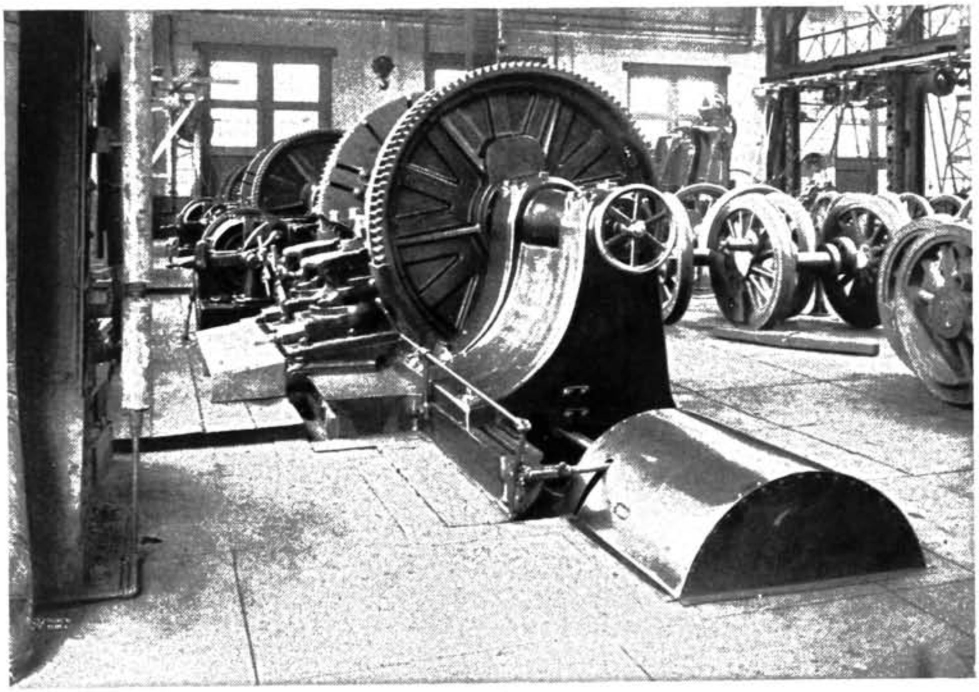
THE ELECTRICAL OPERATION OF RAILROAD SHOPS

Centralization of power, and the operation of tools either individually or collectively by means of motors has been adopted in the various departments of all recently equipped railroad repair shops. Furthermore, the heads of the mechanical departments, appreciating the reduced operating cost and increased output obtained through these methods, have modernized their older shops, thus, in some cases, saving the cost of an entirely new shop, which would otherwise have been necessary.

The numerous benefits derived from electrical shop operation are now well known to the average engineer and it is the main purpose of this bulletin to demonstrate the relative advantages and disadvantages of the two general systems now in vogue, namely, the operation of each individual machine by a single motor, commonly termed "independent drive," and the operation of machinery in groups by means of line shafting, which in turn is driven by a motor; this plan being generally designated as "group drive."

"INDEPENDENT DRIVE" VS. "GROUP DRIVE"

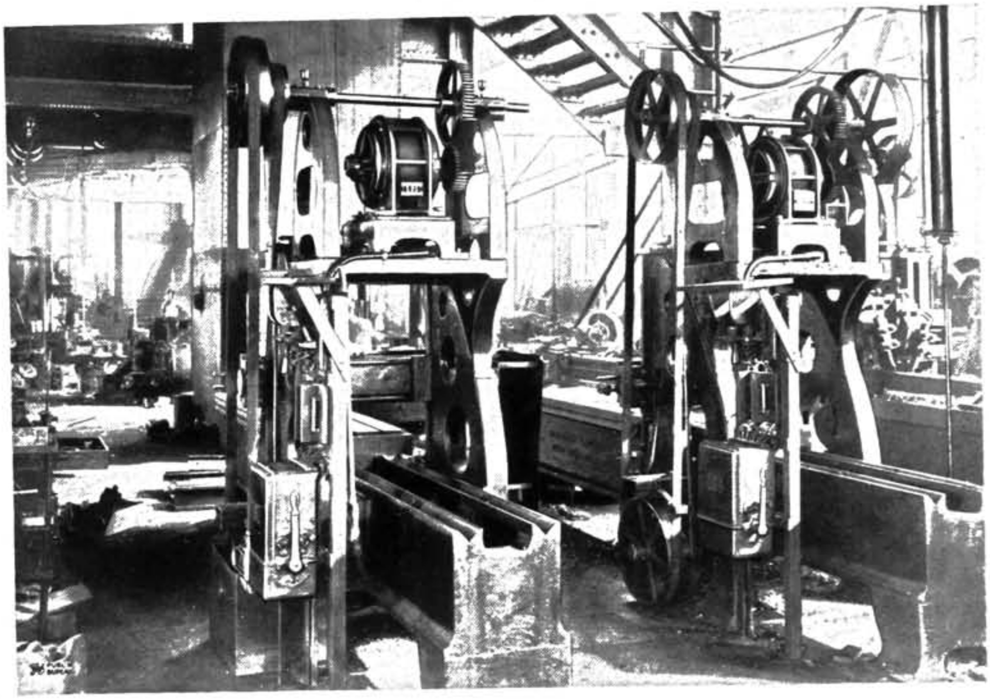
For a comparatively long time it has been the practice, in modern shops, to drive the larger machines by independent motors and group the smaller machines in such a manner as not to interfere with the operation of cranes; but the disadvantages of this arrangement, as compared with the use of independent motors exclusively, are becoming more and more appreciated, so that each year the ideal railroad shop, with all shafting and belting eliminated, becomes more nearly an accomplished fact. Heretofore the main drawback to this arrangement has been the numerous belt driven tools, which were often transferred from old shops to shops of more recent



50 H.P., 715 R.P.M. INDUCTION MOTOR DRIVING 90 INCH WHEEL LATHE
READVILLE REPAIR SHOPS, N. Y., N. H. & H. R. R.

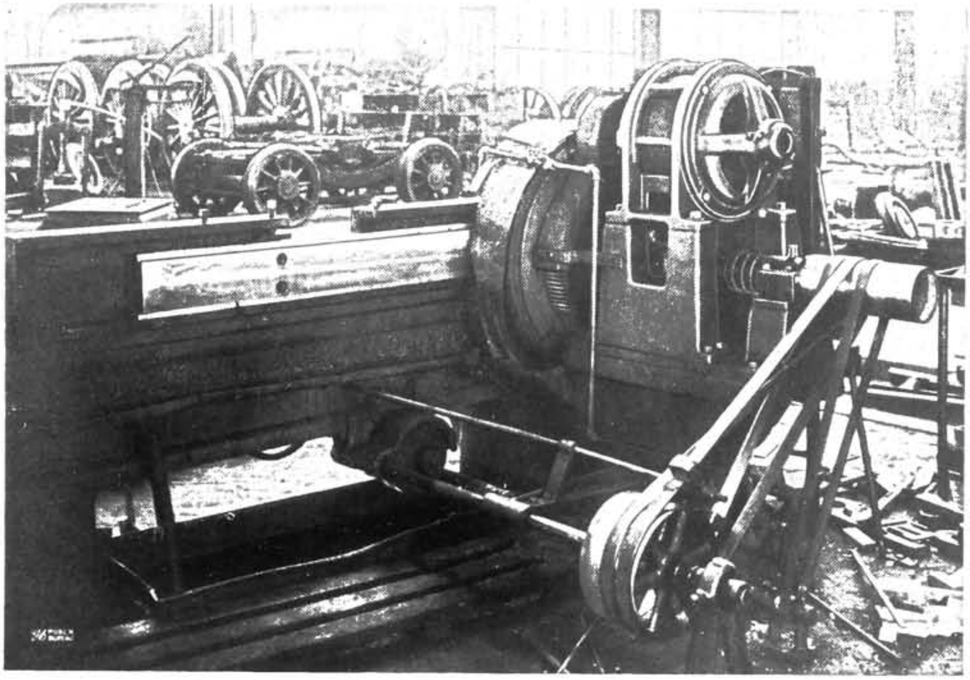
construction, and as a rule under these conditions it was not deemed advisable to make the alterations necessary to provide for independent operation. The radical improvements recently made in all classes of machinery, together with the prevalent high cost of labor, makes it advisable from the standpoint of operating efficiency to rapidly discard this old equipment and replace it by up-to-date, independently operated tools.

When "group drive" was first used extensively, eight or ten years ago, it was a notable improvement over the old practice of placing engines in each shop and transmitting steam through long pipe lines for their operation, with consequent heavy expense for labor and fuel. At that time, however, the motors as generally designed were large, unwieldy, and not suitable for mounting on lathe headstocks or for use in connection with other tools; but great changes in design have taken place since then, and a glance at the illustrations in this bulletin will give a good idea of the highest development in modern motor construction and the adaptability of present designs for direct connection to the various classes of machinery. At the time group drive was being advocated for the smaller tools, the ability to vary motor speeds, except by a complicated multiple voltage system, had not been perfected. At present, however, motors of special design, equipped with commutating poles where necessary and using field weakening rheostats, make any speed variation up to and including a ratio of *four to one*, wholly practicable, with a slight increase in size and cost over that of a constant speed motor of the same capacity.

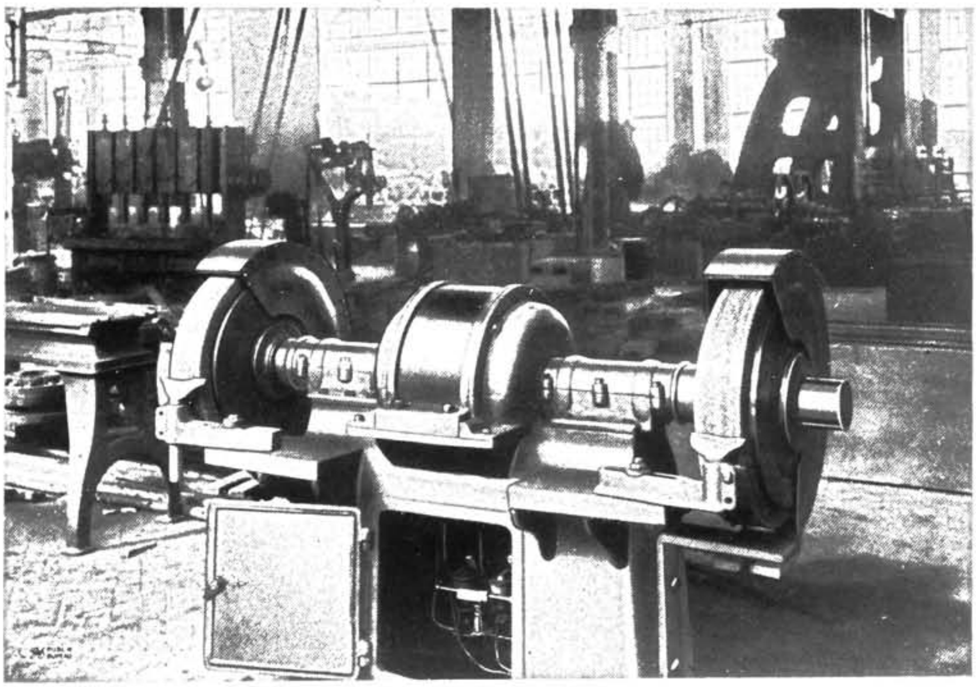


7½ H.P. INDUCTION MOTORS OPERATING PLANERS. C. C. C AND ST. L. R. R. COMPANY BEECH GROVE, IND., SHOPS

The enormous increase in output effected by the electrical transmission of power cannot be too strongly emphasized, for it has been shown in numerous instances to range from 10 to 50 per cent., the latter figure being probably more generally realized in railroad shop service. It is accomplished by always running the machines at the maximum speed



10 H.P. INDUCTION MOTOR OPERATING GUIDE GRINDER, C. C C. AND ST. L. R. R. COMPANY BEECH GROVE, IND., SHOPS



7½ H.P. INDUCTION MOTOR OPERATING SAFETY EMERY WHEEL GRINDER. C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS which tool and material will stand and by saving the time ordinarily used in handling and repairing countershafts, belts, etc.

In making a comparison of the two modern methods of machine tool operation, it might be well to summarize the advantages of each as follows:

Independent Drive

Increased output.

Saving in fuel due to the elimination of frictional losses in shafting, belting, etc.

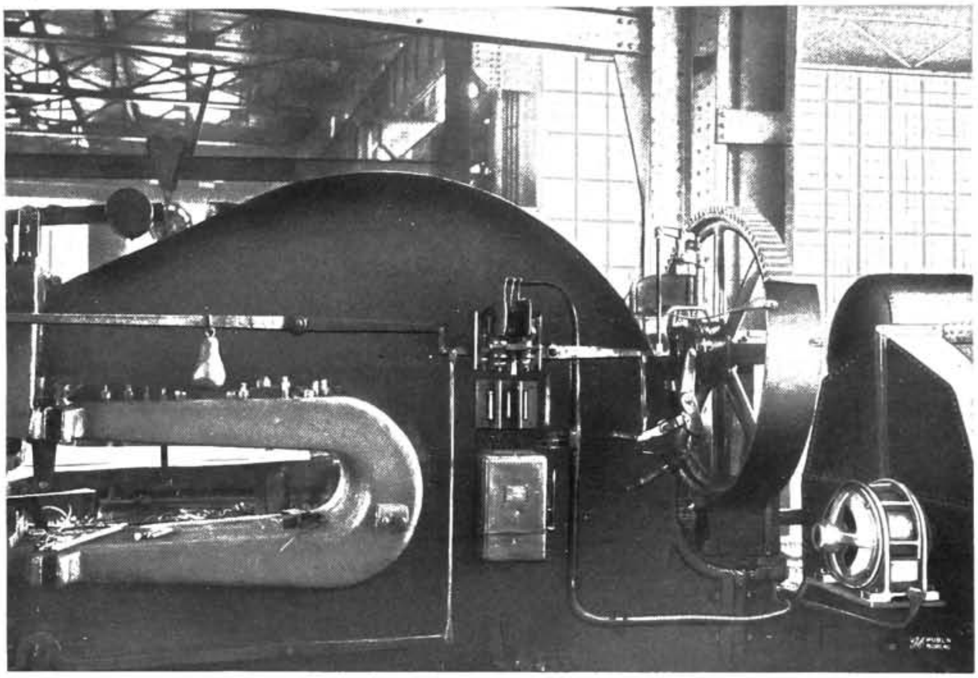
Increased light due to the elimination of shafting and belting.

Elimination of shafting and belting maintenance cost.

The ability to operate a single machine overtime without the necessity of operating any other machine.

Group Drive

Reduction in first cost of tools and motors of about 15 per cent.



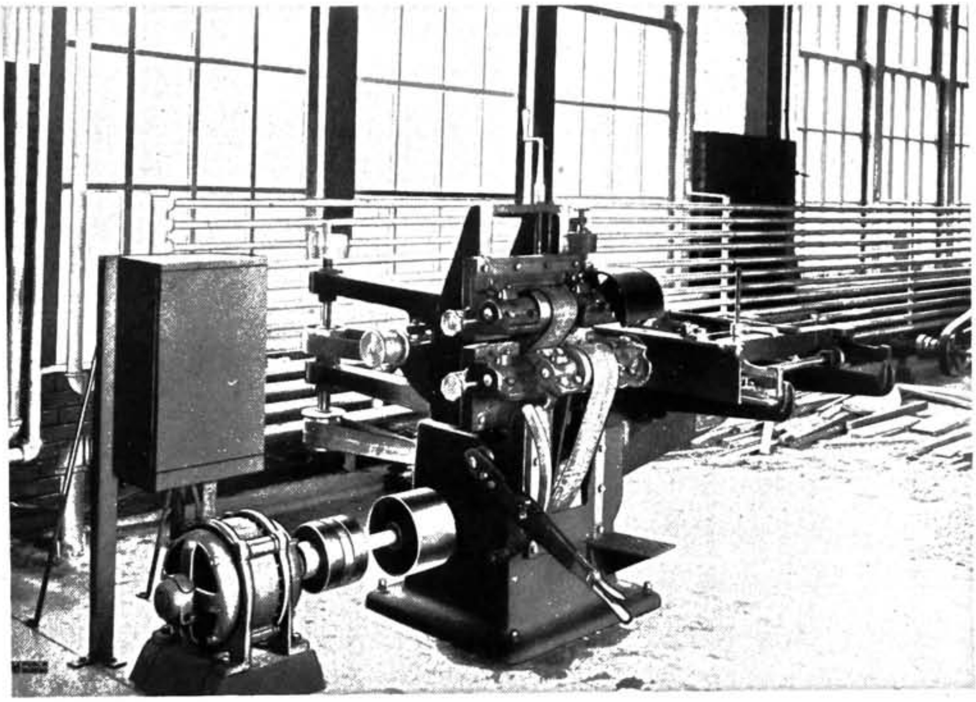
7½ H.P. INDUCTION MOTOR DRIVING BOILER PUNCH PRESS, C. C. C. AND ST. L. R. R. COMPANY BEECH GROVE, IND., SHOPS

Saving in labor by obviating the necessity for shifting belts, lacing belts, repairing friction pulleys on countershafting, etc.

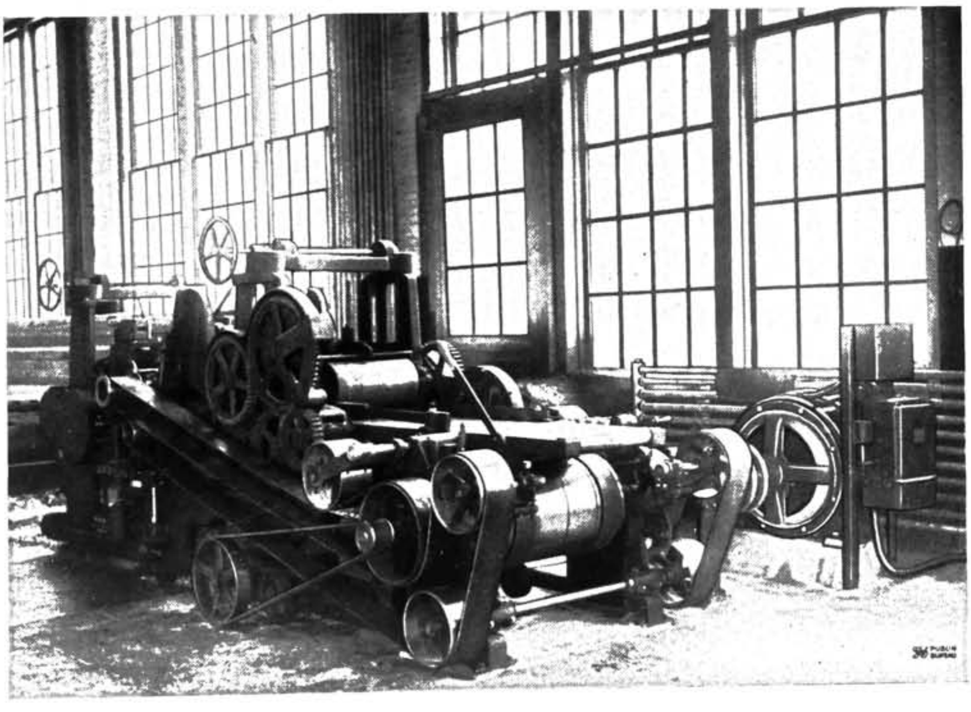
Reduction in the size of power plant required by reducing frictional losses.

Ability to place any machine wherever desired, without reference to shafting or crane locations.

To offset the numerous benefits, shown by "independent drive," the "group drive" system shows a lower first cost, but operating experience has proven that the increased first cost for "independent drive" will be practically counterbalanced by the saving effected during the first two years of operation.



5 H P. 1200 R.P.M. INDUCTION MOTOR DRIVING SASH AND DOOR TENONER
C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS



50 H.P. 1200 R.P.M. INDUCTION MOTOR DRIVING BERLIN 4-SIDED TIMBER SIZER
C. C. C AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS

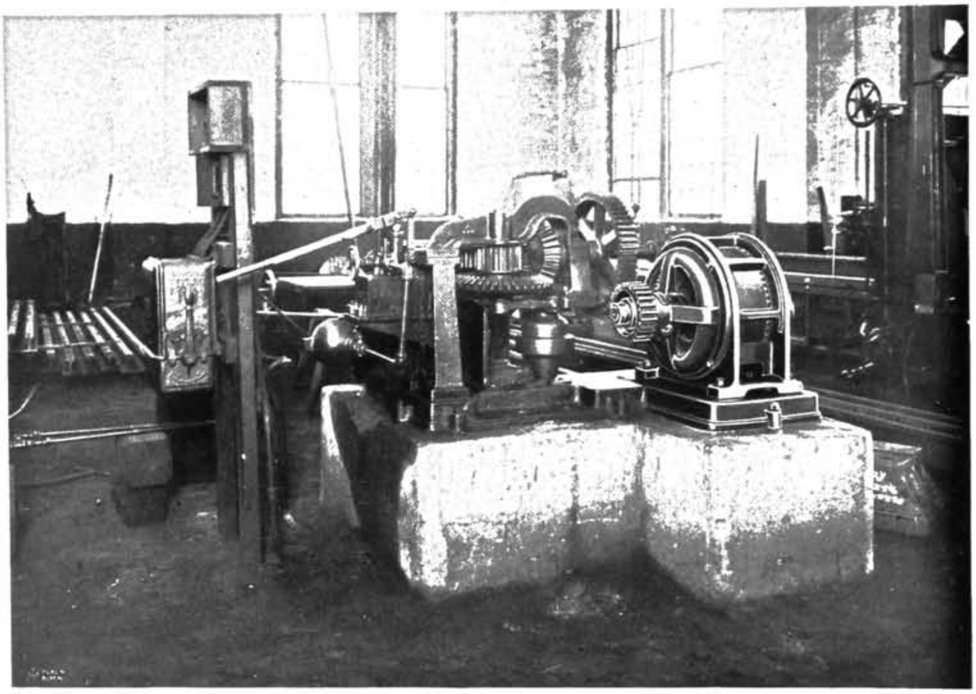
How many times have you watched ineffectual attempts to replace a belt on a line shaft pulley, meanwhile preventing the operation of all machines depending on that shaft? How often do friction pulleys on countershafts refuse to work, requiring sometimes several hours to repair? How much time is required for lacing belts? Could not the speed of a machine often be advantageously increased, but shifting the belt to the next step on the cone makes too great an increase? Have you ever seen a machinist spend valuable time looking for a pole to shift a belt on a countershaft? Can you believe that on an average twenty minutes per day are lost by each machine operator performing these normal labor requirements inherent in group operation?

Today a woodworking shop can be equipped with individual motors at a lower cost than with engine and shafting. If there is no heavy shafting to suspend from the roof trusses a saving of probably 5 per cent. of the total cost of the building will result. Double leather belting will cost about $1.50 per square foot. The machinery builder will reduce his price for the omission of countershafting.

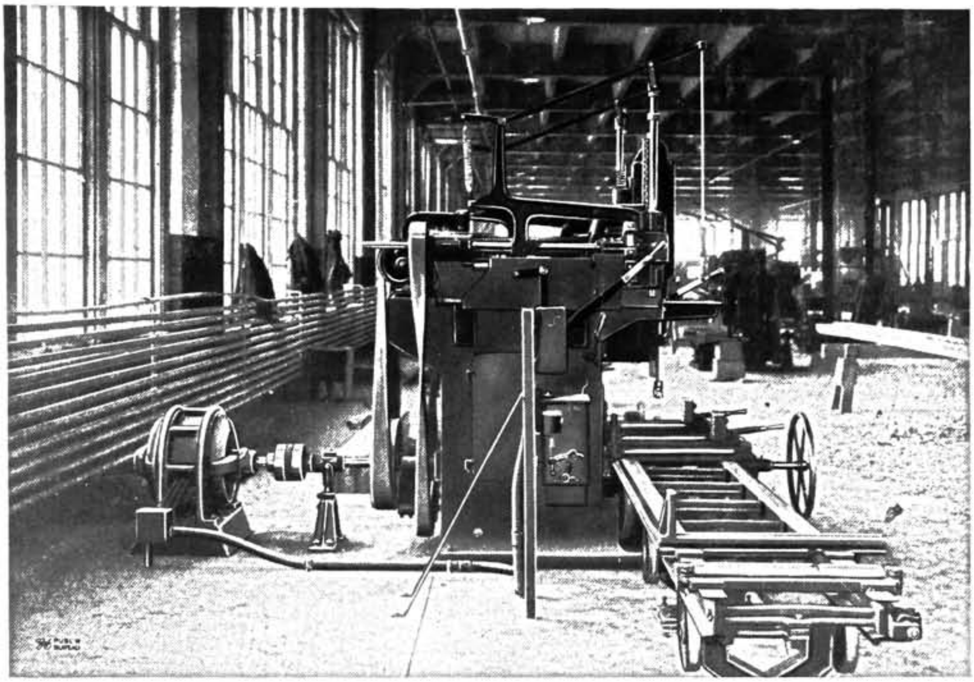
ALTERNATING CURRENT VS. DIRECT CURRENT

It might be well, at this time, to state the relative merits of alternating and direct current for operating motors in railroad shops. Probably seventy-five per cent. of the power required will be for the operation of constant speed machinery and lights. In this connection it should be remembered that the department requiring the most power is the one in which woodworking machinery is placed, this machinery invariably operating at constant speed.

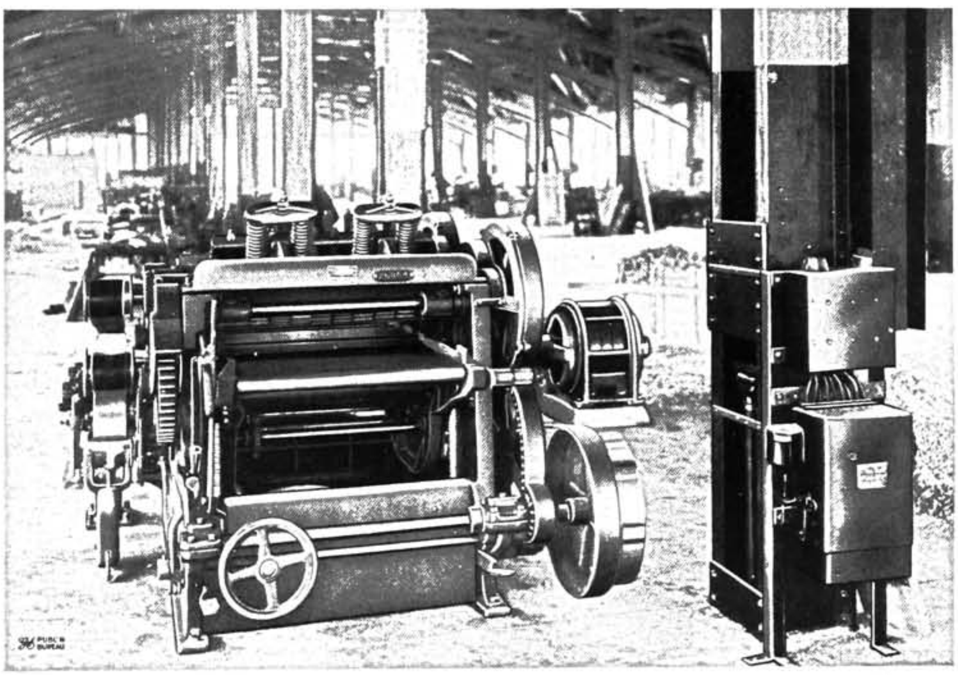
The simplest form of alternating current motor, namely, the induction type, with squirrel cage winding, is essentially a constant speed machine, entailing practically no maintenance charges and being designed and constructed for constant speed work, the opera-



10 H.P., 750 R.P.M. INDUCTION MOTOR DRIVING RAIL BENDER, READVILLE REPAIR SHOPS
N. Y., N. H. & H. R. R.



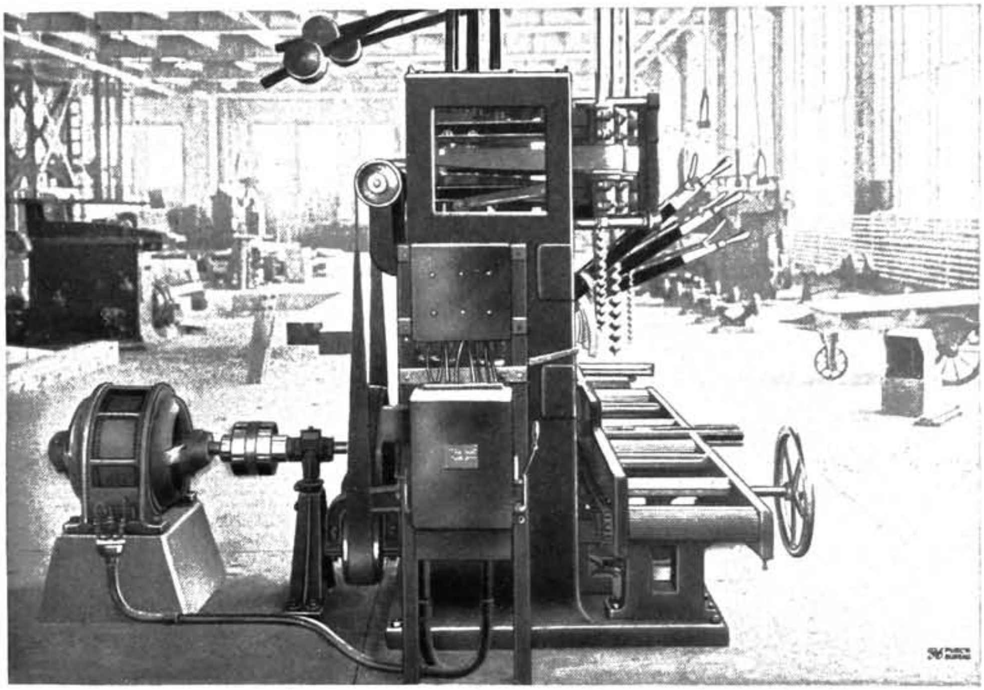
15 H.P. 900 R.P.M. INDUCTION MOTOR DRIVING VERTICAL MORTISER AND BORER
C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE., IND., SHOPS



25 H.P. 900 R.P.M. INDUCTION MOTOR DRIVING BERLIN 30-INCH DOUBLE CYLINDER CABINET SURFACER
C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS

tion of boiler shop machinery, blacksmith shop machinery, woodworking shop machinery, planers, etc. However, where we have to contend with variable speed machinery the best results would be obtained by the use of direct current motors with field weakening control. It has been demonstrated that alternating current motors provide as satisfactory a means for operating cranes, transfer tables, turntables, hoists, etc., as quality and design, in order that it may be best adapted for the service required. Attention to details of construction will insure freedom from interruptions when the plant is in operation.

In a great majority of shop installations, a most satisfactory arrangement will be obtained by using alternating current turbo-generators; probably seventy-five per cent. of the total power requirements, as pre-



10 H.P. 900 R.P.M. INDUCTION MOTOR DRIVING 3-SPINDLE BORING MACHINE
C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS

direct current, and can be successfully used throughout for driving machinery of this character.

POWER PLANT

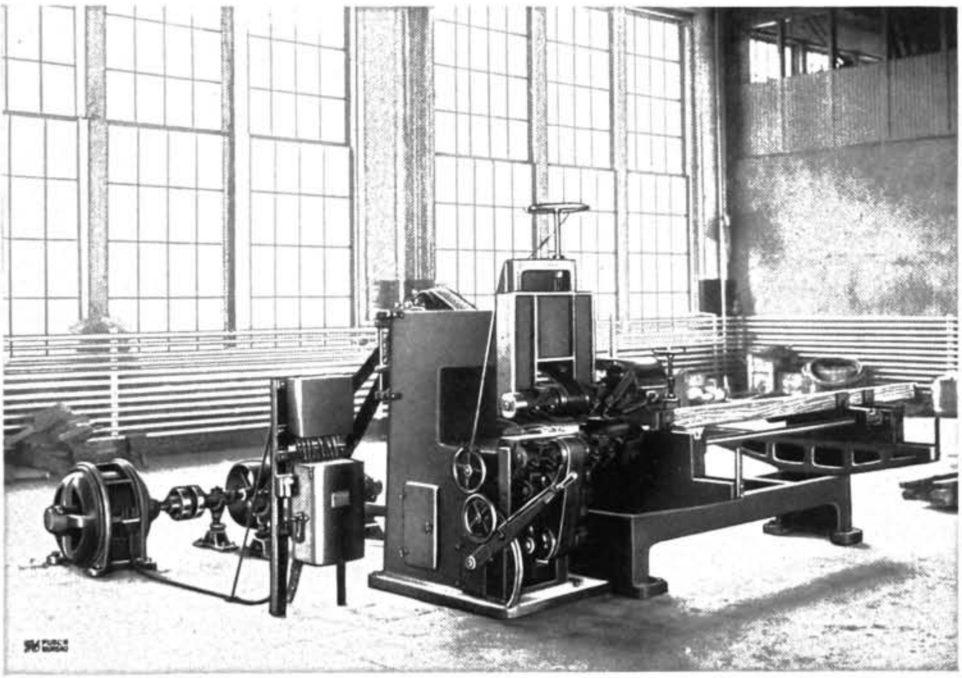
In the construction of a power plant, upon the efficiency and reliability of which the operation of the shops as a whole is primarily dependent, great care should be exercised in the selection of machinery, both as regards viously stated, being for constant speed machinery and lights. The direct current necessary can then readily be supplied from motor-generator sets, composed of direct current generators driven by synchronous motors. A hard and fast rule in engineering can hardly be set down for all cases, but the arrangement, as above outlined, will, in nearly every instance, prove most economical, both from a standpoint of first cost and operating expense.

CONCLUSION

As an indication of the extent to which typical modern railroad shops have adopted electric drive, the following pages give brief illustrated descriptions of the repair shops of a few representative railways. The descriptions cover both old and new shops and exemplify both the group and individual systems of motor drive. It will be noted that while in those shops which have changed over from mechanical to electrical drive, the group system has been retained to a considerable extent in order to minimize the cost of the new equipment, where new shops have been electrically equipped, the individual system of drive has been largely adopted and practically all operations are carried on by means of alternating current motors; the power stations being usually equipped with turbine-driven alternators.

Can you afford to fall behind the times, when each day the opportunity to improve your shops by electrical equipment is presented, insuring increased efficiency and volume of output, and decreasing operating expenses? A first class modern shop will always be a monument to the ability of the man responsible for its installation.

DO NOT BUILD A SHOP TODAY THAT WILL BE OBSOLETE TOMORROW.



15 H.P. 900 R.P.M. INDUCTION MOTOR DRIVING POST TENONING MACHINE
C. C. C. AND ST. L. R. R. COMPANY, BEECH GROVE, IND., SHOPS

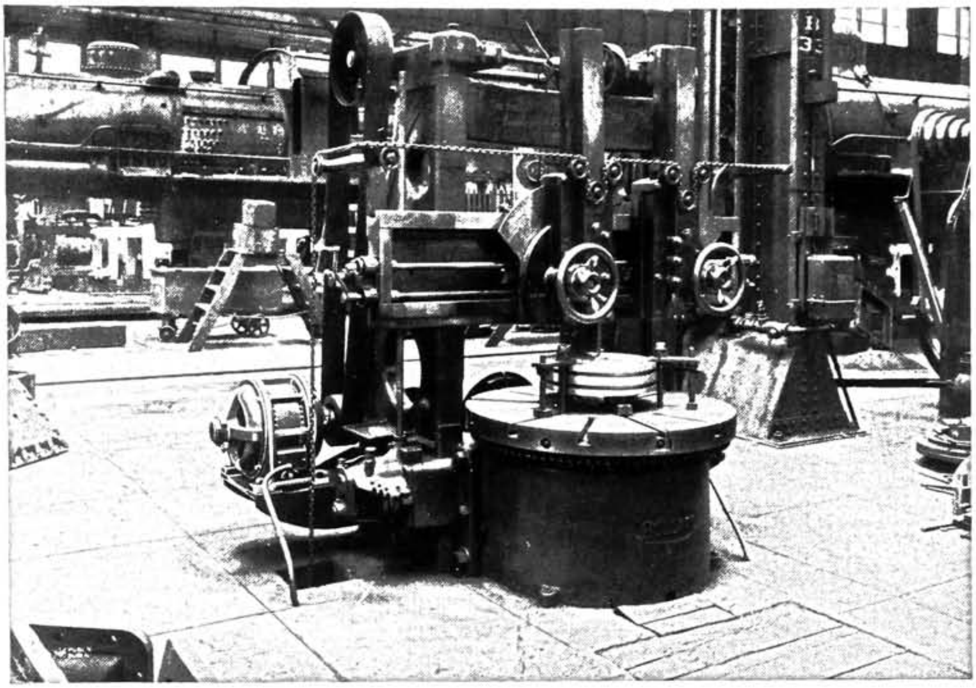
READVILLE REPAIR SHOPS OF THE N. Y., N. H. AND H. R. R.

The main building of the Readville Shops of the New York, New Haven and Hartford Railroad is 900 ft. long by 150 ft. wide and comprises a machine shop, an erecting shop, a boiler shop, and a tank shop. This building is of brick and concrete construction, with structural steel frame.

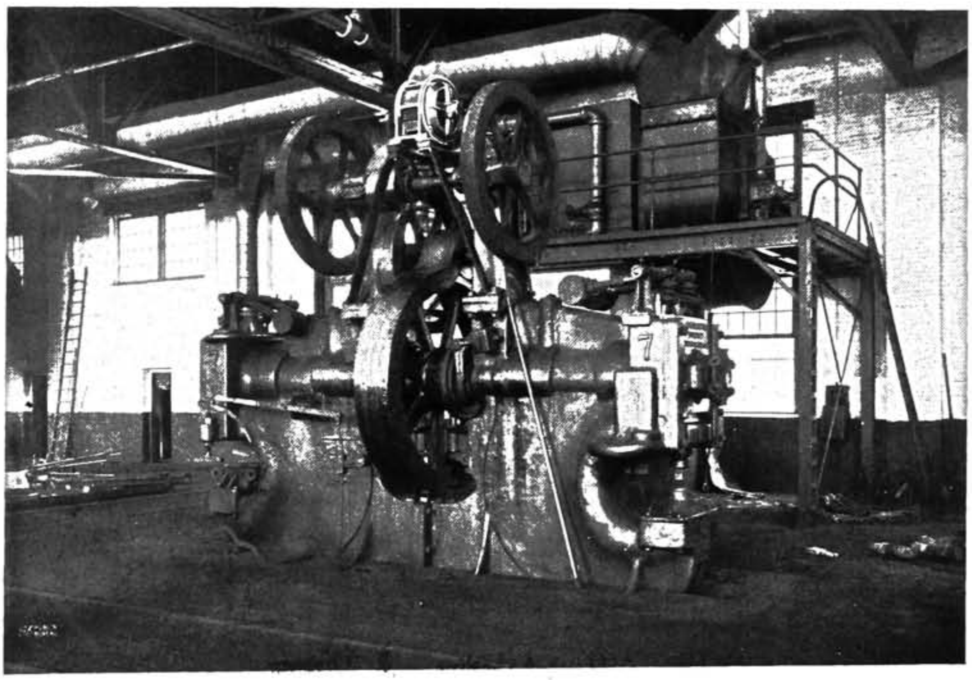
PORTION OF MACHINE SHOP ON THE RIGHT; ERECTING SHOP ON THE LEFT

The erecting shop occupies half the width of the building and two-thirds of its length; it is built on what is known as a longitudinal design, will house 36 locomotives, and can make heavy repairs to 45 locomotives per month. The three longitudinal tracks are spaced on 23 ft. centers, the two outside tracks being used for engine repairs and the middle track for stripping and erecting, also for the storage of driving wheels during the period that the engines are in the shop. Stripping and erecting pits 150 ft. long are located under the center track at each end of the erecting shop, and between the central and outside tracks are storage pits which extend the full length of this shop. These pits are covered with 4 in. by 12 in. yellow pine plank, every tenth plank being provided with heavy malleable iron handles to facilitate its removal.

At the end of the erecting shop and occupying about 300 ft. of the total length of the building, is the boiler shop. These two shops are served by two 60-ton and two 20-ton cranes, the former being used for handling locomotives and the latter for handling boilers and the lighter work in connection

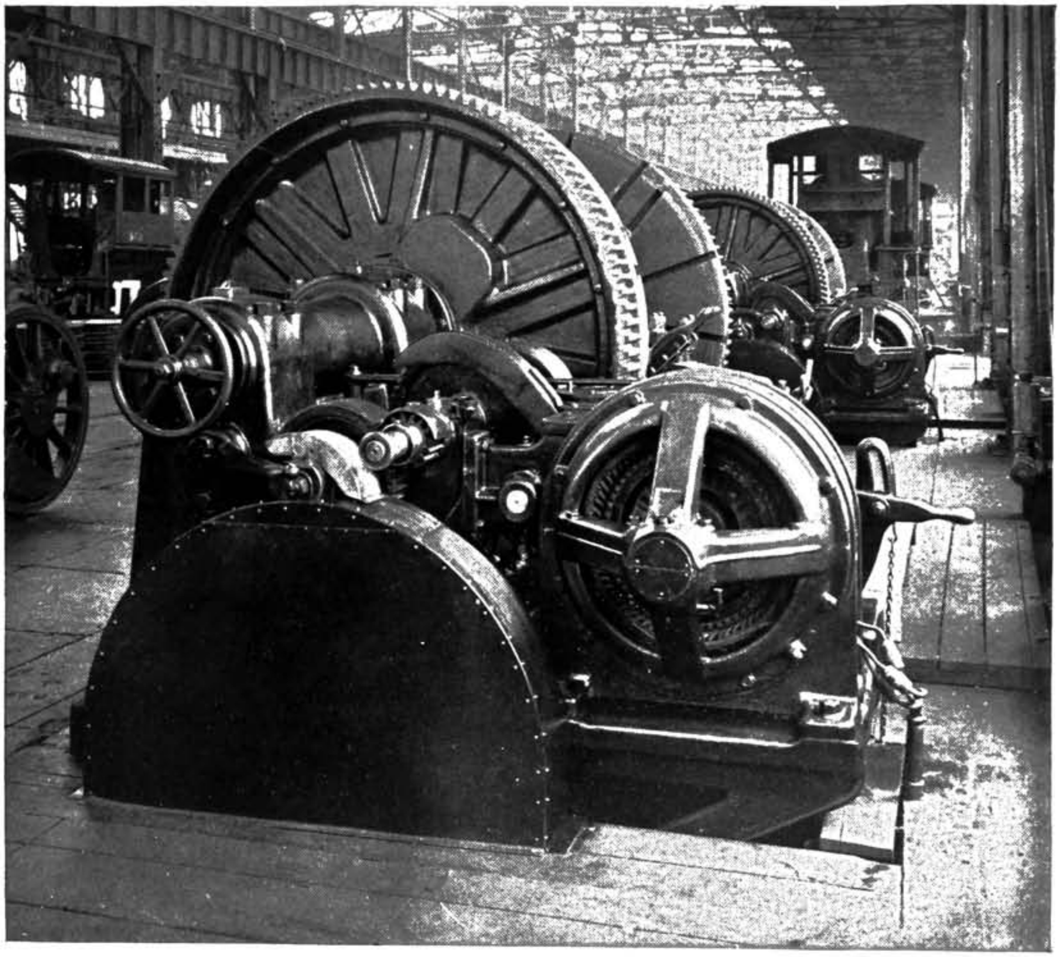


51 IN. BORING MILL DRIVEN BY 7½ H.P., 1750 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR



PUNCH AND SHEAR DRIVEN BY 15 H.P., 750 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR with stripping, erecting, and transferring the various parts. These cranes, as well as all other cranes in the shops, are operated by alternating current induction motors. At one end of the erecting shop are placed driving wheel lathes, large boring mills, etc., to avoid the necessity of handling driving wheels and the heavier locomotive parts between the erecting shop and the machine shop.

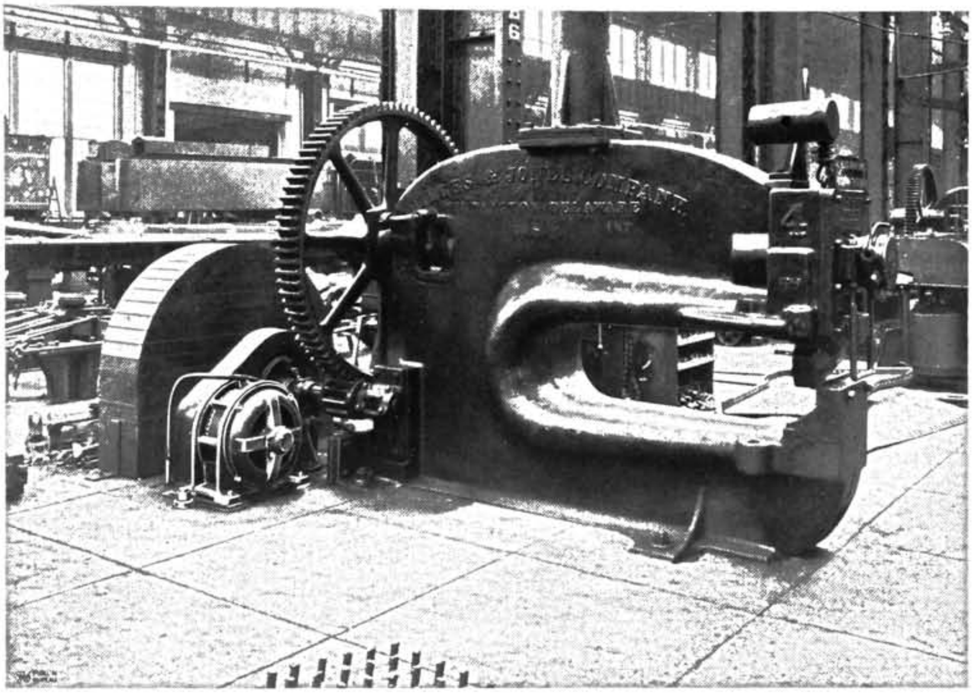
work, electrical repair work, tin and copper work, and cab work. Hatches are located at intervals in the floor and an I-beam trolley is used both for transferring material in the gallery and for raising material from the ground floor to the gallery floor through the hatches. In the gallery are located two Sturtevant indirect radiation heating systems which provide heat for the whole building.



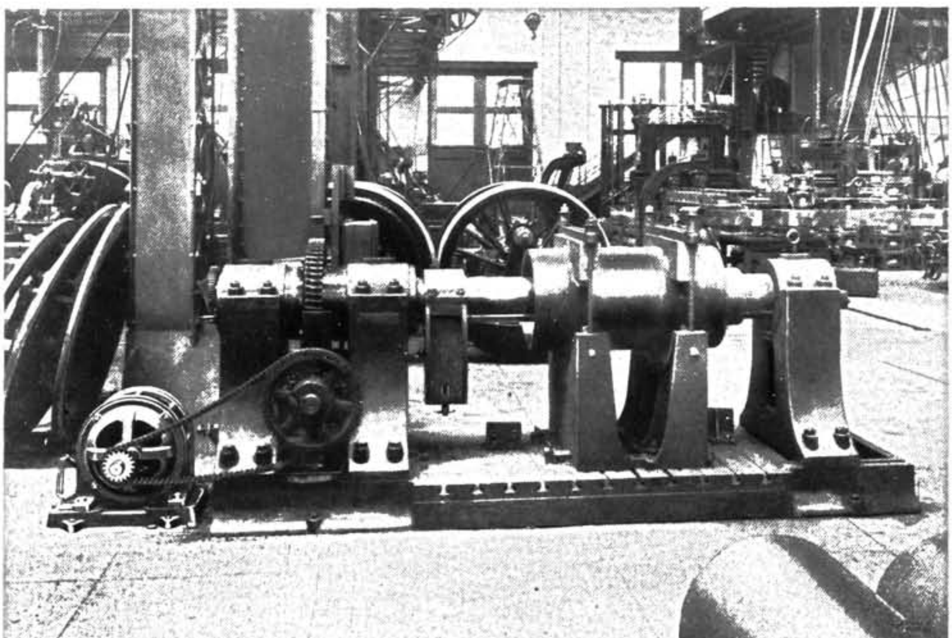
90 IN. DOUBLE WHEEL LATHE DRIVEN BY 50 H.P., FORM K INDUCTION MOTOR

The machine shop is of the same length as the erecting shop and occupies the opposite half of the building. In addition to the ground floor space in this department, there is also a gallery 35 ft. wide, the full length of the building. This gallery is used for brass work, bolt work, lubricator and injector repair

The heavier tools on the ground floor of the machine shop are located outside of the gallery and served by three 10-ton cranes. In addition to the traveling crane service the more important machines have each an independent jib crane, so that material can be handled in and out without the



SHEAR DRIVEN BY 10 H.P., 750 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR



CYLINDER BORER DRIVEN BY 7½ H.P., 750 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR necessity of waiting for the traveling cranes.

Beneath the gallery are located the lighter tools, which are operated in groups from line shafting running the full length of the shop. This line shafting is divided into sections, each section being operated by an

90 IN. 600-TON WHEEL PRESS, OPERATED THROUGH GEARING BY 25 H.P., 750 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR

independent motor. At the dividing point between any two sections is placed a flange coupling with the bolts removed. In case it is desired to take any motor out of service for repairs or other reasons, the bolts can be inserted in the flange coupling and two sections of the shafting run by a single motor; or, by connecting the flange couplings at each end of the section, two motors can be made to operate three sections of shafting.

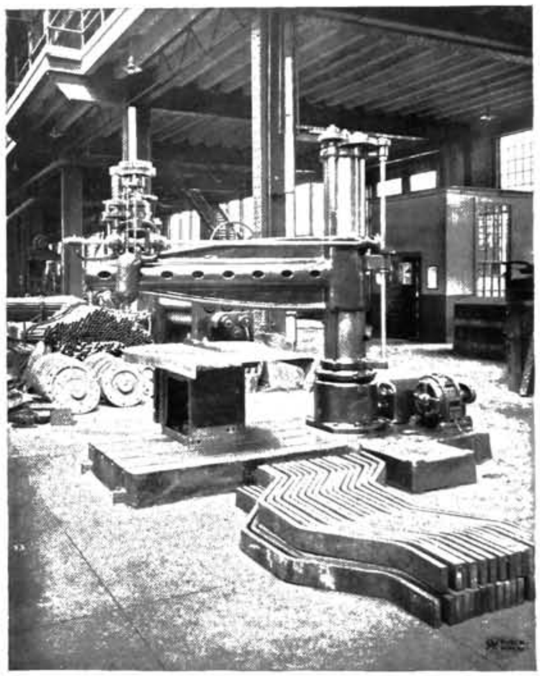
The majority of large tools are independently motor-driven.

There is what might be termed a manufacturing tool room in the gallery, and immediately beneath this is a corresponding room on the ground floor for the distribution and grinding of tools. A central station for a complete shop telephone system is located in the distributing tool room, this arrangement saving the time that would be necessary for mechanics to go to and from the tool room. When any special tool is desired, it is called for by telephone and delivered by messenger, who takes a check as a receipt.

The blacksmith shop is in a separate building paralleling a portion of the erecting shop.

The power plant contains the following equipment:

Six 400 h.p. Babcock & Wilcox boilers, five of which are equipped with mechanical stokers, the remaining one being arranged for burning shavings and refuse from the planing mill. These boilers are provided with Sturtevant economizers.

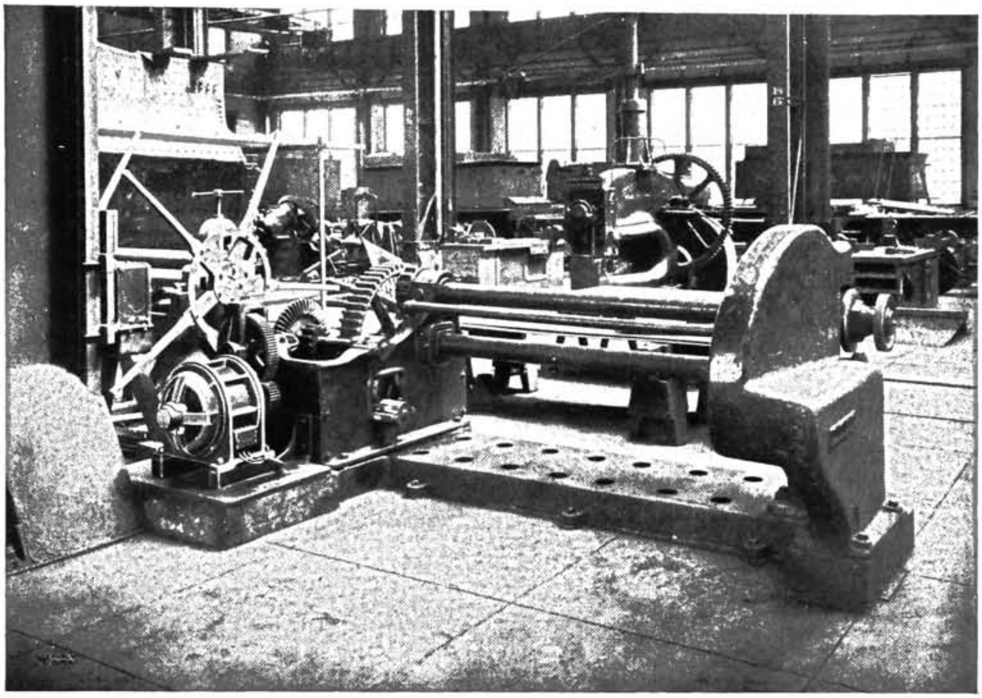


6 FT. RADIAL DRILL GEARED TO 5 H.P., 1500 R.P.M., 550 VOLT FORM K INDUCTION MOTOR

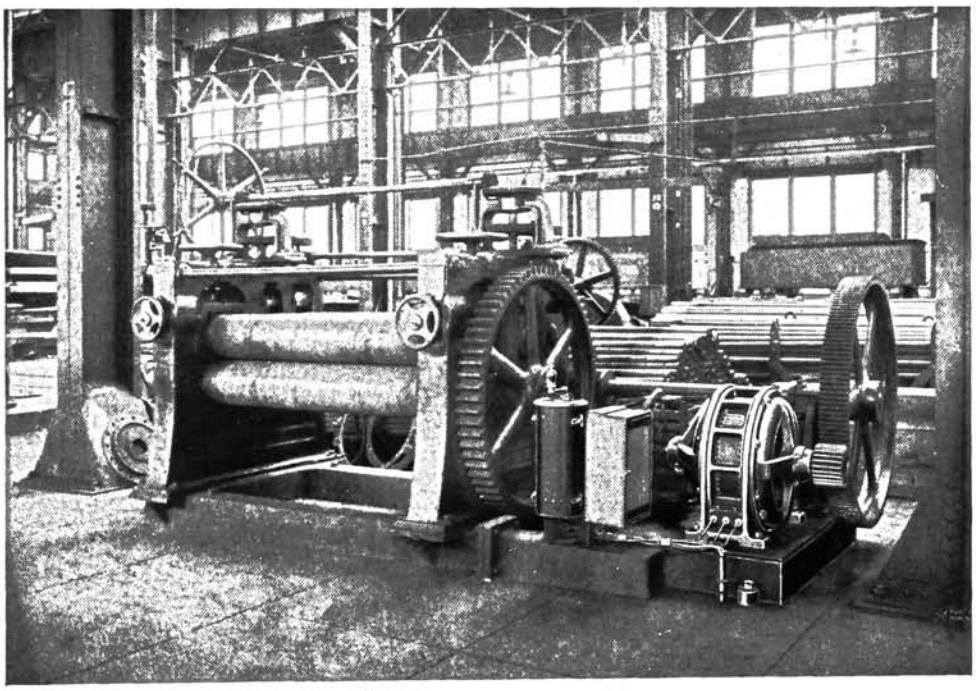
Three 400 kw., 150 r.p.m., 600 volt, 25 cycle General Electric generators direct connected to Hoovens Owens Rentschler Company's cross compound 18 in. by 28 in. by 30 in. non-condensing engines.

Two 50 kw., 280 r.p.m., 125 volt exciters driven by simple Watertown engines.

Two 12-B Brush arc generators direct connected to one 200 h.p., 550 volt motor.



SPLITTING SHEARS DRIVEN BY 7½ H.P., 715 R.P.M., 550 VOLT, FORM K INDUCTION MOTOR



STRAIGHTENING ROLL DRIVEN BY 10 H.P., 450 R.P.M., 550 VOLT, FORM M INDUCTION MOTOR

One 12-B Brush arc generator direct connected to one 100 h.p., 500 r.p.m., 550 volt motor.

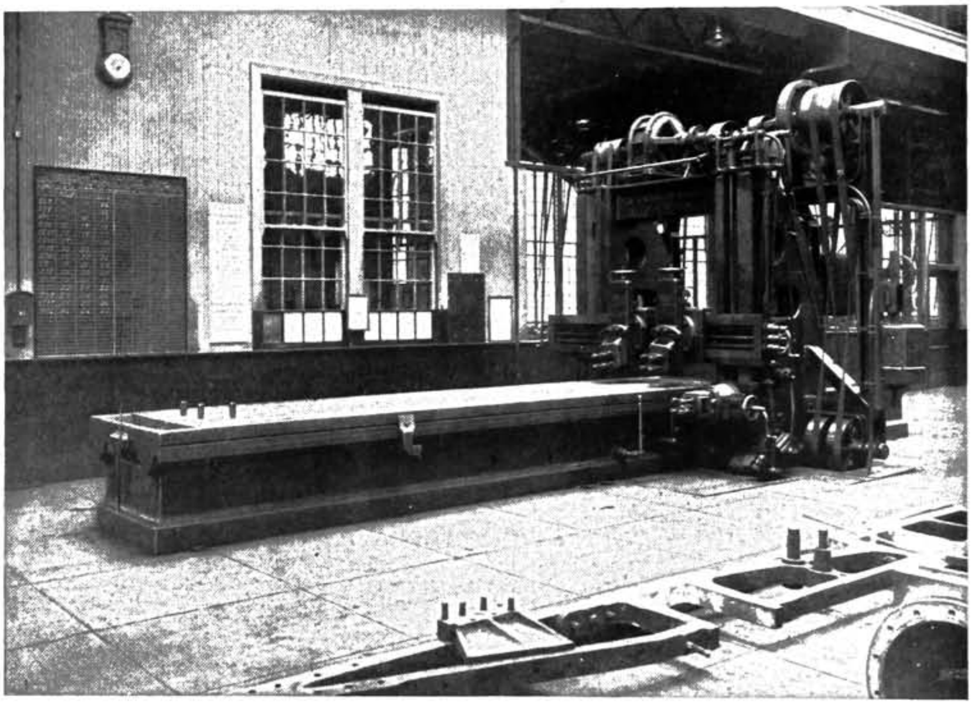
One 24 panel blue Vermont marble switchboard, equipped with General Electric Type TA voltage regulator.

One Franklin cross compound air compressor with a capacity of 1700 cubic ft. of free air per minute. Two Franklin air compressors with a capacity of 1100 cubic ft. of free air per minute.

In addition to the building described above, there is a car department, which was, however, built a number of years ago. The machinery in this department is operated throughout by motors receiving current from the central power station.

This entire plant is operated by 25 cycle alternating current, the only direct current apparatus being the exciters for the alternating current generators.

In the various departments are installed 173 motors with a total capacity of 3160 h.p., all of which are of General Electric manufacture. The average motor load at the switchboard varies from 600 to 700 kw., the average lighting and power load combined varying from 800 to 900 kw. It is therefore seen that the percentage of average load to total capacity of motors installed is about 30 per cent. The power-factor throughout the day time is about 69 per cent., increasing to 71 or 72 per cent. when the lights are placed in operation.



5 FT. BY 20 FT. PLANER DIRECT CONNECTED TO 35 H.P., 750 R.P.M., 550 VOLT FORM K INDUCTION MOTOR

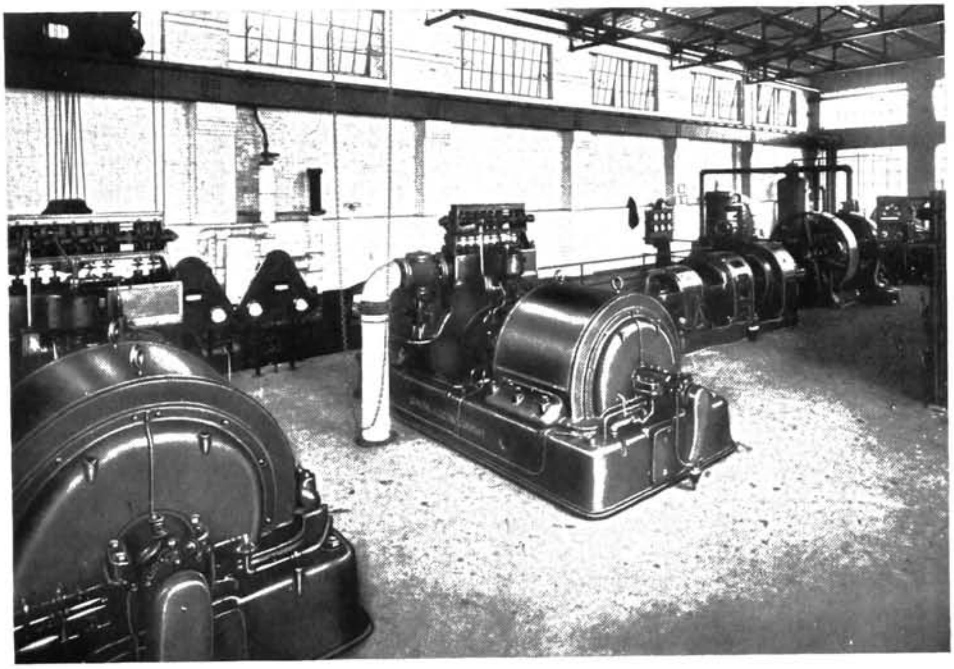
ROCK ISLAND SHOPS, CHICAGO, ILL.

An excellent example of the conversion of a railroad shop from mechanical to electrical drive is found in the repair shops of the Chicago, Rock Island & Pacific Railroad, which are located at the Chicago terminus in the southern part of the city, along the main line of the road.

Prior to the installation of the present equipment, these shops were operated by means of four isolated boiler plants and three engines, which drove the machinery through long lines of shafting and belting, thereby involving the loss, through friction, of a large percentage of the initial power developed.

It was decided to supersede this system of power application by the construction of an up-to-date central generating station, with sufficient boiler capacity to operate the generating equipment and also to supply steam for the coaches standing in the yard, in cold weather.

The electrical equipment in the power station comprises two General Electric horizontal turbo-alternators rated at 500 kw. at 80 per cent. power-factor; these operate non-condensing on 150 lb. of steam at 3600 r.p.m., and supply three-phase power circuits at 480 volts. Excitation for the turbo-alternators is supplied by means of a 100 kw. 125/250 volt direct current engine-driven generator which was part of the original equipment and is now used as an exciter when starting up the plant. After the turbines are in operation, however, they are excited from a motor-generator set, which consists of three direct connected units mounted on a common base. The driving motor is rated at 190 h.p., is of the synchronous type, and operates at the generator voltage. There are two direct current generators; one of 100 kw. capacity three-wire at 125-250 volts, the other being 25 kw. two-wire, 125 volts, this latter unit normally supplying the exciting current, while the larger unit is utilized for the lighting system of yards and also serves a few direct current motors.



TWO 500 KW., 3600 R.P.M., TURBO-ALTERNATORS AND MOTOR-GENERATOR EXCITER SET IN POWER STATION

The machinery in the power station is compactly arranged, as shown in the accompanying illustration, and all the principal apparatus is contained in one room and on one level, while the accessories are installed in the basement.

In providing the shops with motor drive, three-phase alternating current motors have been used almost entirely and current is supplied to the various power circuits at the generator voltage. There are, in all, thirty-five motors, ranging from 1½ h.p. to 50 h.p. in capacity, the aggregate rating being about 1000 h.p. Both the group and individual systems of motor-drive are used, there being approximately twenty-two examples of the former and thirteen of the latter.

In the operation of the individually driven machines, the power losses entailed by belts and countershafts have been practically eliminated, and while it was necessary in this case to minimize the cost of change over from mechanical to electrical drive by retaining the group system for a considerable portion of the machinery, these remaining groups have short shafts, as compared with the engine-driven system, and the motors are located so that they deliver their energy through relatively short belts to the centers of the countershafting, thereby greatly reducing the friction power losses. The shorter shafts can be more readily maintained in true alignment and the actual power consumed for each group can be readily determined by connecting a meter in the individual motor circuits, so that any injury to the machinery, which would involve unnecessary friction loss can, in this way, be readily detected.

As none of these motors exceed 50 h.p. in capacity, they are light in weight and do not require special foundations, and, in the Rock Island shops, most of the motors utilized for group drive are installed on brackets mounted on the wall, near the ceiling, or centrally located on the ceiling beams, and their application in this way did not necessitate a re-arrangement of the machinery, thereby tending to minimize the cost of the change over.

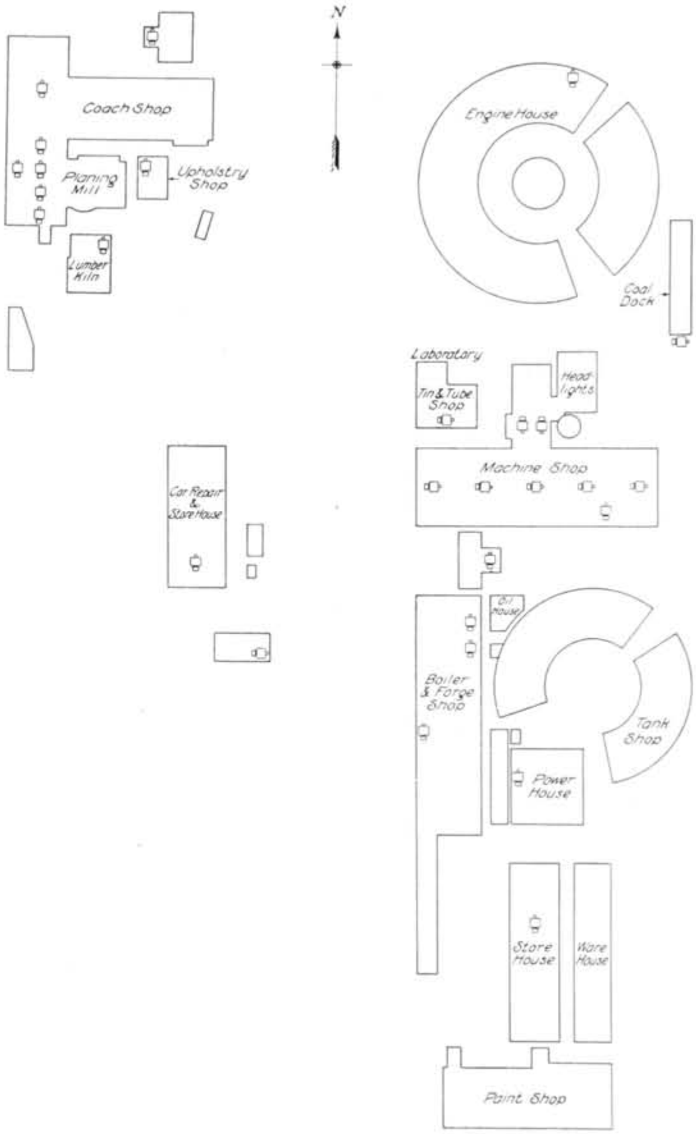
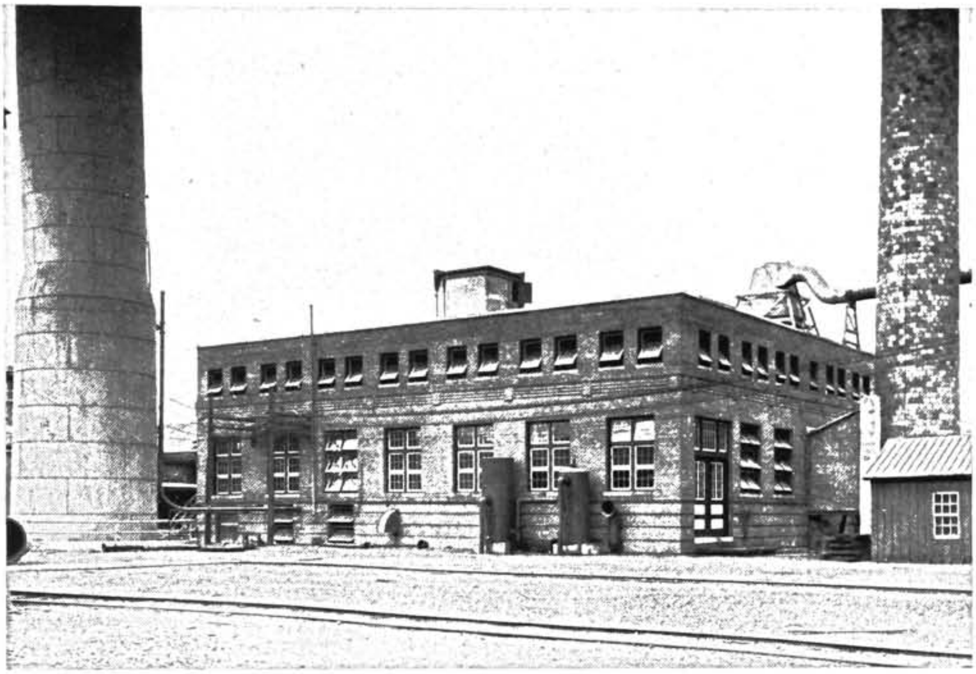
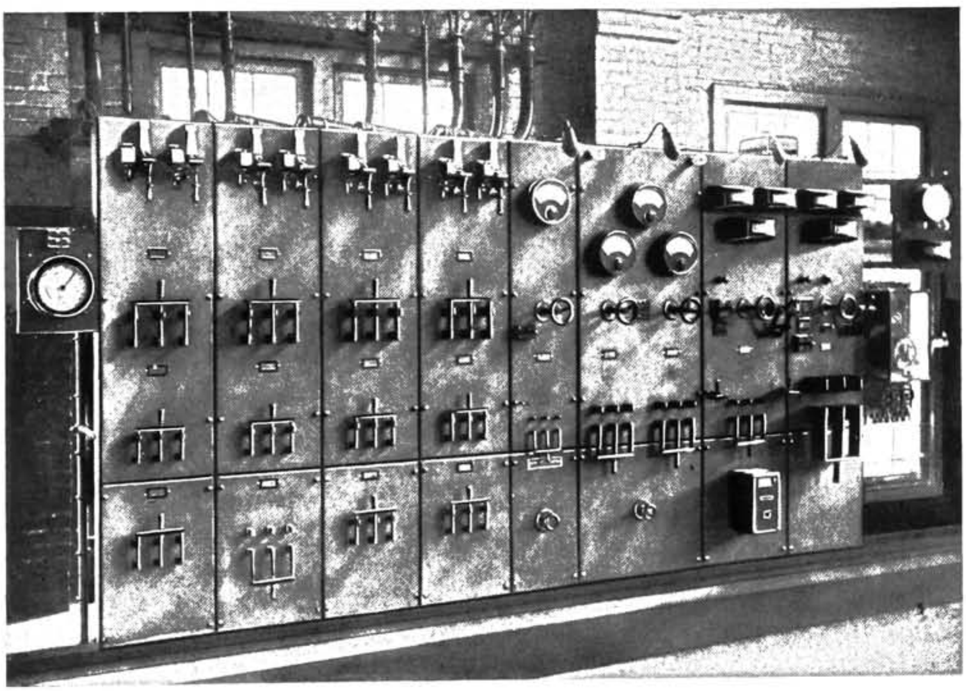


DIAGRAM SHOWING DISTRIBUTION OF INDUCTION MOTORS IN SHOP BUILDINGS

The entire equipment was designed and installed by the Arnold Company of Chicago, the new power station apparatus and about 85 per cent. of the rated capacity of the motors being of General Electric manufacture.



POWER STATION, CHESAPEAKE & OHIO RAILROAD SHOPS, HUNTINGTON, W. VA.



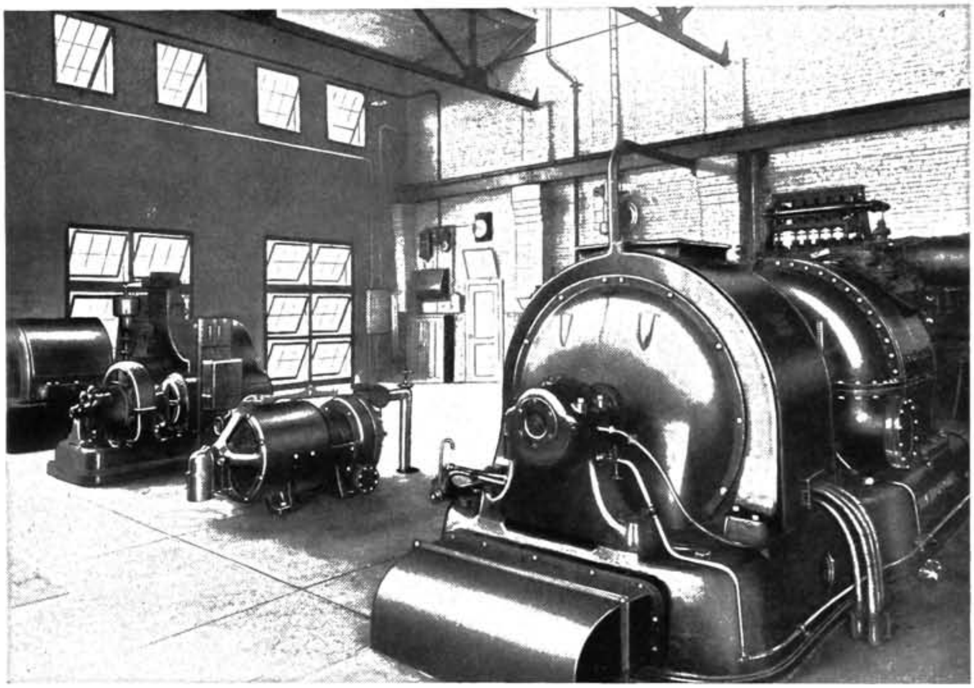
MAIN SWITCHBOARD IN POWER STATION, CHESAPEAKE & OHIO RAILROAD SHOPS, HUNTINGTON, W. VA.

HUNTINGTON, W. VA., SHOPS OF THE CHESAPEAKE & OHIO RAILWAY COMPANY

These shops were originally established in 1872 and the equipment has been added to from time to time, meeting the growing demands of increased traffic. At present the shops handle all repair work on locomotives and cars for both freight and passenger service on the West Virginia general division of the railroad. This group of shops is the largest on the system, its normal operating force being about 2000 men.

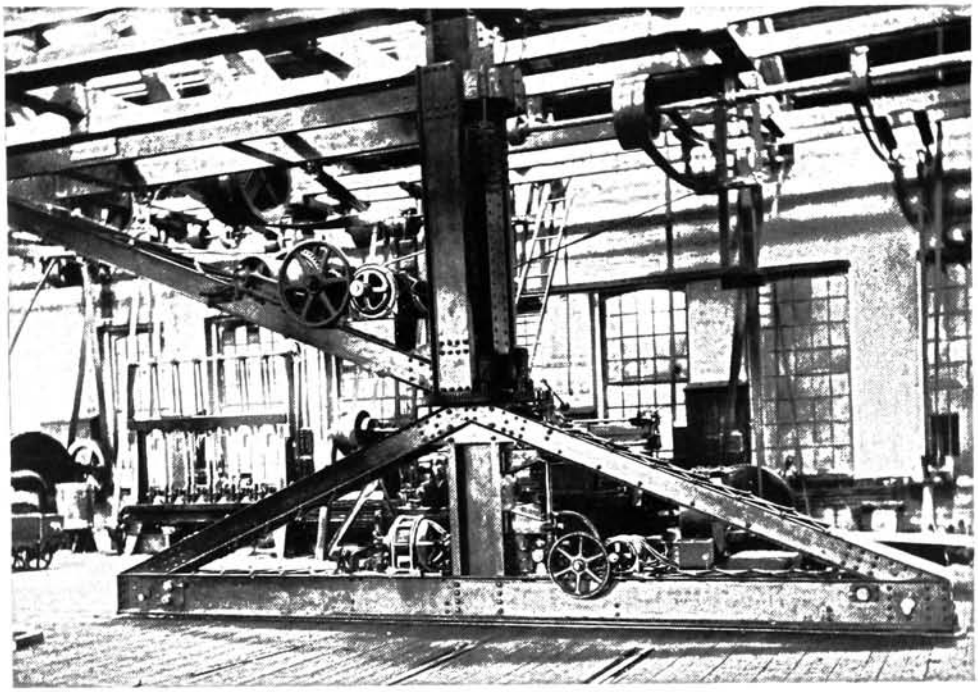
Prior to 1910 power for all operations was supplied by means of six steam engines supplied from locomotive boilers located at various points in the yards. This method involved a heavy expense for labor and maintenance, while belting, and line shaft losses consumed a large percentage of the power developed. The old system of power distribution was superseded on March 10, 1910, when the present power station was placed in service. With the exception of two engine-driven compressors in the power station, the feed water pumps and steam hammers, all machinery is operated electrically.

The generating equipment includes two 750 kw., 480 volt, three-phase, 60 cycle Curtis steam turbine-driven alternators rated as above at 80 per cent. power-factor, and operated condensing, with a steam pressure of 150 pounds, and a vacuum of from 27 to 28 inches.

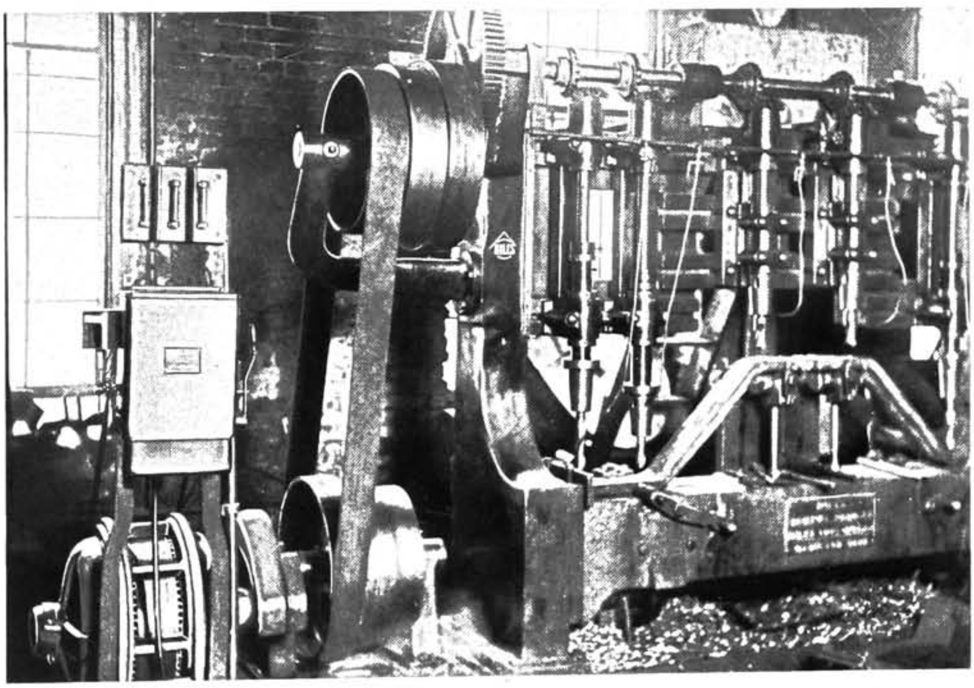


TWO 750 KW., THREE-PHASE, 60 CYCLE, 480 VOLT TURBO-ALTERNATORS WITH TURBINE DRIVEN AND MOTOR-GENERATOR EXCITERS IN POWER STATION

Exciting current is supplied by a 25 kw., 125 volt, 3600 r.p.m. turbo-generator for starting, but after the alternators have come up to speed excitation is accomplished by means of a motor-generator exciter set consisting of a 35 h.p. 440 volt motor, driving a 23 kw., 175 volt generator; the set operating at 1200 r.p.m. The switchboard is provided with a Tirrill regulator and a curve drawing voltmeter, and current is supplied to the various



TRAVELING JIB CRANE IN BOILER SHOP OPERATED BY THREE INDUCTION MOTORS

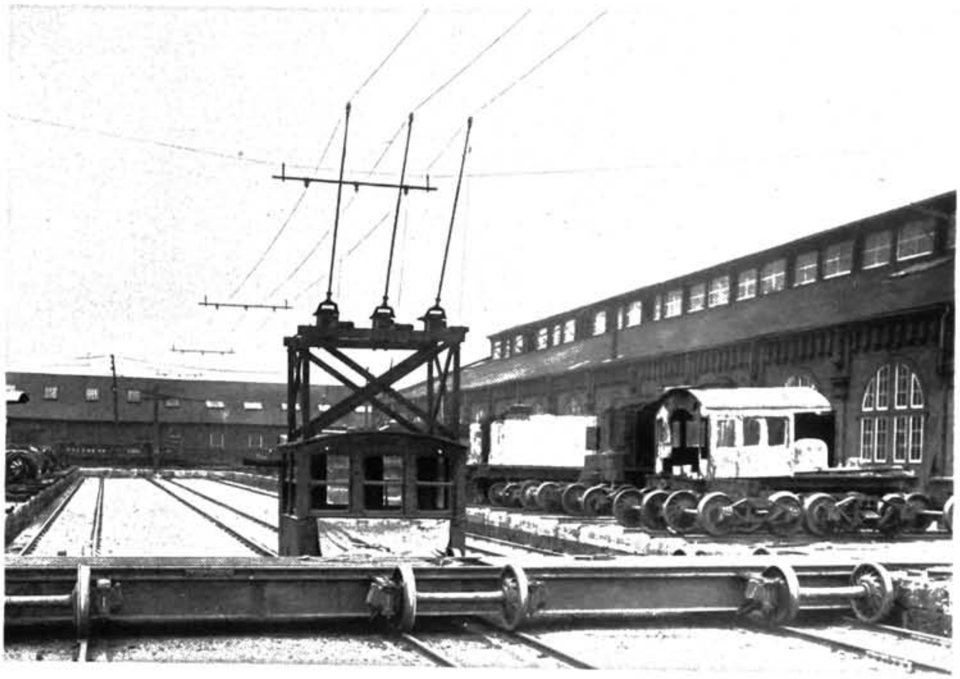


15 H.P. INDUCTION MOTOR DRIVING FIVE-SPINDLE ARCH BAR DRILL IN BLACKSMITH SHOP

motors at a potential of 470 volts during the working hours (from 7 a.m. to 3:30 p.m.) and at 460 volts at other times, the voltage variation being secured through the Tirrill regulator; no transformers being used for the power circuits, although there are a number of small units serving the lighting system.

Alternating current motors are used throughout and the General Electric 440

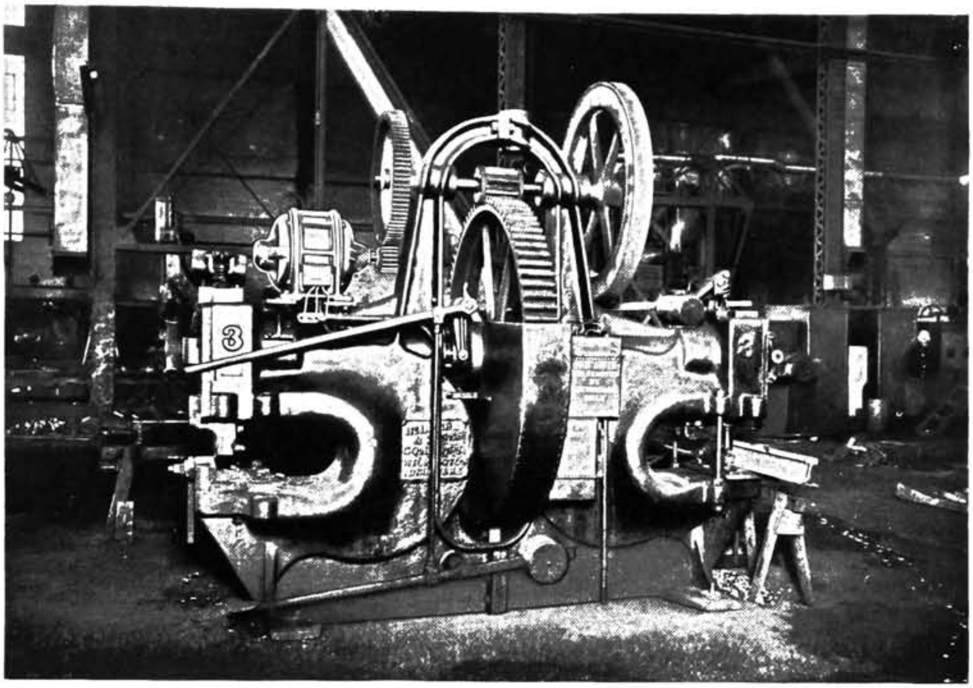
In applying the motors both the group and individual systems of drive have been employed. There are in all 55 motors, aggregating 1175 h.p. in capacity, and the present demand on the power station averages about 170,000 kw-hr. per month. The cost, including fuel and water charges, labor and superintendence, maintenance, interest and depreciation, averages about six-tenths of a cent. per kw-hr. at the switchboard.



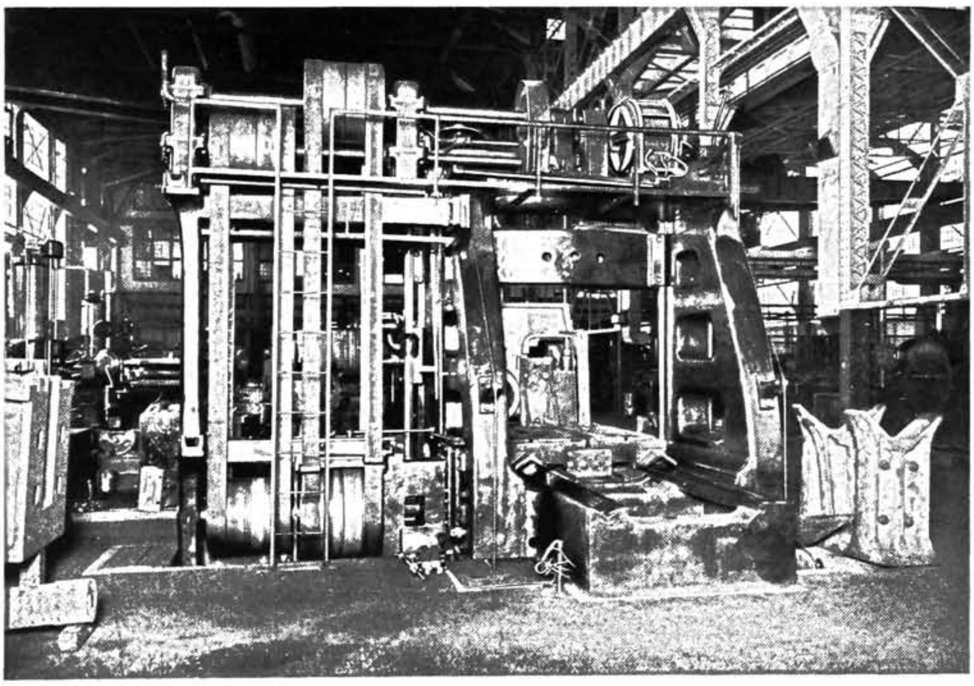
TRANSFER TABLE DRIVEN BY A 10 H.P. FORM K INDUCTION MOTOR

volt, Form K motor has been adopted as a standard. At the present time no synchronous motors are used, but their use for supplying auxiliary air service is contemplated, inasmuch as they can then be utilized as phase modifiers to improve the power-factor of the system, which, due to the operating conditions, is at present maintained at about 70 per cent. Current is transmitted to the various buildings over pole lines and the yards are lighted by forty-five 110 volt General Electric multiple arc lamps operated in local transformer groups.

Since it was started the present system has been in continuous service, there having been no interruptions due to the electrical equipment. As an indication of the efficiency of the turbines, the operating records show that one unit has been in continuous service (24 hours per day) for the past year. All the electrical apparatus in the power station and about 90 per cent. of the motors are of General Electric manufacture, while the system was designed and all construction work performed by Westinghouse-Church, Kerr & Company.



7½ H.P., TYPE I FORM K MOTOR DRIVING COMBINED PUNCH AND SHEAR IN BLACKSMITH'S SHOP
WEST ALBANY SHOPS OF THE N. Y. C. & H. R. R. CO.



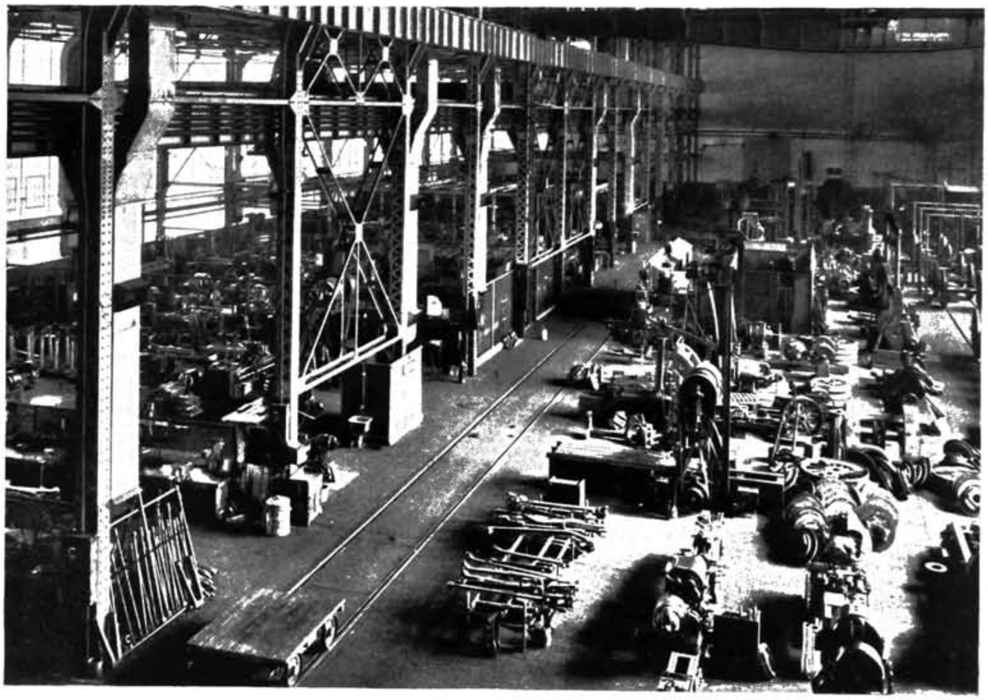
50 H.P., TYPE I FORM K MOTOR DRIVING 60 IN. BY 60 IN. PLANER IN MACHINE SHOP
WEST ALBANY SHOPS OF THE N. Y. C. & H. R. R. CO.

THE WEST ALBANY SHOPS OF THE N. Y. C. & H. R. R. CO.

The West Albany shops handle all locomotive and car repair work for the Mohawk Division of the New York Central Railroad. They are the largest shops on the system, normally employing about 2700 men, and their electrical and mechanical equipment represents the most up-to-date engineering practice. Electricity is used for all power applications except the operation of air hoists, steam hammers, large air compressors in the power station, and the boiler feed system, which is operated by means of a steam turbine. There are in all 269 motors, aggregating 3678 h.p., of which 198 motors—with a total rated capacity of 2868 h.p.—are of the three-phase alternating type.

In a large majority of applications the individual system of drive has been adopted, although there are a few small groups for which the total demand is less than 200 h.p. The present system of electric drive was adopted in 1904, and the original installation has been added to from time to time to meet the growing demands for increased output.

The power station is equipped with two 600 kw. and two 500 kw., three-phase, 60 cycle, 480 volt engine-driven alternators, supplemented by two 35 kw., 250 volt, direct current generators, and a 100 kw. alternating current-direct current motor-generator set, these three units being used as exciters.



GENERAL VIEW OF MACHINE SHOP, LOOKING EAST

There are also two 300 kw., 250 volt generators, direct driven by 35 kw., 440 volt synchronous motors, the output of these sets being utilized for the operation of the direct current motors in the shop. For night service a 75 kw., 250 volt direct current generator direct driven by a 100 h.p., 440 volt motor is used.

Power is distributed to the various shop buildings through insulated cables, the conductors being carried on substantial structural steel towers in the immediate vicinity of the power station supplemented by wooden pole lines in the yards. Current is distributed at the generator voltage, and all alternating current motors are designed for operation at

VIEW LOOKING SOUTH SHOWING STEEL TOWER TRANSMISSION LINE, WITH POWER HOUSE IN BACK GROUND, AND WEST END OF MACHINE SHOP AT THE LEFT

440 volts. The power demand averages about 300,000 kw-hr. a month, and the cost for current delivered at the switchboard varies from 0.7 to 0.8 of a cent. per kilowatt-hour.

The arc lighting circuit totals 900 kw. at 2300 volts, being stepped up from 480 volts through air-cooled transformers, and down to 110/220 volts on a three-wire system for use in the shops. There are no motors on the lighting circuits, the lines being separate.

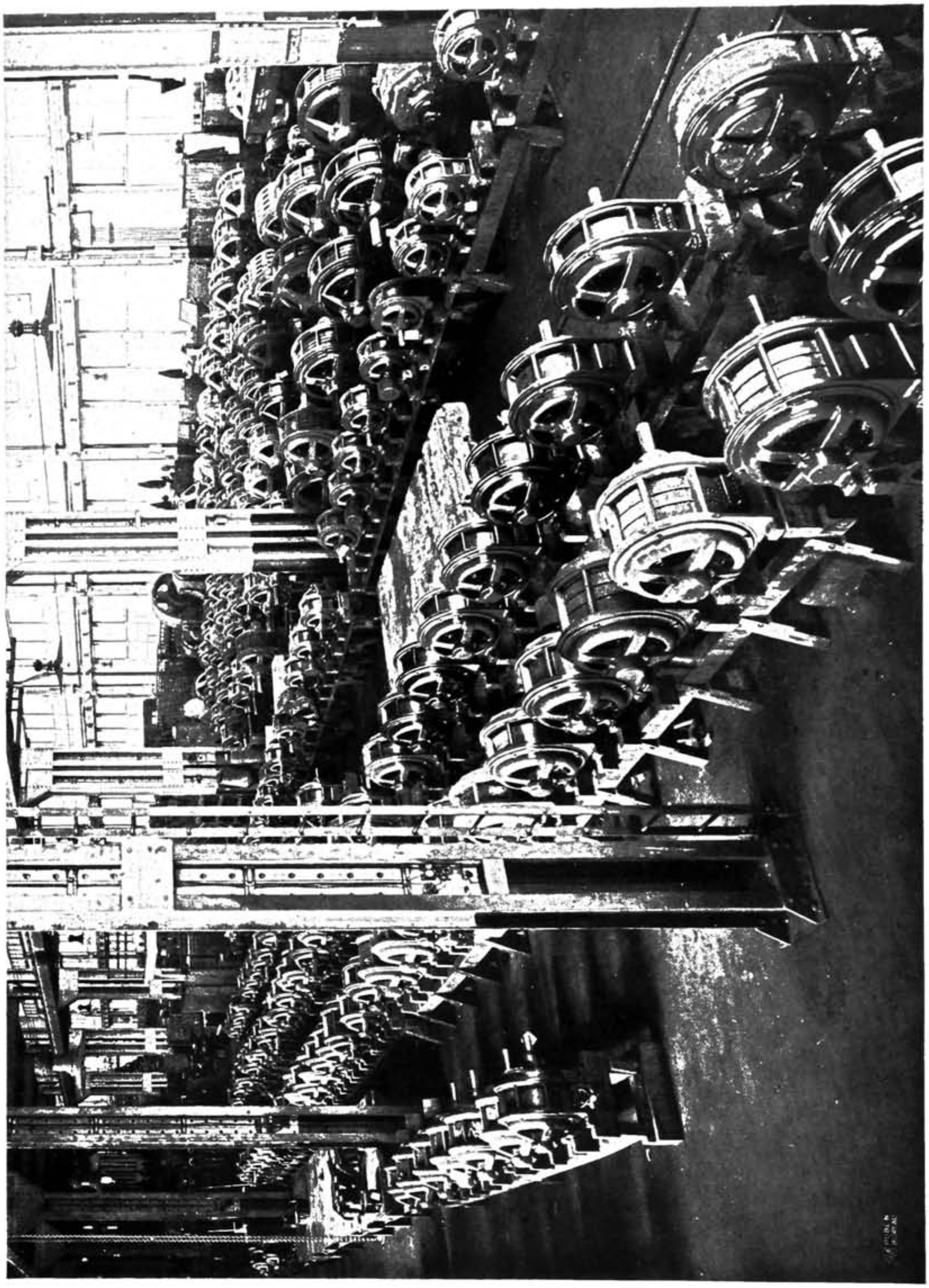
All indoor wiring is carried in iron conduit, and the fuses for the various motor circuits are grouped in heavy sheet iron boxes. From the power house the conductors are carried to distribution panels located in each shop, and from that point are distributed to the various groups of motors. For the operation of the numerous cranes ranging from 5 to 120 tons in capacity, both alternating and direct current motors have been used, the General Electric Form M induction motor being utilized on all alternating current cranes.

Approximately 90 per cent. of all the electrical apparatus is of General Electric manufacture.

7½ H.P. TYPE I FORM K MOTOR DRIVING 300 POUND HAMMER IN BLACKSMITH'S SHOP

MOTOR DISTRIBUTION

Department	System of Drive	ALTERN'NG CURRENT		DIRECT CURRENT	
		No.	H.P.	No.	H.P.
Locomotive .	Individual	100	1319	67	735
Locomotive .	Group	7	145	..	...
Car shop . .	Individual	87	1353	4	75
Car shop . .	Group	4	51	...	...
Total . .	. . . .	198	2868	71	810



INDUCTION MOTORS ASSEMBLED IN PAINT SHOP AT THE SCHENECTADY WORKS OF THE GENERAL ELECTRIC COMPANY

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E. C., England, 83 Cannon St.

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

General Electric Company

Schenectady, N.Y.

SUPPLY DEPARTMENT

June, 1912

Bulletin No. 4960

LIGHTNING ARRESTERS FOR ELECTRIC RAILWAYS

The protection of electric railway equipment from damage by lightning and the consequent repair expenses, interruption of service, and loss of traffic, are matters for serious consideration. In some localities the fear of damage is so great that during lightning storms, cars are stopped, trolleys pulled from the wires and the crews remain idle until the storm has passed; the passengers impatiently await the resumption of the service or disgustedly walk. On most street railway systems there is some interruption of service during lightning disturbances, and the consequent loss of patronage and good will is considerable. This trouble could be practically eliminated by the installation of the proper lightning arresters.

TYPE M FORM D-2 ARRESTER

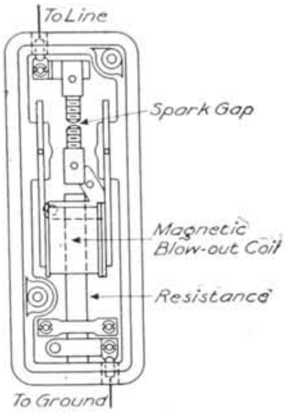
TYPE M FORM D-2 ARRESTER SHOWING INTERIOR

As the lightning arrester is of the nature of insurance, only the best should be considered. Arresters which do not protect are worthless, and, regardless of first cost, will prove the most expensive in the end. Since the beginning of electric railway work the General Electric Company has studied the problem of protecting railway equipments with the result that actual experience shows conclusively that G-E arresters do protect. Lightning arresters are supplied with every railway equipment and it is of the utmost importance that they be of a kind that will afford the necessary protection.

For the protection of electric railway equipments, the General Electric Company offers two types of arresters, the magnetic blowout (Types MD-2 and ME), and the aluminum arrester. Of these two types, the aluminum arrester gives more nearly perfect protection, and the magnetic blowout only a slight degree less. The type to use depends upon the conditions to be met.

For average conditions, the magnetic blowout type of arrester will be found to give the desired protection. This type is supplied with all General Electric railway equipments. Where lightning disturbances are exceptionally severe, so that the problem of lightning protection becomes of vital importance, the selection of the aluminum arrester will be found advisable.

While the aluminum arrester is built to withstand the rigors of railway service, it has certain inherent characteristics which compel attention and inspection. The use of the aluminum arrester for the protection of car equipments is advisable only where the problem of protection is of such importance that the arresters will receive the attention necessary to keep them in good operating condition. They should always be used for the protection of generators and rotary converters. Magnetic blowout arresters should be placed along the line at intervals of at least four per mile and either the aluminum or the magnetic blowout arresters on the cars.



CONSTRUCTION OF TYPE M FORM D-2 ARRESTER

MAGNETIC BLOWOUT ARRESTERS

The magnetic blowout arrester has always been the standard railway arrester. Years of service testify to its undoubted excellence. The construction of the 600 volt arrester (MD-2) is shown in the accompanying diagram.

It consists of an adjustable spark gap in series with a resistance. Part of the resistance is in shunt with a blowout coil, between the poles of which is the spark gap. The parts are mounted in a strong, porcelain box, which, for car and pole use, is in turn mounted in a substantial, asbestos lined, wooden box.

How the Arresters Operate

When the lightning potential comes on the line, it causes the spark gap to break down and a discharge occurs through the gap and the resistance rod to ground. Part of the current shunts through the blowout coil, producing a strong magnetic field across the spark gap. The magnetic field blows out the discharge arc and restores normal conditions.

The resistance is only 60 ohms (for 500 volt rating work), and the spark gap only one-fortieth of an inch (0.025 in.).

The resistance material is of carborundum which will not crack or blister under the heat of the current, *and which at the same time will retain its resistance.*


TYPE M FORM D-2 ARRESTER IN WOODEN BOX FOR OUTDOOR SERVICE

The blowout coil is not in the main circuit, but merely shunts it. It is firmly fixed in position, and the blowout magnet is so mounted over the spark gap that the arc is blown out of the arc chute.

The arrester can be readily inspected by simply pulling off the porcelain cover which is attached with clips. The spark gap is attached to the cover and is easily adjusted. It has the following important characteristics:

Small spark gap (0.025 in.).

Low series resistance (about 60 ohms for 500 volts).

Discharge arc blown out by magnetic field.

The greater the discharge the stronger the blowout, and it acts as quickly as lightning.

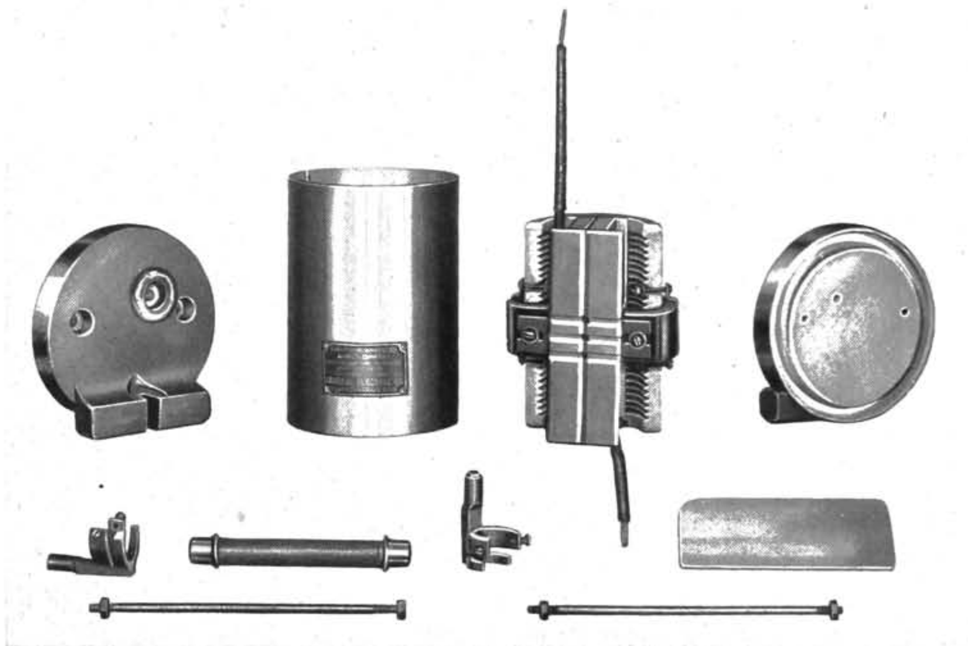
TYPE M FORM E ARRESTER FOR LINE USE

Magnetic blowout always ready for discharges, no matter how rapidly in succession they occur.

No moving parts.

Direct path for lightning discharge.

Mechanical construction unquestionable.



TYPE M FORM E ARRESTER, DISASSEMBLED

They stand the test of time and service.

Easy to inspect.

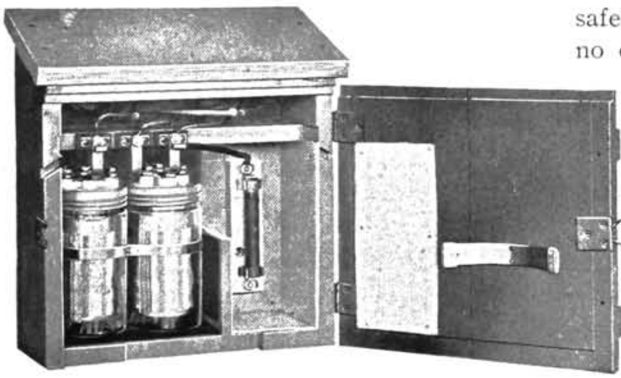
The Type M Form E arrester consists essentially of a small spark gap which is in series with a resistance, and between the poles of a magnet. The operation is similar to that of the MD-2 arrester but the magnet is a permanent and not an electro magnet. The spark gap and the magnet are mounted within porcelain blocks in such a way that the discharge arc is blown by the magnet through an arc chute and a cooling grid which is also held by the porcelain. The cooling grid in the arc chute materially assists the magnet in extinguishing the discharge arc, giving the arrester a high arc rupturing quality. The series resistance rod is of carborundum and is connected externally to the other portion of the arrester, as shown in the accompanying illustration.

The arrester is self-contained, no protecting box being necessary for line use. In order to arrange the magnet, spark gap, arc chute and cooling grid to secure the maximum arc rupturing power and the minimum value of spark gap, and also to do away with the protecting box, it was necessary to closely adjust the various parts and the porcelains are therefore sealed together to prevent the likelihood of subsequent changes. This, of course, makes inspection of the operating parts impossible, but thorough and exhaustive tests under conditions seldom met in practice, show that the operation is perfect and that there is no necessity for inspection. In order to provide for the remote contingency of injury to the working parts a sort of safety valve in the form of the external resistance exists, which will fail and clear the line. The advantage of this is that arresters along a line of railway can readily be inspected by looking them over from a car to see whether the resistance rods are intact.

For car use the arresters are provided with substantial weatherproof boxes to protect them against mechanical injury.

The ME Arrester is more efficient than the MD-2, having a much lower series resistance, a more sensitive spark gap and greater arc rupturing power.

THE DIRECT CURRENT ALUMINUM ARRESTER



DIRECT CURRENT ALUMINUM ARRESTER CONNECTED

The 600 volt direct current aluminum arrester for car use consists of two aluminum cells in series and arranged for connection between the line and the ground. The flow of current through the cells keeps a film formed on the aluminum plates at the normal voltage. The leakage current is only a few mil-amperes, but when the potential is suddenly raised, due to lightning or similar disturbances, the excess potential is relieved by a current flow through the arrester limited only by the internal resistance of the cells, which is extremely low. The arrester operates somewhat like the safety valve of a steam boiler, which allows no escape of steam at normal pressures but permits a free escape when the pressure is excessive. In series with the cells is a fuse, and in multiple, a high resistance coil which balances the voltage across the cells. The connections are such that by merely removing three nuts the cells may be taken from the box, thus facilitating inspection. The box is well padded to prevent breakage. Evaporation of the electrolyte is entirely prevented by a layer of oil on the surface of the electrolyte.

DIRECT CURRENT ALUMINUM ARRESTER DISCONNECTED

SELECTION OF ARRESTERS

For the protection of railway generating equipment and rotary converters, use aluminum arresters.

For the protection of station apparatus, one direct current aluminum arrester should be installed on each outgoing feeder; the total number of arresters should be such that there is one arrester for approximately each 500 kw. of station capacity. If arresters in excess of the number required on the feeders are necessary to provide for a large station capacity, the additional arresters should be connected directly to the generators.

For the protection of rotary converters against lightning and electromagnetic surges, aluminum arresters should be connected directly to the direct current end of the rotary, the size of the arresters depending upon the capacity of the rotary. Special arresters consisting of several cells in series are designed for this purpose and information will be furnished upon request.

For car service on 600 volts, use aluminum, ME or MD-2, depending upon the severity of conditions and the degree of protection desired. For 1200 and 1800 volts, use aluminum or ME.

For line service on 600 volts use the ME or MD-2, depending upon the severity of conditions and the degree of protection desired. For 1200 and 1800 volts use ME arresters.

MAGNETIC BLOWOUT ARRESTERS

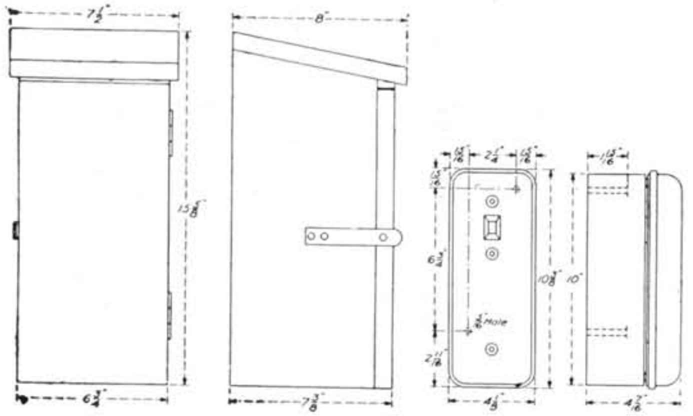
Cat. No.	Type	Form	Description	Volts	Approx. Ship. Wt. in Lb.
33621	M	D-2	For station use	125–375	15
33622	M	D-2	For car and line use	125–375	25
33623	M	D-2	For station use	250–850	15
33625	M	D-2	For car and line use	250–850	25
79111	M	E	For station and line use	600	25
79112	M	E	For station and line use	1200	25
79113	M	E	For station and line use	1800	25
79497	M	E	For car use	600	40
79498	M	E	For car use	1200	40
79499	M	E	For car use	1800	40

DIRECT CURRENT ALUMINUM ARRESTERS

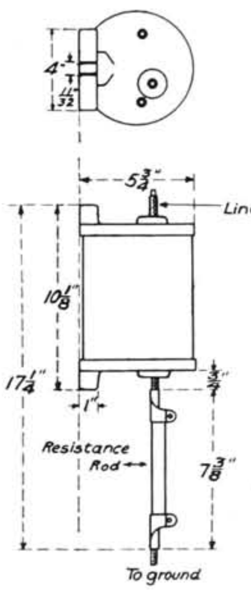
Cat. No.	Description	Volts	Approx. Ship. Wt. in Lb.
77160	For car use	450–675	70
* 79526	For station use	450–675	50
* 79659	For car or station use	675–900	95
* 79525	For station use	900–1350	110
79660	For car use	900–1350	140

*For number of arresters to be used see second paragraph above.

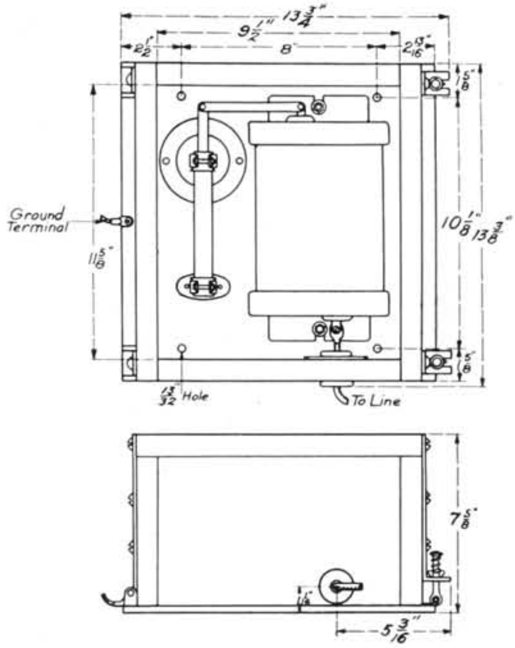
DIMENSIONS



TYPE M FORM D-2 ARRESTERS UP TO AND INCLUDING 850 VOLTS



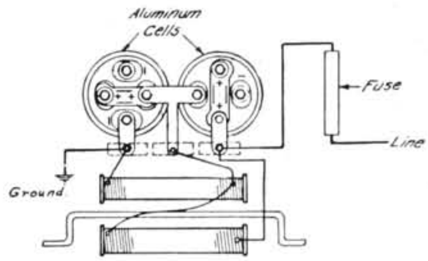
FOR LINE USE

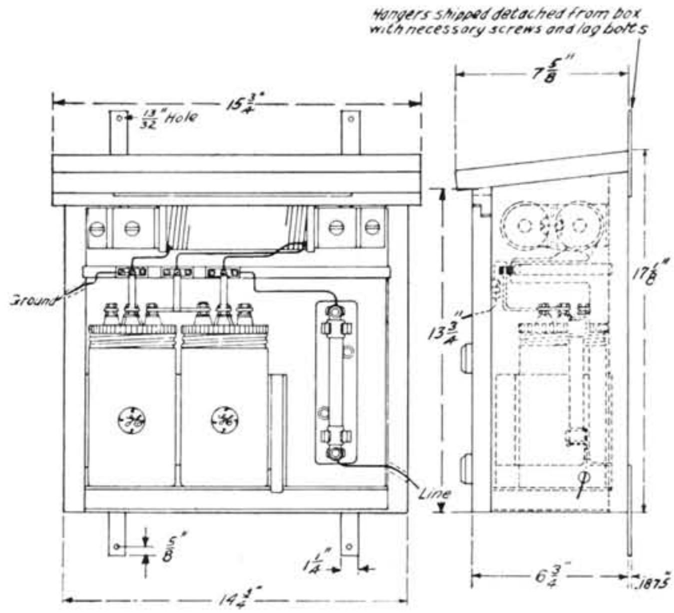


FOR CAR USE

TYPE M FORM E ARRESTERS

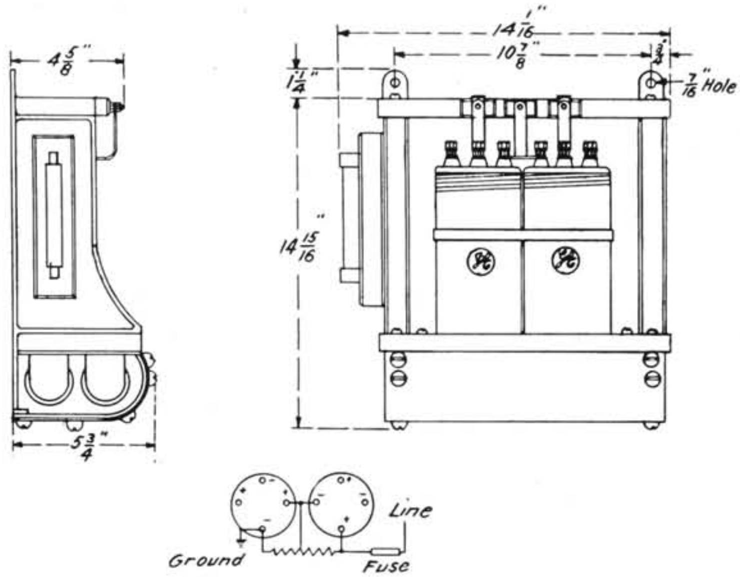
DIMENSIONS



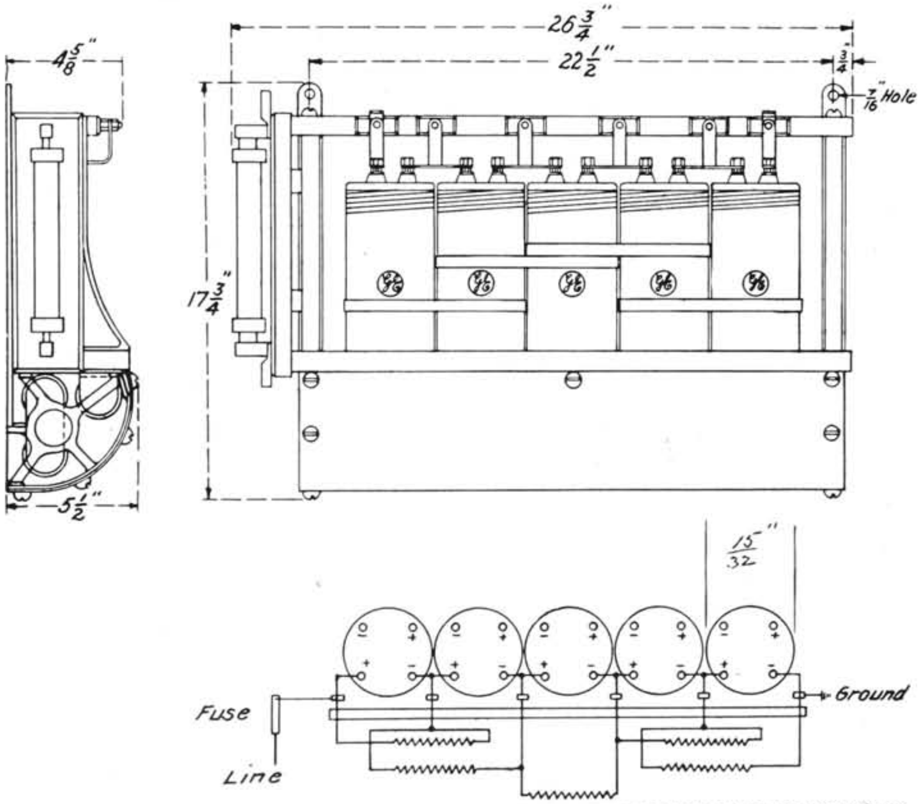


600 VOLT ALUMINUM LIGHTNING ARRESTER
CAT. NO. 77160

DIMENSIONS AND CONNECTIONS



600 VOLT DIRECT CURRENT ALUMINUM ARRESTER WITH BALANCING RESISTANCE AND FUSE ON SLATE SHELF FOR STATION USE—CAT. NO. 79526



1200 VOLT DIRECT CURRENT ALUMINUM ARRESTER WITH BALANCING RESISTANCE AND FUSE ON SLATE SHELF FOR STATION USE—CAT. NO. 79525

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General Electric Company
Schenectady, N.Y.

POWER AND MINING DEPARTMENT

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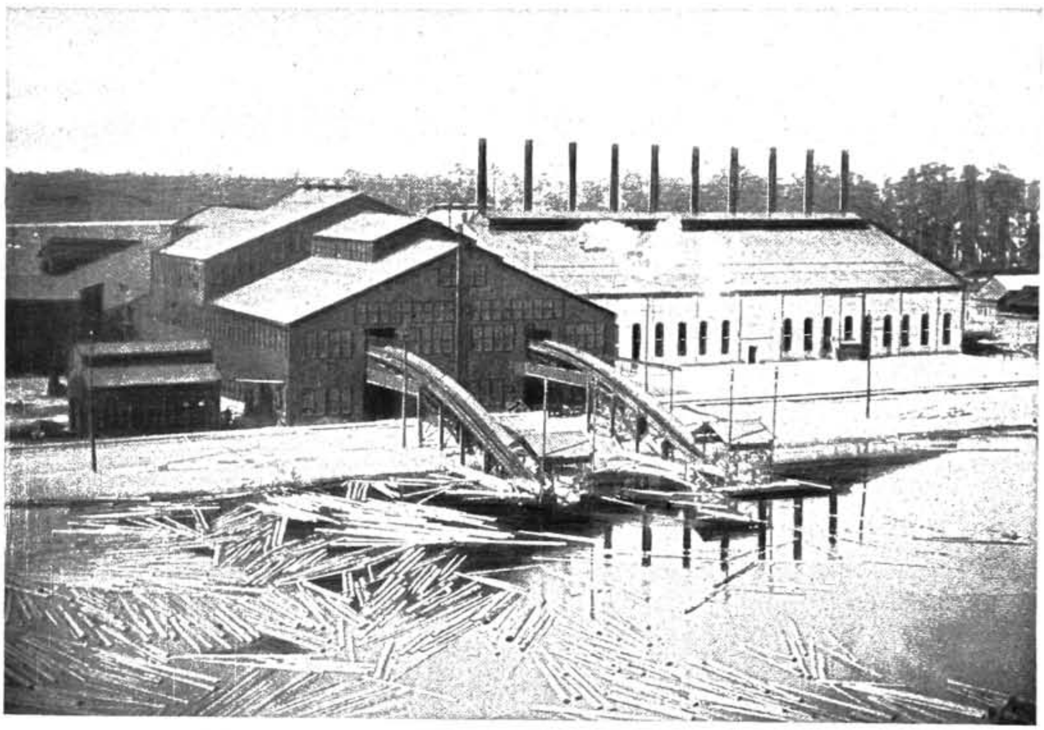
ELECTRIC POWER IN THE LUMBER INDUSTRY

The ideal attainment of modern production is a maximum output from a given investment in plant and machinery: electric power, in so far as it contributes to this result, is being given an ever increasing degree of attention where saw mill and woodworking machinery is used, as experience under the severest service conditions has proven that it possesses advantages of efficiency and economy that meet most successfully the peculiar conditions of the lumber and woodworking industries.

When compared with mechanical drive for machinery, the application of electricity has the following characteristics: It greatly reduces the waste of power in transmission and thereby increases production for a given amount of power generated.

Experience has shown that it improves the quality of the product and increases the factor of safety both to machinery and operatives, while at the same time there is a marked reduction in the fire hazard, especially from open flames and hot boxes.

It practically eliminates overhead shafting and belts which not only interfere with the proper distribution of light and air but fre-



GENERAL VIEW OF SAW MILL, GREAT SOUTHERN LUMBER COMPANY, BOGALUSA, LA.

*Supersedes No. 4641

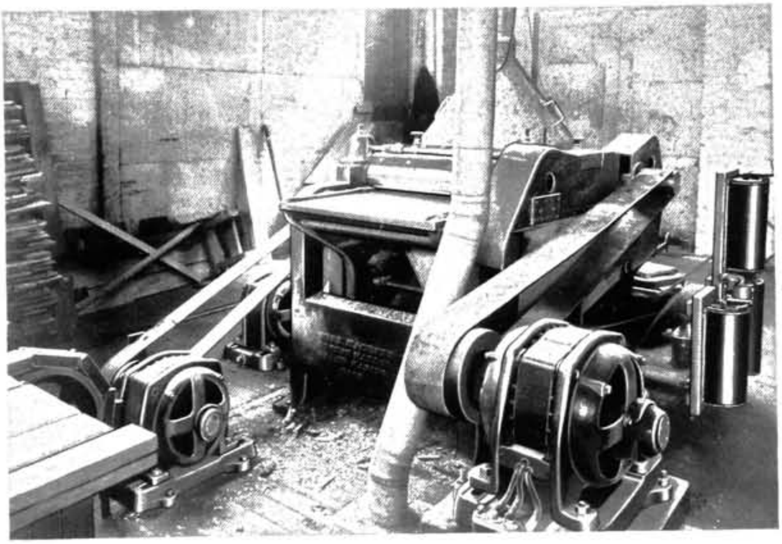
quently limit the location of machinery and thus prevent that sequence of operations which is essential in order to avoid the rehandling of work with its attendant expense, damage and congestion.

An important feature of its application is the ability to operate any group or any individual machine overtime or at unusual hours without putting the whole power equipment of the plant into operation, and when the current is obtained from an outside source the cost of running any machine stops when the machine does.

installation of an electric lighting and power plant. Prospective purchasers will find it desirable to place their orders for electrical apparatus with one concern, as by so doing responsibility is not divided, and a complete uniform, standard outfit will be obtained.

ISOLATED PLANTS

For small plants located near a central station, it is usually advisable to purchase power and in this way avoid the expense of installing and operating a generating plant. The improvements achieved



26 INCH DOUBLE HEAD PLANER DRIVEN BY THREE 7 1/2 H.P. MOTORS
PAINE LUMBER COMPANY, OSHKOSH, WIS.

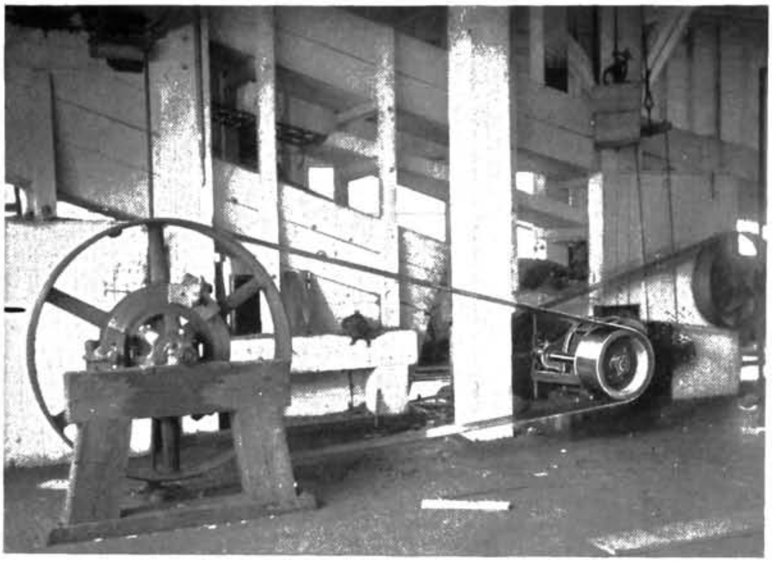
By means of motor-driven cranes or hoists, it furnishes a rapid and convenient method of handling materials.

It effects a reduction in the amount of floor space required and combines a marked improvement in the general appearance of a plant, with cleanliness and safety.

The General Electric Company occupies an unique position in the electrical business in that it can furnish from its own shops every electrical device necessary for the complete

in generating apparatus and transmission lines enable the modern central station not only to grant low rates but their reserve machines insure uninterrupted service.

Where a plant requires a large amount of power or is located at a considerable distance from a central station or has already installed a steam plant which can be used for the operation of generators, it is usually more advantageous to install an isolated generating plant.



BACK GEARED MOTOR OPERATING CONVEYOR TO WOOD BURNER
ELK RIVER MILL, POTLATCH LUMBER CO., ELK RIVER, IDAHO

ALTERNATING CURRENT VS. DIRECT CURRENT

The question as to whether alternating or direct current should be used in any particular plant must be governed by the character of the work required.

Unless variable speed tools are largely used alternating current should be selected, as both generators and motors are somewhat simpler in mechanical design than direct current machines and are better adapted to conditions where flying dust is encountered.

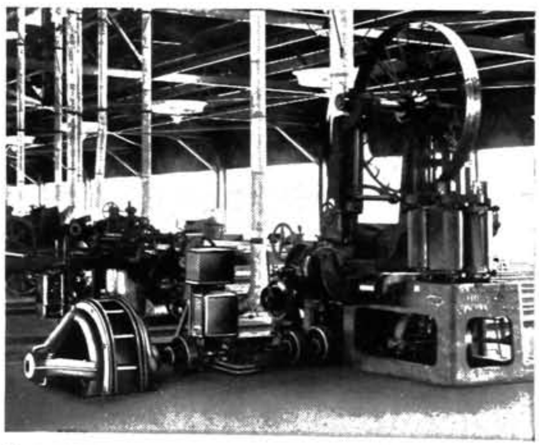
If, however, there is considerable variation in the speed of the tools used, direct current machines will permit of speed variation over a wider range than is possible with alternating current machines.

In general the requirements of the Lumber and Woodworking industries can be met by constant speed motors and therefore alternating current should be adopted in a majority of installations.

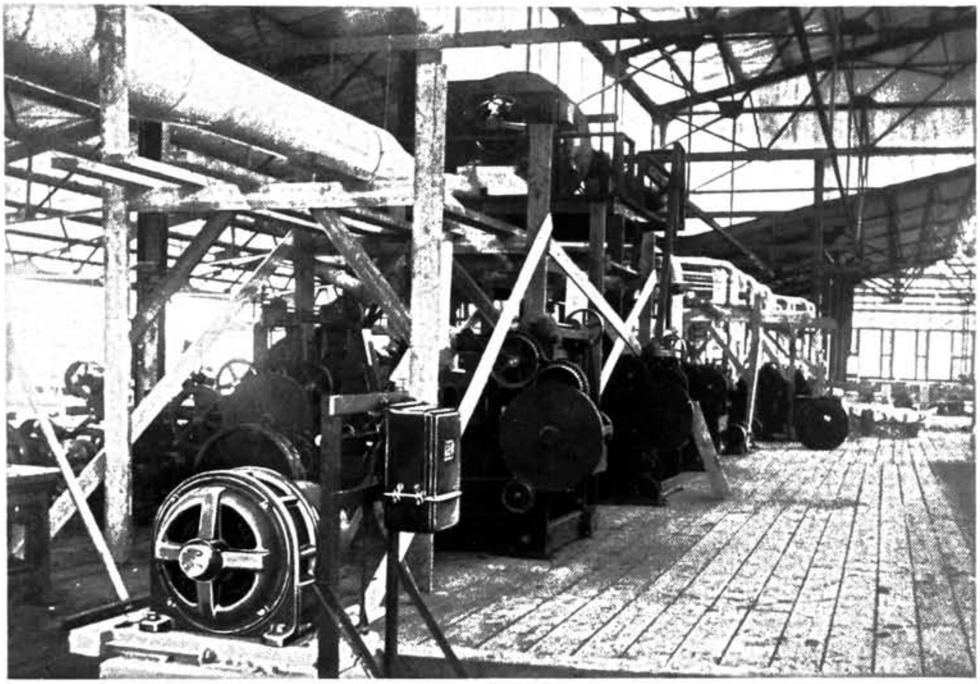
ALTERNATING CURRENT MOTORS

When utilizing electric motors for driving woodworking machinery it is essential that they be safe, reliable, and capable of maintaining high efficiency under the most severe service conditions. The General Electric Company has designed a complete line of induction motors suitable for either direct connection to the driven machine or for belt drive. This motor is simple in construction and although light in weight for a given output in comparison with other motors, has ample mechanical strength, and is able to withstand hard usage and to operate continuously under disadvantageous conditions. The parts are few in number and have been carefully designed so that a minimum of attention is required when the motor is in operation, and the cost of maintenance and repairs is practically eliminated. The electrical design is such that high efficiency is obtained over a wide load range, and the motor is capable of withstanding heavy overloads for considerable periods without serious overheating.

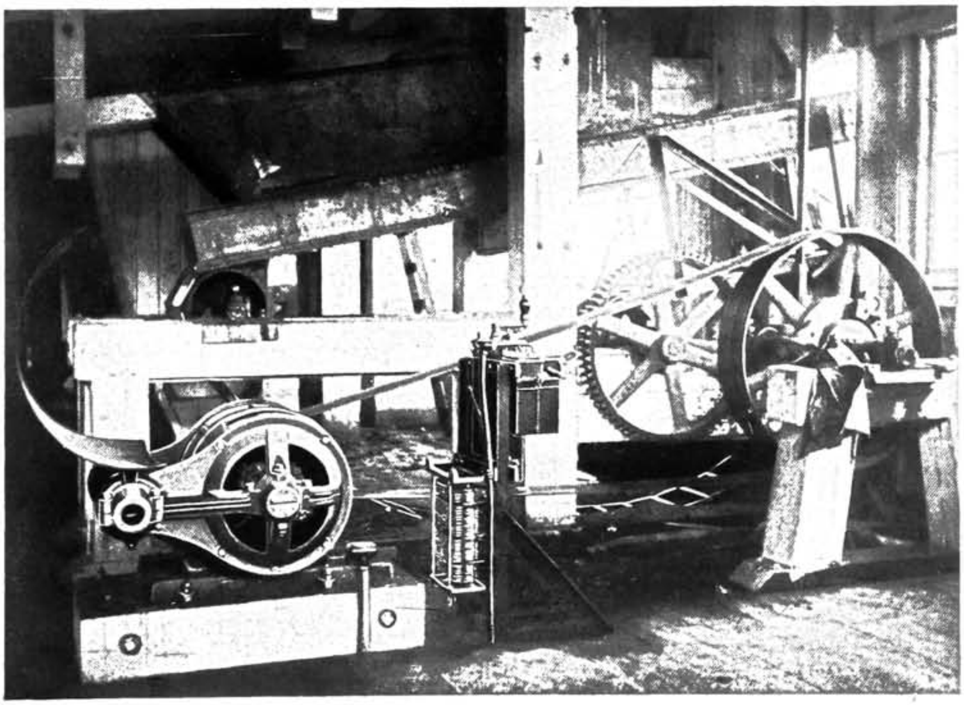
The induction motor does not require a commutator and the danger of sparks from



NO. 285 BERLIN BAND RE-SAW OPERATED BY DIRECT CONNECTED 55 H.P. FORM K INDUCTION MOTOR
THE GREAT SOUTHERN LUMBER CO.
BOGALUSA, LA.



VIEW IN PLANING MILL BEFORE COMPLETION SHOWING ARRANGEMENT OF INDUCTION MOTORS AND COMPENSATORS
POTLATCH LUMBER COMPANY, ELK RIVER, IDAHO



BACK GEARED INDUCTION MOTOR DRIVING WASTE CONVEYOR
POTLATCH LUMBER COMPANY, ELK RIVER, IDAHO

this cause is thereby avoided. This is an especially valuable consideration when the motors are operating in woodworking plants where the conditions affecting fire risk are of vital importance.

The General Electric induction motor is easily controlled and it will start readily under full load. Its rigid construction and light weight enables the user to mount it wherever desired, and in many cases where floor space is valuable and a machine is belt-connected to a motor, space economy can be effected by suspending the motor from the ceiling or wall. For special applications these motors can also be arranged to operate on vertical shafts with the same high efficiency obtained with the horizontal shaft type.

All motors before being sent out undergo severe tests in the factory, and the General Electric Company guarantees motors of standard rating to operate at full load with a temperature rise above the surrounding air not exceeding 40 deg. C. and with a 25 per cent. overload for two hours with a temperature rise above the surrounding air not exceeding 55 deg. C. based on 25 deg. C. room temperature.

Many manufacturers of saw mill and woodworking machinery realizing the importance of electric drive are designing their machines with a view to motor operation, and their serviceability has been proven by the success of numerous installations, some of which are illustrated herewith.

SHED USED FOR THE GRADING OF KILN DRIED LUMBER. LIGHTED BY GENERAL ELECTRIC ENCLOSED ARC LAMPS FITTED WITH LIGHT BALANCING CEILING DIFFUSERS—THE GREAT SOUTHERN LUMBER CO., BOGALUSA, LA.

It should be borne in mind, however, that every woodworking plant has conditions peculiar to itself, and that the rating of a motor doing any given work in one locality may not form a proper basis for estimating the motor capacity required for similar work with different materials. The General Electric Company is always ready to place at the disposal of prospective customers the experience obtained in successful manufacture and installation, and to assist in the solution of problems involving special conditions.

POTLATCH LUMBER COMPANY, POTLATCH & ELK RIVER, IDAHO

The saw mill of this company at Potlatch is one of the largest in the west and has a daily capacity of 750,000 feet. Previous to the adoption of electric drive it was mechanically driven by a 1500 h.p. engine belt-connected to line shafting, while the planing mill was similarly operated by means of an 1100 h.p. engine.

Due to increased production the power demand rose beyond the capacity of the steam engines and electrification was started by adding one 800 kw., 2200 volt, three-phase, 60 cycle low pressure turbo-generator, which was operated from the exhaust of the 1500 h.p. engine, provision being made for running the turbine with live steam in the event of a shut-down of the engine. The output of this turbo-generator is utilized in the box factory where a 300 h.p. motor drives the blower on the sawdust conveyor. Power is also supplied for the operation of the machine shop, car shop and power house, and during the summer months 200 h.p. is consumed by a local brick making plant. In addition to this, current is provided for the mill building and town lighting. This increase in available energy has been secured without any addition to the boiler capacity.

For handling the lumber between the saw mill, kiln and planing mill, six 7-ton storage battery locomotives are used, and two 40 kw. belt-driven generators are provided for charging the locomotive batteries.

At the Elk River mill the power equipment comprises one 800 kw. and one 500 kw., 600 volt, three-phase, 60 cycle turbo-generator, and motor drive is used throughout.

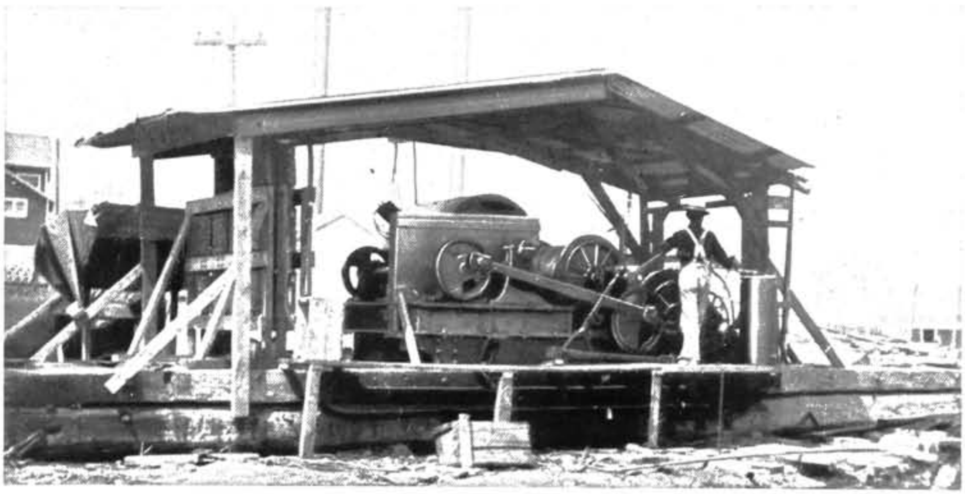
WOOD BURNER, MILL, POWER STATION AND LOG POND, ELK RIVER MILL

In order to determine accurately the most efficient motor for the various machines at this mill, a series of tests was made by disconnecting the machines from the line shafting and belt connecting them individually to a motor of the estimated required horse power, wattmeter readings were then taken during a period of ten hours operation at normal load. By this method it developed that the band mills took from 30 h.p. at no-load to as high as 275 h.p. on full load, and it was, therefore, decided to provide them with 200 h.p. wound secondary motors, three of these equipments being provided. The edgers have 75 and 60 h.p. squirrel cage motors, while the planers in the planing mill are driven by 75 h.p. motors. In all cases where the load conditions render it advisable, wound secondary motors have been used. In the filing room the saw sharpeners and stretchers are individually driven by 2 and 3 h.p. motors and the forge blower is also motor driven.

The wiring throughout is carried in conduit to minimize the fire risk.

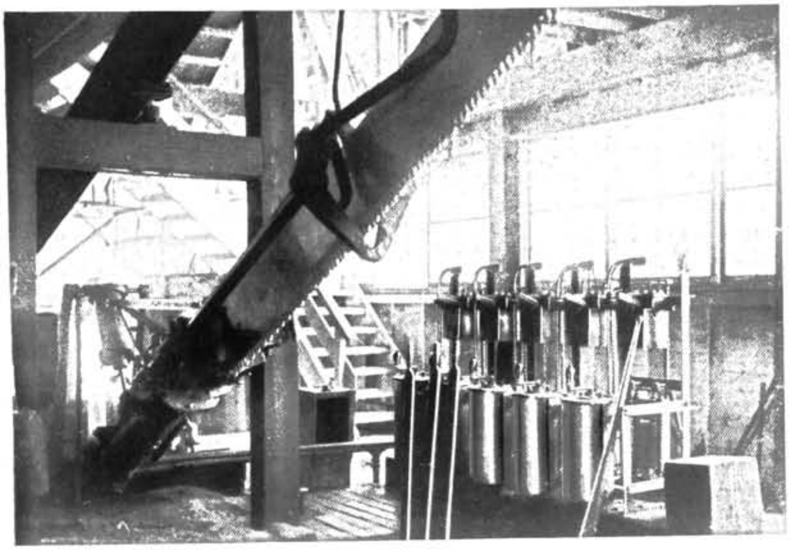
In addition to the service in the mill buildings, electricity will eventually be used for dredging the log pond, which has a tendency to silt up. The outfit for this purpose will consist of a rotary cutter operating directly in front of the intake of a powerful pump and conveyor which will carry the refuse to the shore through a pipe line supported by pontoons. The pump and cutter will operate from a barge, and for the former a 35 h.p. motor will be used, while the cutter will be driven by a 25 h.p. motor. These will be 440 volt standard induction type and cable drums will be provided on the barge to pay out or haul in the conductors as the location of the dredge is changed.

An electrical application of special importance is found at the Elk River Logging Camp, consisting of a motor driven logging engine, which was changed over from steam to electric drive. It is of the type commonly known as a road engine, and when operated by steam, it had two 11 by 13 cylinders which gave a drum speed of 200 r.p.m. at 150 pounds steam pressure, the haul-in drum having a capacity of 5200 ft. of 1⅛ in. steel cable. In converting this to electric drive, the drum was geared direct to a counter shaft driven by connecting rods, which were in turn driven by the motor through back gearing; the arrangement being shown in the accompanying illustrations. While the method of drive adopted gave low efficiencies, due to the friction in the many moving parts, it avoided the expense of remodelling the original outfit, and as it was intended only for experimental purposes, it gave satisfactory service and enabled the operators to determine the value of a logging engine of this type and the approximate power demands of an electric logging engine when especially designed for the service.

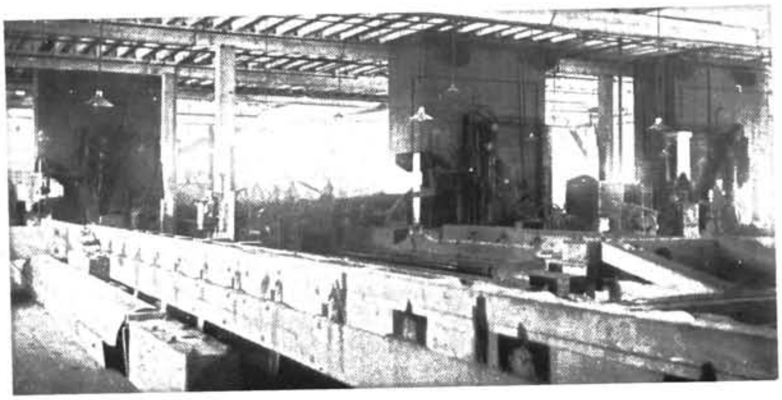


ELECTRIC LOGGING ENGINE IN OPERATION AT THE ELK RIVER LOGGING CAMP

The motor utilized was a 150 h.p., 550 volt wound secondary, three-phase, 60 cycle, 435 r.p.m. induction motor, specially constructed to meet the anticipated load conditions. A bank of resistance grids and an oil switch were mounted on skids behind the motor and a controller was installed on the side



ELECTRICAL CONTROL EQUIPMENT FOR CONVEYOR CHAINS ON THE LOG TABLE AND THE LOG HAUL, ELK RIVER MILL



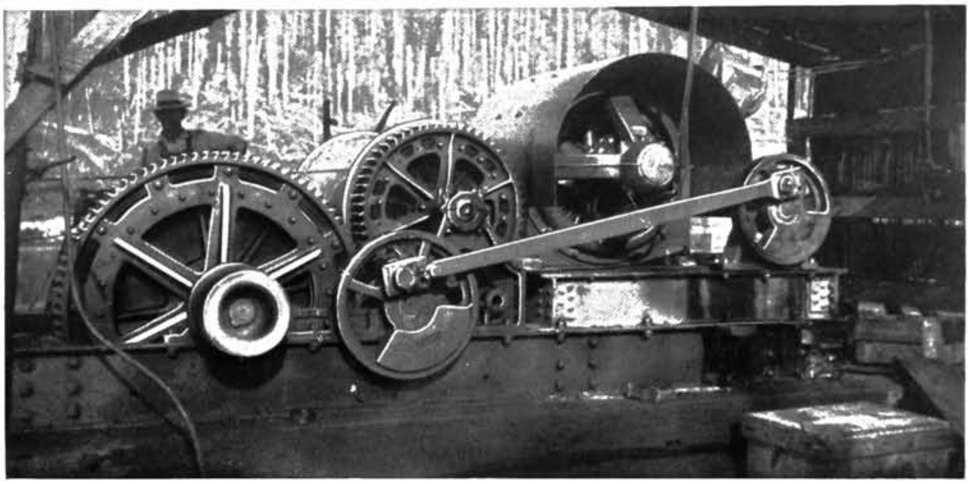
VIEW IN ELK RIVER MILL SHOWING THREE HEAD RIG BAND SAWS AND CARRIAGE

TWO 200 H.P. INDUCTION MOTORS AND CONTROLLERS FOR DRIVING TWO OF THE THREE HEAD RIG BAND SAWS ILLUSTRATED ABOVE ELK RIVER MILL

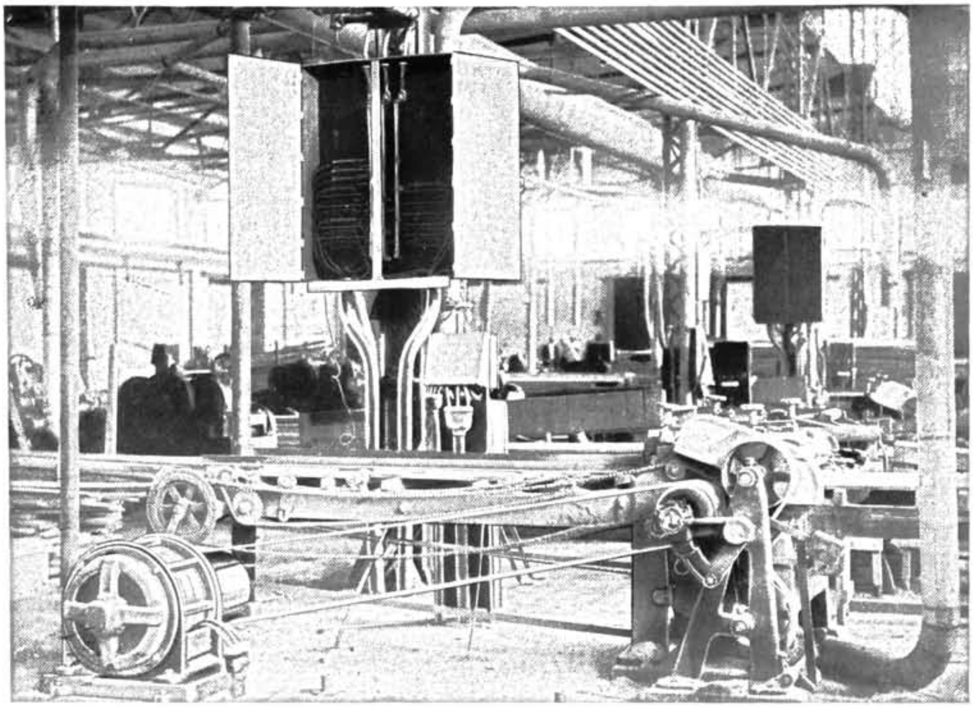
between the haul-in and haul-back drums, which enabled the operator to control the power, friction clutches, and foot brakes.

Hauling was commenced from a distance of 3,000 ft. from the engine, and careful measurements of the power demand were made by means of an indicating wattmeter. The largest single load was one scaling 5100 ft. of lumber, and the input averaged 176 h.p. with momentary peaks of from 250 to 280 h.p. on the motor. The nature of the load imposed on the motor can be realized by the fact that many of the logs had to come through dry ditches of over six feet in depth, cut by haulage early in the season when the ground was soft. In spite of these conditions, the operation of the motor was such as to secure an absolutely steady haul, there being no speed variation from start to finish, whereas with steam, on a long haul it is not unusual to have to suspend work for varying periods, to allow the boiler pressure to come up to normal after being subjected to excessive demands. On logs averaging 2500 or 3000 ft. by scale, and power required varied from 120 to 130 h.p. on a straight haul with peaks corresponding to those already referred to when obstructions were encountered. During the test an attempt was made to force a log through an obstruction, which proved to be stronger than anticipated, and while this resulted in breaking the bull chain and clevis, the motor remained uninjured.

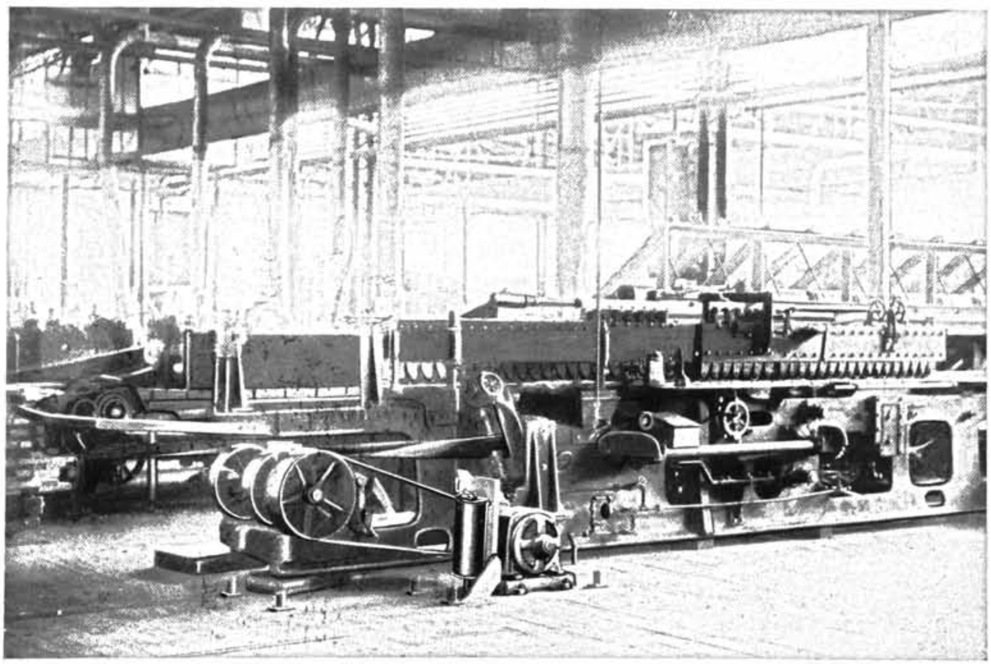
The logging engine was thoroughly tested under varying conditions of service for a period of a week, during which time it demonstrated indubitably its ability to perform the work. It was thereupon decided to adopt electric drive for other logging sections of the camp and to secure higher efficiencies than were possible with the experimental engine by designing the new engines as complete units, utilizing in their construction the experience obtained in the operation of the experimental outfit.



ELECTRIC LOGGING ENGINE SHOWING LOCATION OF MOTOR



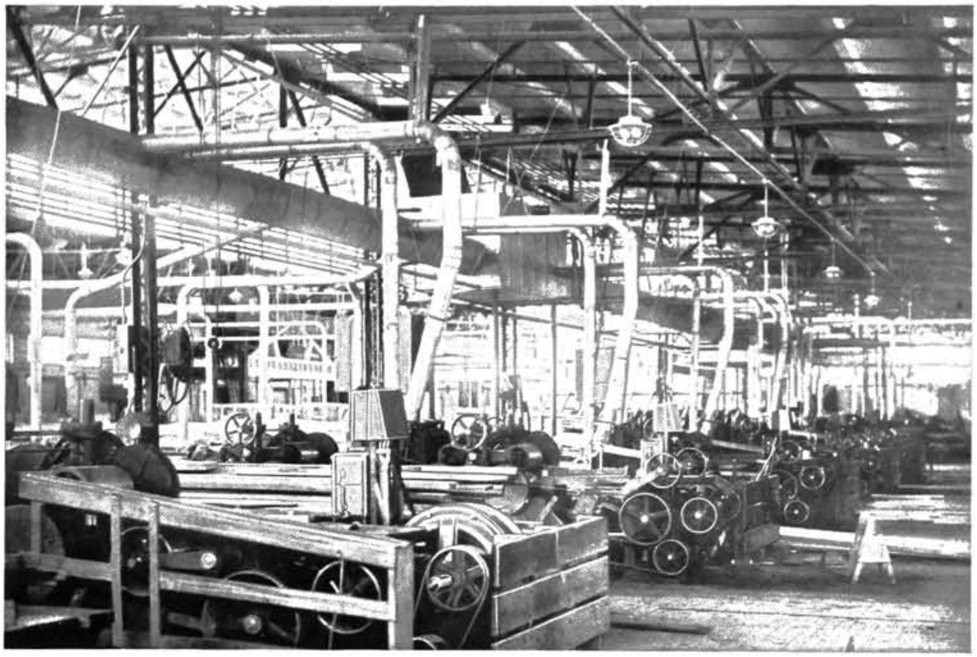
EIGHT-GANG RIP SAW DRIVEN BY 50 H.P. MOTOR
PAINE LUMBER COMPANY, OSHKOSH, WIS.



LINDERMAN DOVETAILER DRIVEN BY TWO 7 1/2 H.P. MOTORS
PAINE LUMBER COMPANY, OSHKOSH, WIS.

PAINE LUMBER COMPANY, OSHKOSH, WIS.

This company is the largest manufacturer of veneered doors in the world and the newer mill buildings at Oshkosh are equipped with electric drive throughout, there being a total of 315 motors used in the planing mill and odd shop. All motors are served from an isolated plant containing two high pressure turbo-alternators, one rated at 1000 kw. at 1800 r.p.m., and one 500 kw. at 3600 r.p.m.; current being generated at 480 volts, three-phase, 60 cycles. Excitation current for the turbo-alternators is supplied by means of a marine engine driven exciter and a motor generator set.

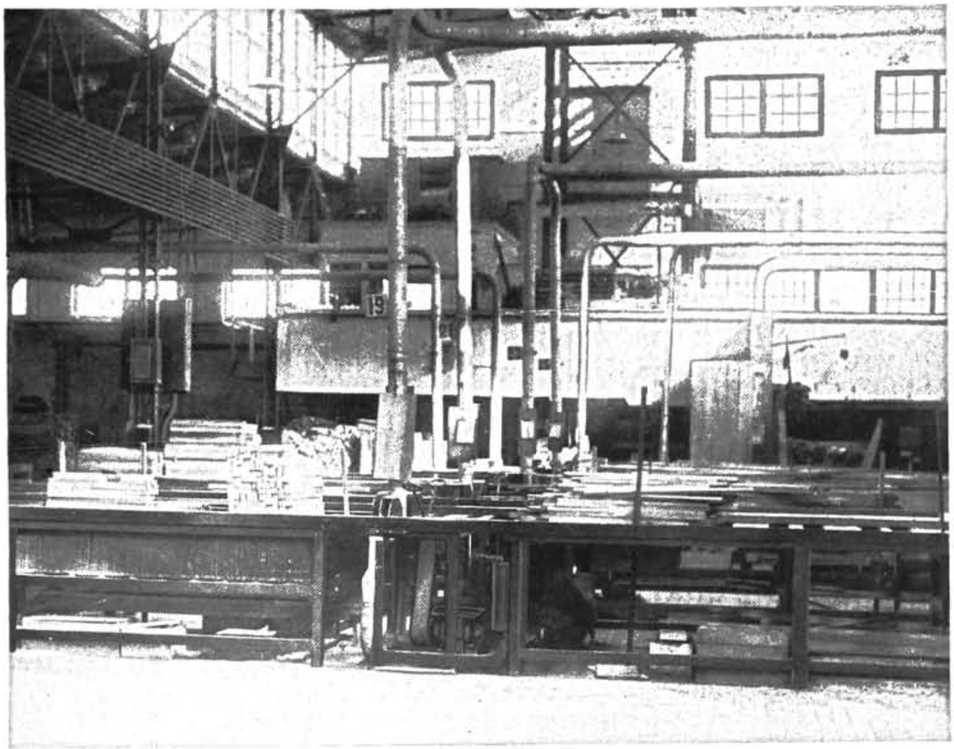


BATTERY OF PLANERS WITH INDIVIDUAL MOTOR DRIVE

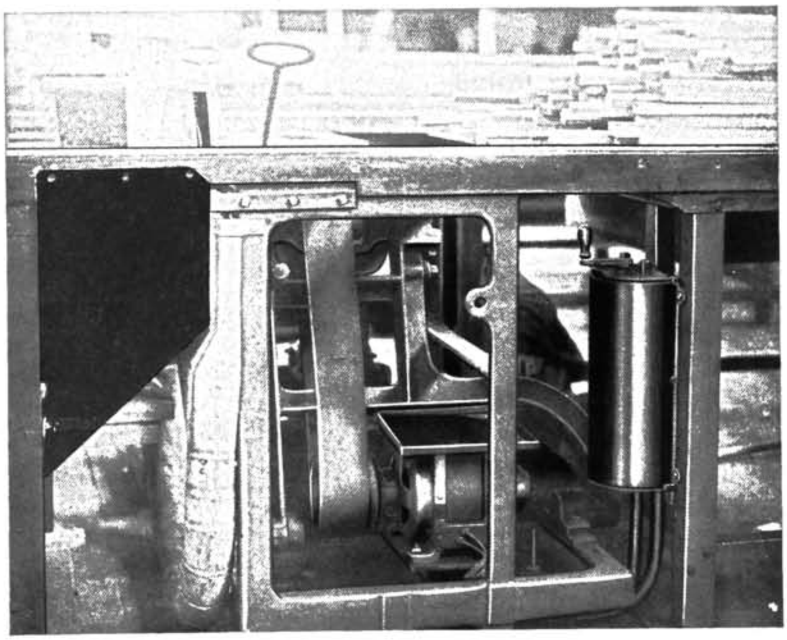
The switchboard equipment consists of a 9-panel main board and a 5-panel station board, with the oil switches mounted back of the boards. The main switches are all electrically operated and pilot lights are provided on all main and feeder circuits.

Steam is supplied by four 300 h.p. boilers which are mechanically fired with mill refuse, and in the power station there is one 10 h.p. motor driving the conveyor belt from the saw mill to the boiler house.

The turbines are operated condensing and one 50 h.p. and one 85 h.p. motor are each direct connected to centrifugal condenser pumps. The main distribution is effected through two underground feeders utilizing 2,000,000 c.m. conductors. One feeder runs to the planing mill utilizing 113 motors; the other serving the odd shop where 202 motors are installed. In addition to the main feeders, current is carried over two pole lines, one an incoming circuit from the power system of the Oshkosh Gas Light Company; current from this source being used for lighting only. The second pole line runs from the power house to office and factory buildings, and is used principally for the supply of the lighting system, although there are a few small motors connected in this circuit. The lighting throughout is effected by means of 60 and 120 volt incandescent lamps.



BATTERY OF SLASHERS EACH DRIVEN BY A 2 H.P. MOTOR



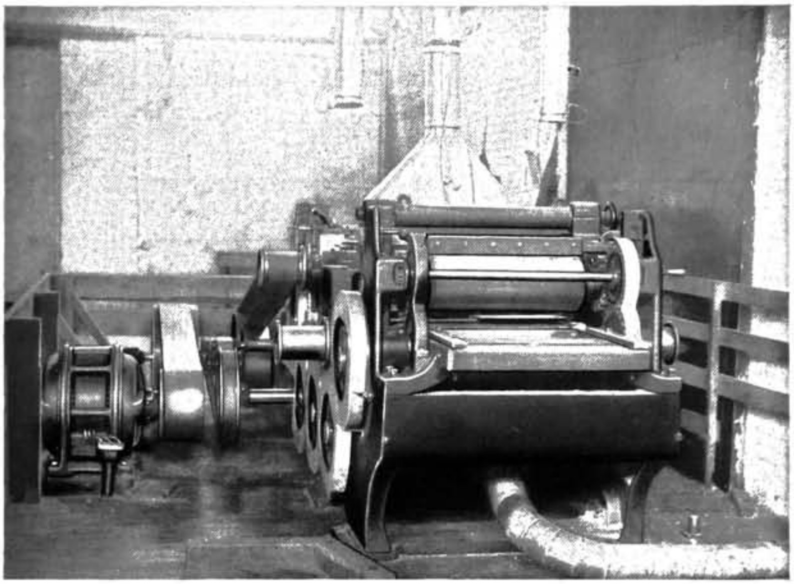
DETAIL OF SLASHER SHOWING LOCATION OF 2 H.P. MOTOR AND CONTROLLER

In the factory buildings four-light 50 watt Tungsten clusters are used, and in the power station there are both Tungsten and carbon incandescent lamps.

The turbo-alternators generate current at a potential of 480 volts and the power station is equipped with three 10 kv-a., 440/220 volt single-phase delta connected transformers serving two transfer tables, each driven by a 5 h.p. motor and provided with a winch, separately operated by a 2 h.p. motor. There is also a yard locomotive driven by a 7½ h.p. motor: These motors are three-phase, 60 cycle, G-E Type I, Form M, and current is distributed to them by means of a double trolley and bonded rail.

Every precaution has been taken to minimize the fire risk and the wiring for the planing mill enters through the floor and runs directly to a building switchboard, from which point it is carried to heavy sheet iron junction boxes located near the motors; all feeder circuit fuses being enclosed in these junction boxes. All the motors are operated through compensators, and additional fuses are mounted in the boxes above each compensator; the wiring throughout is carried in conduit.

The planing mill equipment contains a large percentage of individually driven machines and a few small groups operated through belts. The mill handles birch, oak, elm, hemlock, pine, and basswood, which is largely of the Paine Lumber Company's own sawing, a large part of the output is devoted to the manufacture of veneered doors which is carried on in the adjoining odd shop. There is also manufactured annually, about five million boxes and about twenty-five million feet of moulding. The planer equipment consists of ten double-head units ranging in size from 15 in. to 30 in., each driven by a 35 h.p. motor, six of these being direct connected to the driving shaft through flexible couplings, while the remaining four are belt driven. There are also two single-head pony planers: one 24 in. and one 30 in., each belt driven by 7½ h.p. motors, while a third is a double-head machine with three 7½ h.p. motors, two of which drive the top head and the third the bottom head — all motors driving through belts.



26 INCH DOUBLE PLANER DRIVEN BY 35 H.P. MOTOR

The rip saw outfit comprises twelve 5-gang units, each belt driven by a 50 h.p. motor, four single rips, each driven by a 20 h.p. motor, and twenty-nine slashers, each utilizing a 3 h.p. motor; all these saws being belt driven. There are five band saws, individually driven through silent chains,—three of these are 8 in. and have 50 h.p. motors, the remaining two being 4 in. driven by 35 h.p. motors.

In addition to the regular planing mill equipment there is a battery of fifteen molders, ranging in size from 6 in. to 12 in. One of these is driven by a 15 h.p. motor; the others being operated in small groups by motors ranging from 15 to 25 h.p., all belt connected. There is also a 15 in. six-knife head molder which is direct driven by a 35 h.p., 1200 r.p.m. motor.

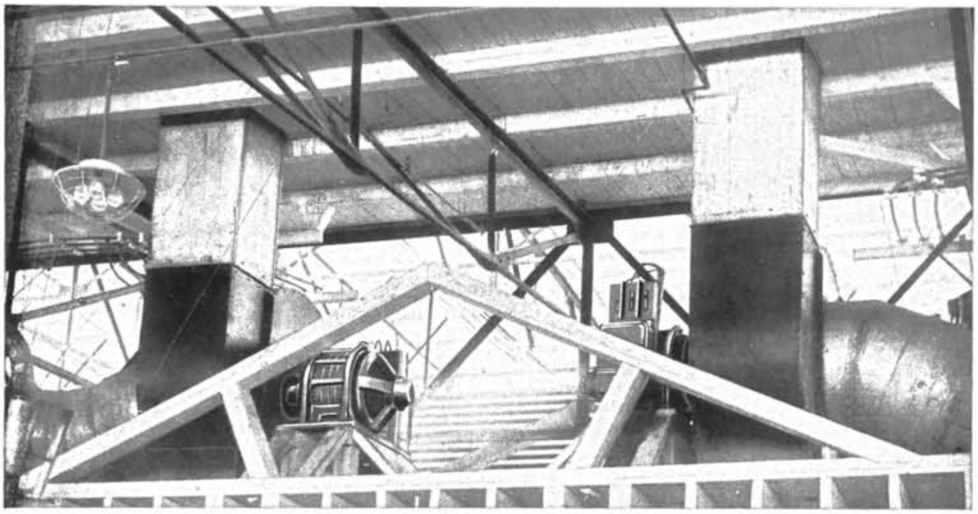
Among the auxiliaries are a broom sander driven by a 7½ h.p. motor and a 24 in. drum sander driven by a 35 h.p. In the box department of the mill, individual drive has been used throughout for the operation of saw trimmer, hand feed rip saws, bundle cutter saw, printing machines and box nailers, the motors used ranging from 3 to 35 h.p. in capacity.

The planing mill machinery also includes two Linderman dovetailers, each driven through belts by two 7½ h.p. motors.

For the blower system there are four 80 in. units, two of them driven by 35 h.p. and two by 50 h.p. motors, direct coupled to the blower rotor. These blowers deliver shavings and sawdust to the boilers at the power station, while the waste wood is carried by a 10 h.p. motor conveyor to one end of the mill where it is collected for sale locally.

For grinding and jointing the planer knives without removing them from the machines, seven special grinding sets have been provided, each driven by a 1 h.p. motor, which is permanently mounted on an overhead beam and serves two machines; the grinding rig being driven through belting having an adjustable counterweight to insure uniform belt tension. In addition, the grinding outfit includes a six-wheel single spindle set with small wheels of the usual type, and two 36 in. knife grinders, driven respectively by 2 h.p. and 3 h.p. motors.

In spite of the fact that the load on the power station consists almost entirely of induction motors, the power-factor of the system is maintained at about 74 per cent. average. The motors are covered with sheet metal boxes to protect them from accumulations of sawdust. These covers are readily removable and all the motors are cleaned each week with compressed air.



TWO SINGLE BLOWERS EACH DIRECT DRIVEN BY A 35 H.P. MOTOR

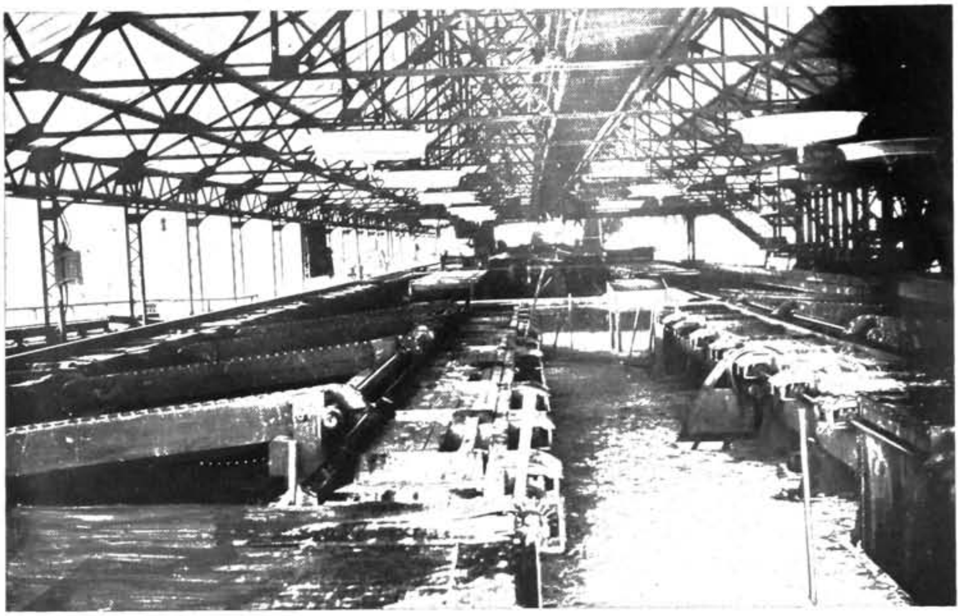
GULF LUMBER COMPANY, FULLERTON, LA.

The mills of this company are situated in the heart of the long leaf yellow pine district of Western Louisiana, the plant being owned by the Chicago Lumber Company of St. Louis, Mo., which also owns and controls 250,000 acres of the finest yellow timber land in the south.

There are two saw mills which are at present driven by steam engines, but the planing mill is provided with electric service throughout. The motors are in nearly every case direct connected to the machines, and constitute a very effective example of the benefits of electric drive in the lumber industry. The arrangement of the motors is such that great space economy is obtained, the usual assortment of belts and countershafts being practically eliminated, while the maximum power efficiency is obtained by the direct application of the motors, thereby avoiding a large percentage of the friction losses which must commonly be carried by the power plants of steam driven mills.

The power station is of thoroughly modern construction and has a boiler outfit consisting of twenty-four 150 h.p. marine type boilers arranged in two batteries of twelve each. They are designed for 150 lb. pressure and supply steam for the entire plant, including engines, pumps and dry kilns.

Two engines are used for separately driving the two mills, while the current for the electrical equipment of the planing mill is provided for as follows:



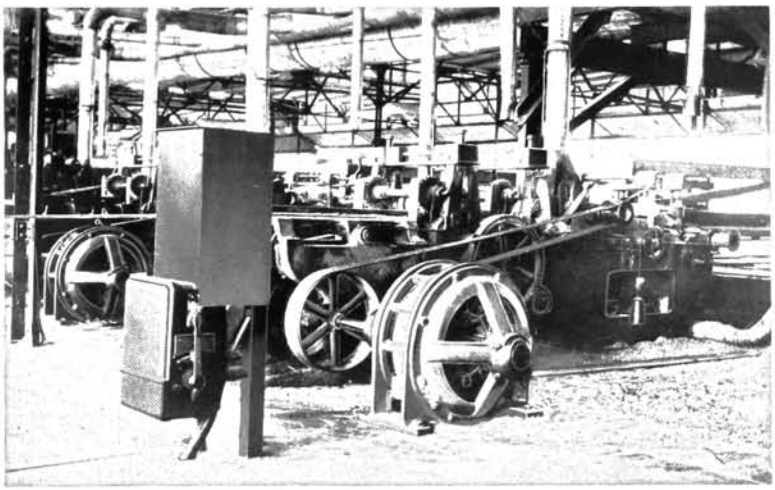
G.E. ARC LAMP DIFFUSERS IN TAIL OF TIMBER MILL

Two ATB, 500 kw., 2300 volt alternators are direct driven by engines at 100 r.p.m., the necessary excitation being supplied by a 25 kw., 125 volt steam turbine driven exciter, and two motor-generator exciter sets, one of 25 kw. and one of 50 kw. There are also two 50 kw. induction motor-generator sets for supplying current to a monorail haulage system, and in addition the power station contains a 25-light, 4 amp. outfit for the operation of magnetite arc lamps. Current is generated at 2300 volts, three-phase, 60 cycles, and transmitted through triple conductor cable to transformer substations, from which it is stepped down and carried to the motors at 550 volts. All the motors operate at this voltage, excepting a few direct current units which, together with the haulage locomotives, are fed at 230 volts from the motor-generator sets referred to above.

The transformer substations are built of concrete and contain only disconnecting switches in addition to the transformer units. The engines can be operated condensing if required, as a condenser outfit has been provided, but due to the low cost of fuel this has not as yet been utilized.

The planing mill building is a steel frame structure, 200 by 500 ft., provided with concrete floors and a loading platform which extends 1200 ft. along the front of the mill and the dressed lumber shed.

The extent and character of the motor drive in this mill is clearly indicated by the following list of induction motors and the machinery which they drive:



35 H.P. 900 R.P.M. 550 VOLT MOTOR DIRECT CONNECTED TO 15 IN. BY 6 IN. MATCHER

Distribution of 550 Volt Induction Motors

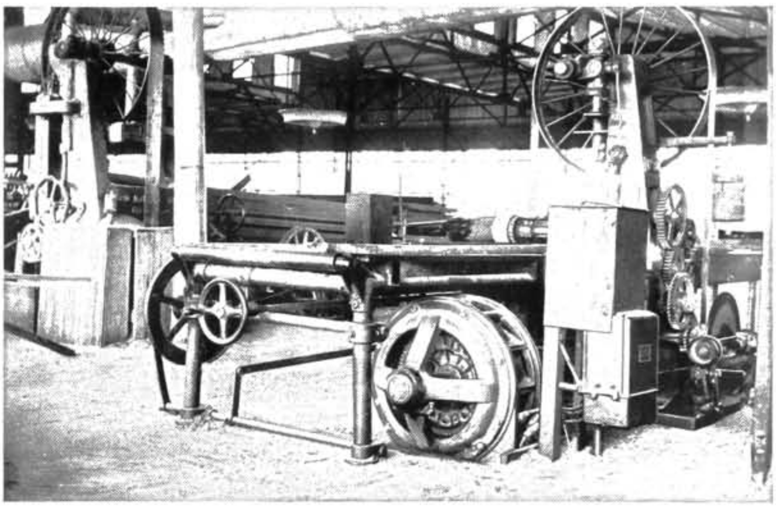
H.P.	Service	H.P.	Service
150	90 in. blower	10	42 in. swing cutoff saw
75	80 in. blower	35	Two double 12 in. edger saws
35	60 in. blower	35	Two double 12 in. edger saws
50	Three 6 in. x 15 in. matchers	15	400 ft. turtle back chain
50	Two 6 in. x 30 in. sizers	15	150 ft. turtle back chain
35	Four 6 in. by 9 in. matchers	15	250 ft. line rolls
35	Two 6 in. x 15 in. moulders	10	Knife grinder, head grinder, 2-wheel emery stand, two band saw grinders and 20 in. cutoff saw
35	Two outside moulders	15	Experimental motor for direct connection to mandrels on planing machines
35	6 in. band resaw	35	Belted to centrifugal pump for filling log pond
20	3 in. band rip saw	35	Timber loaders
35	30 in. multiple moulder	35	Machine shop
100	18 in. x 30 in. sizer		
7½	24 in. swing cutoff saw		
5	Four motors, each driving one set of 2–14 in. swing cutoff saws		
7½	30 in. swing cutoff saw		

It will be noted that there are some unusually large blower units, these are direct driven by motors, and carry all of the shavings, sawdust and mill refuse into a fuel house adjoining the power station, from which it is fed mechanically to the boiler fires.

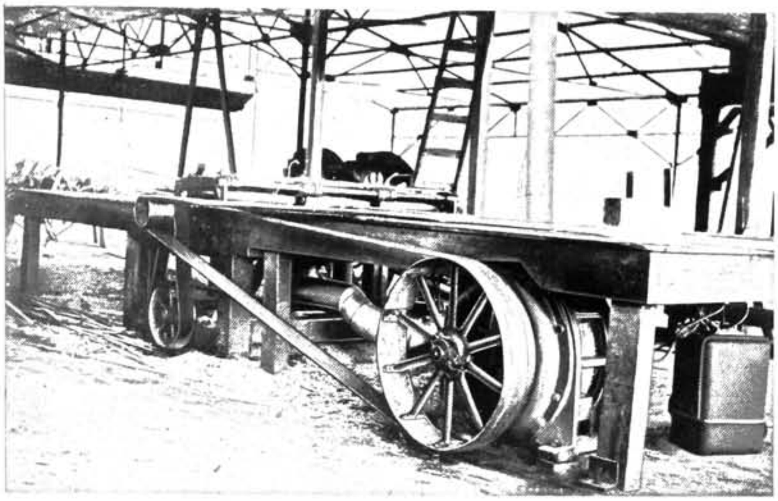
For delivering lumber to the dry kilns and rough sheds, transfer cars, designed and constructed by the company, are used, the cars being equipped with 10 h.p. General Electric constant speed direct current motors. The platforms of the cars are fitted with tracks and the car itself operates at right angles to the tracks leading to the rough shed and dry kilns, so that the trucks which carry the lumber may be pulled off and on the transfer cars by means of a cable and drum which is driven by the car motor. The lumber is carried from the storing sheds to the planer mill and shipping departments by means of an overhead electrically operated monorail system which extends throughout the rough sheds, planing mill and shipping departments, and renders possible the most rapid and economical handling of both rough and finished product.

In hauling the timber out of the log pond an endless conveyor is used, extending below the water, so that the timbers may be floated to the loader and automatically carried to the cars. Until recently this work was performed by a steam loader operating on the hoist principle, but this method was found to be too slow and was abandoned in favor of the present method, which utilizes a 55 h.p. induction motor.

The plant is provided with ample lighting facilities for both buildings and yards, the outdoor lighting being provided by 25 magnetite arc lamps which are installed in a circle of about 15 feet in diameter on top of a water tower 150 feet high. This system provides ample illumination for both yards and log pond, and avoids the necessity for running lighting wires in the yards where they might tend to complicate working conditions. The interior lighting is accomplished by means of enclosed arc lamps equipped with light balancing selective diffusers.

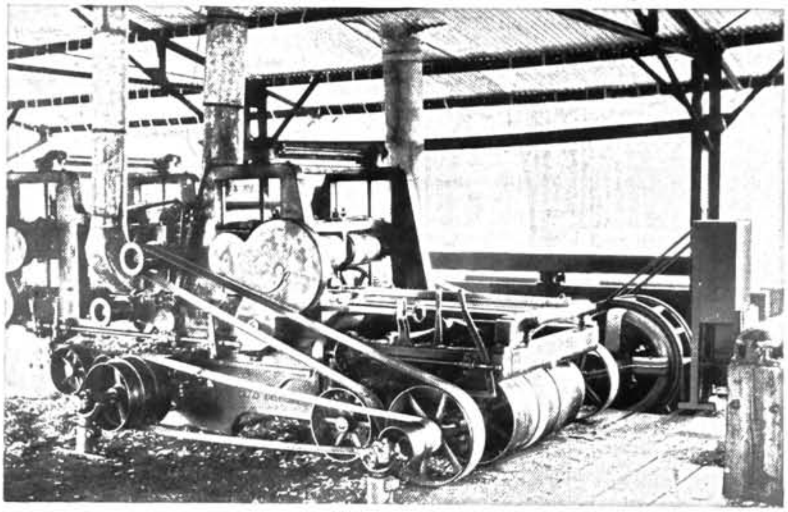


55 H.P. 600 R.P.M. 550 VOLT MOTOR DIRECT CONNECTED TO 6 IN. BAND RE-SAW



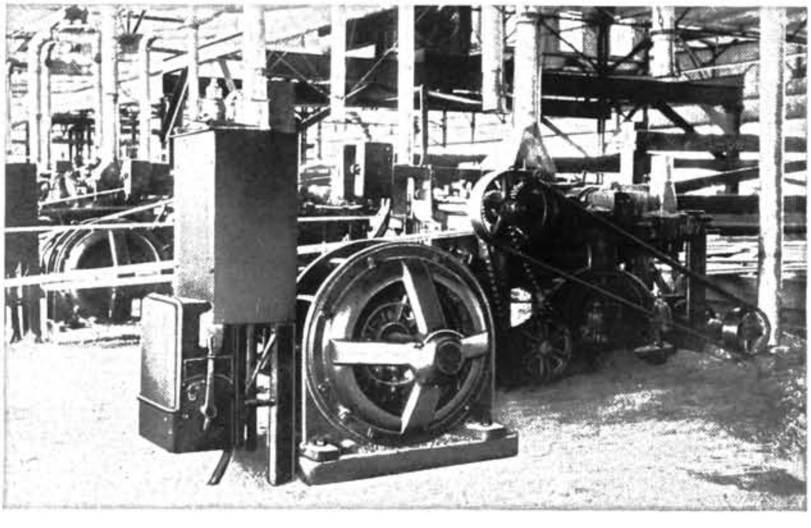
35 H.P. MOTOR DRIVING SAW EDGER

100 H.P. MOTOR OPERATING



30 IN. BY 18 IN. SIZER DIRECT DRIVE

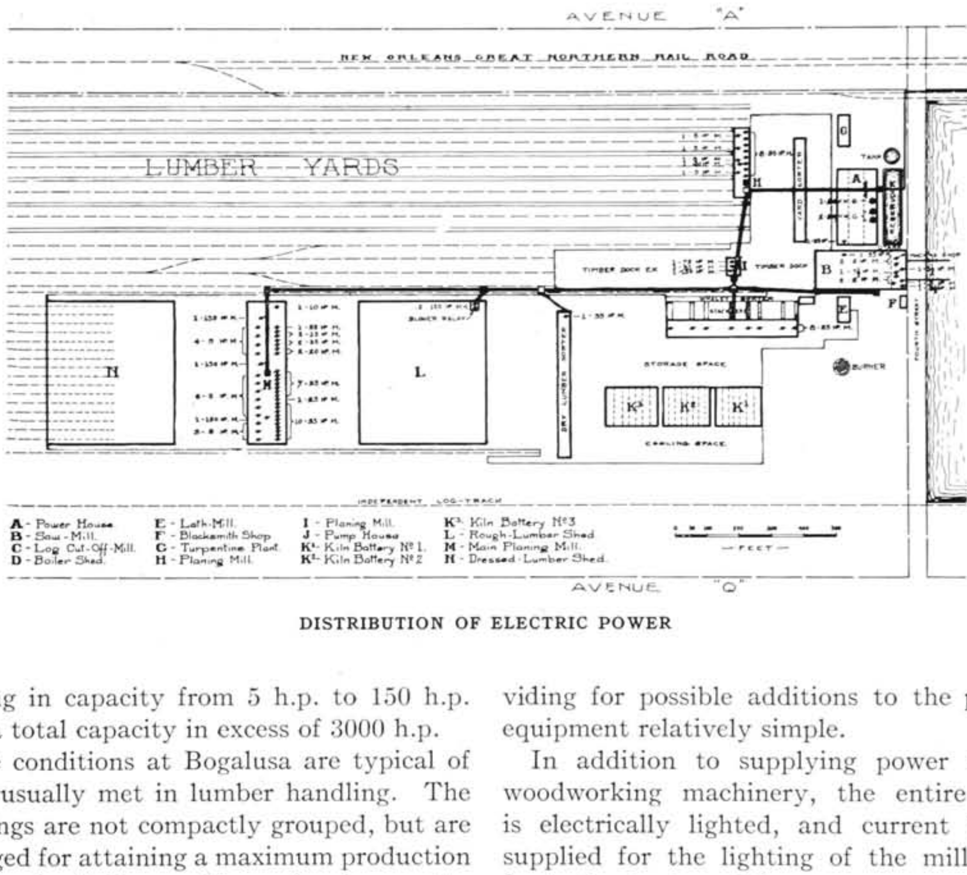
35 H.P. MOTOR DIRECT CONNECTED TO MULTIPLE MOULDER



THE GREAT SOUTHERN LUMBER COMPANY

To the practical user of woodworking machinery a brief description of the electrical equipment of the Great Southern Lumber Company's plant at Bogalusa, La., will present graphically the inherent advantages of electric light and power. This is one of the largest electrically operated lumber manufacturing plants in the world, and has an annual production of 175,000,000 feet of lumber. There are more than 100 General Electric motors in use in the various buildings entailing heavy expense for maintenance and operation, but with electric power the energy developed can be readily distributed with small loss, and at the Bogalusa plant all the machinery is operated from one generating room.

By centralizing the generation of power it is obvious that the cost of attendance is reduced to a minimum, while the ease with which the electric current may be distributed and controlled renders the problem of pro-



DISTRIBUTION OF ELECTRIC POWER

ranging in capacity from 5 h.p. to 150 h.p. with a total capacity in excess of 3000 h.p.

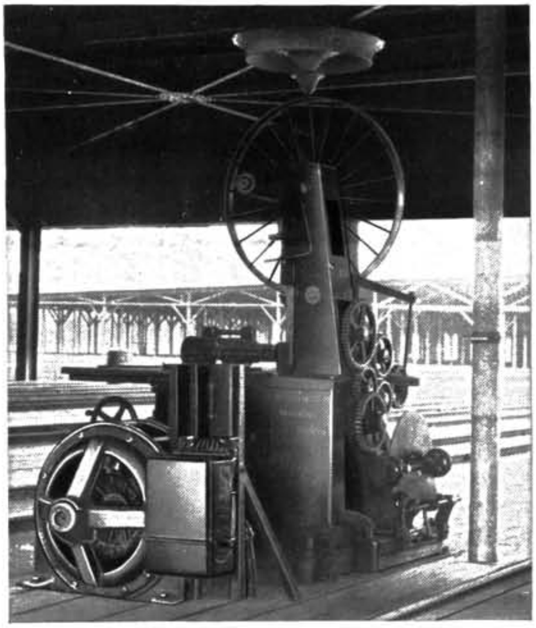
The conditions at Bogalusa are typical of those usually met in lumber handling. The buildings are not compactly grouped, but are arranged for attaining a maximum production and much of the machinery is of necessity located at a distance from the main saw mill. Under the old conditions of purely mechanical transmission of power this would have involved an almost prohibitive transmission loss or the expensive alternative of installing a number of separate steam power plants viding for possible additions to the present equipment relatively simple.

In addition to supplying power for all woodworking machinery, the entire plant is electrically lighted, and current is also supplied for the lighting of the mill town, for both streets and houses.

The equipment exemplifies both the individual and group system of motor drive, the majority of the machines being operated by individual motors, while the filing room machinery is operated by motor driven shafting.

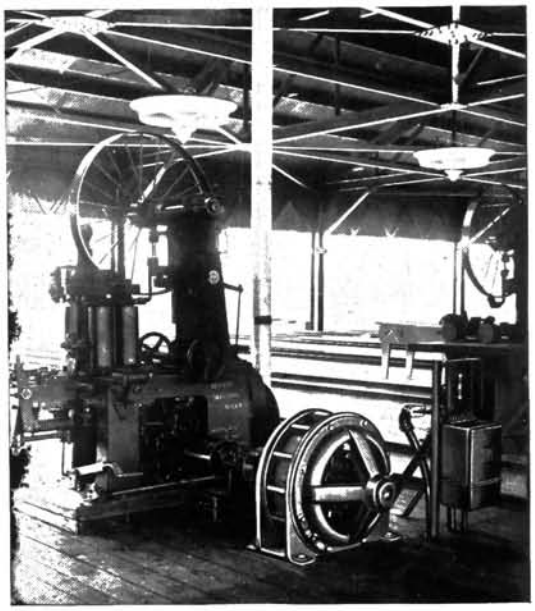
In the accompanying illustrations, motor applications and the use of the General Electric diffuser arcs for interior lighting are shown. The power house provides both alternating and direct current service.

The current is generated and transmitted at 2300 volts alternating current, the pressure being reduced by means of transformers to 440 volts, for which voltage the alternating current motors are designed. A few direct current variable speed motors are used in the machine shop, and these are supplied by means of a motor-generator set. The type of alternating current motor used is the well-known General Electric Form K induction motor, which is simple and strong in construction and capable of maintaining high efficiency over a wide load range. It requires practically no attention while running, and is able to carry large overloads for considerable periods without serious overheating. In addition to this, it is quick and certain in starting under load, and the starting apparatus is extremely simple. These characteristics insure continued operation under the severest service conditions that are met in woodworking plants, and formed the principal reason for the adoption of the K motor for constant speed work throughout the Bogulusa plant.



NO. 281 BERLIN BAND RESAW OPERATED BY DIRECT CONNECTED 25 H.P. FORM K INDUCTION MOTOR

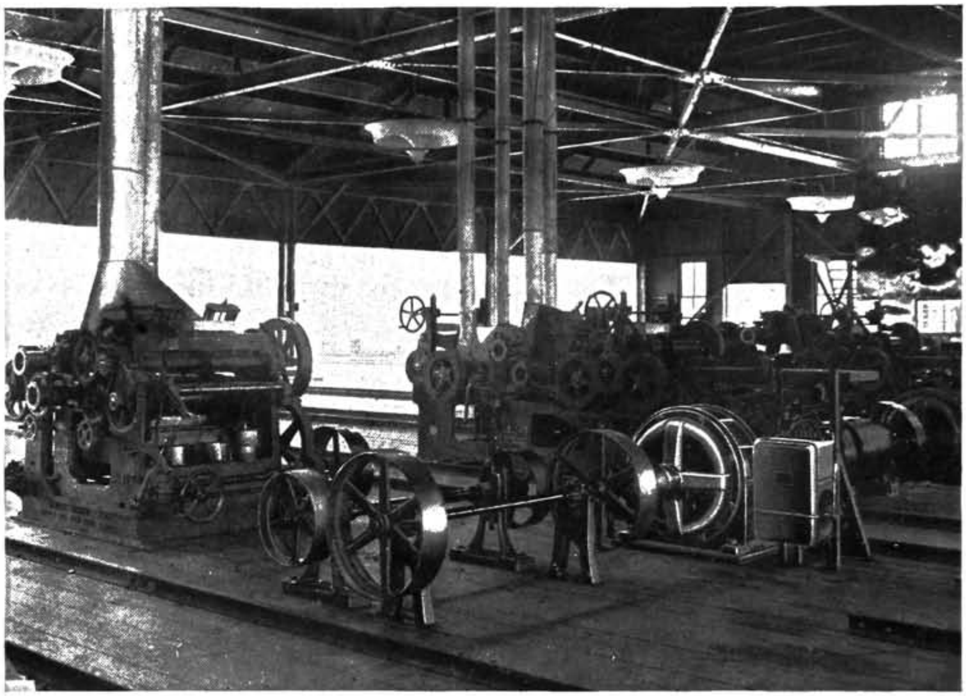
Each motor is supplied with a starting device and protected by fuses so that each machine or each shaft driven group is a plant in itself and practically independent of the other machines. The fuses protect both the motor and the cable from internal injury, and as the cables are enclosed in iron conduits the danger of fire from this source is avoided.



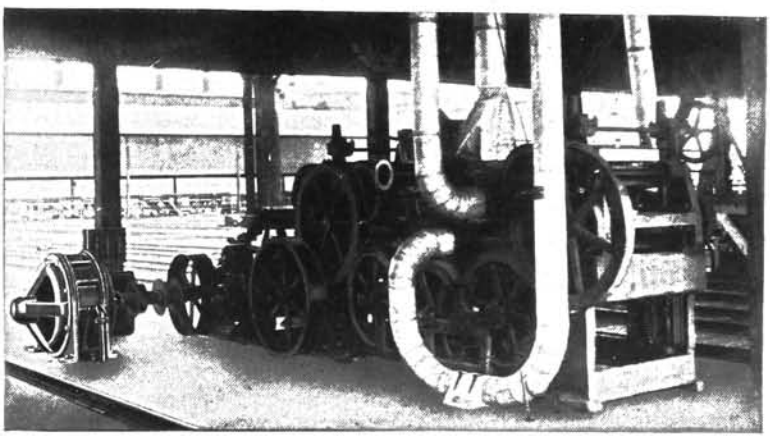
NO. 283 BERLIN 44 IN. BAND RESAW OPERATED BY DIRECT CONNECTED, 25 H.P. FORM K INDUCTION MOTOR

In order to eliminate the dust nuisance which is so commonly met with in saw mills, motor-driven double blowers with an elaborate piping system are distributed through the mills, and about eight ounces constant pressure is maintained. This not only carries away dust and fine shavings, but also knots and large chips.

The use of motor-drive practically eliminates overhead belting and greatly simplifies the problem of interior lighting. The Bogalusa plant uses General Electric arc lamps with diffuser reflectors in combination with small incandescent units for interior lighting, while for illuminating the mill yards steel towers have been erected on which groups of luminous arc lamps have been installed. This method insures well distributed light and obviates any possibility of the wires interfering with the handling of lumber in the yards. The steel towers are supplemented by poles with one arc lamp each, and arc lamps are also provided for lighting the streets of the mill town. In all 3067 incandescent and 289 arc lamps are used.



NO. 177 BERLIN PLANER DRIVEN BY A 35 H.P. FORM K INDUCTION MOTOR

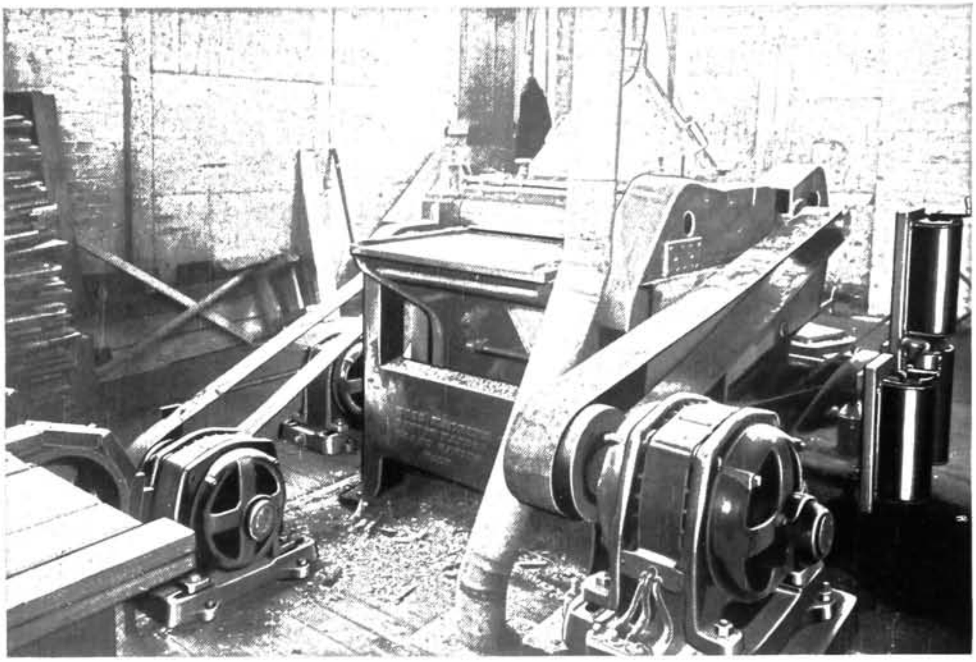


NO. 94 BERLIN 9 IN. BY 6 IN. AND 15 IN. BY 6 IN. PLANER AND MATCHER, DRIVEN BY A 35 H.P. FORM K INDUCTION MOTOR

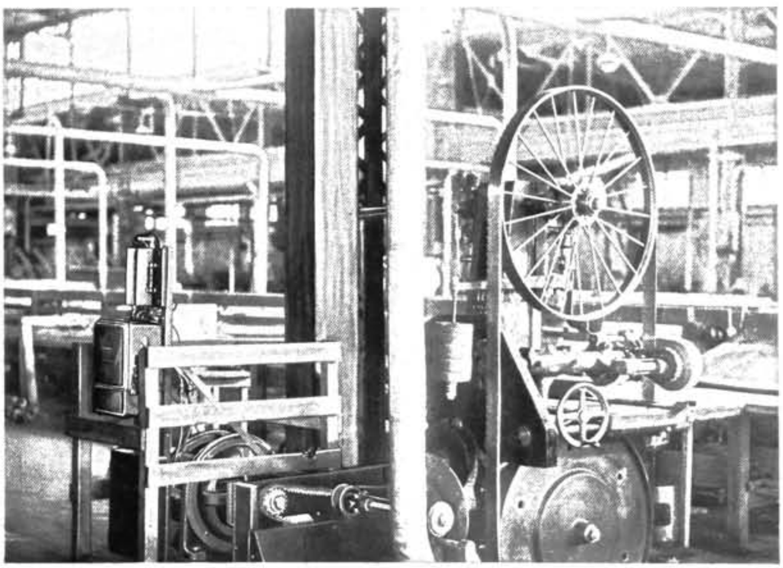
DISTRIBUTION OF MOTORS—THE GREAT SOUTHERN LUMBER CO.

Machinery	MOTORS		
	No.	H.P.	r.p.m.
DRY PLANING MILL			
9 in. matcher	1	35	900
9 in. matcher	1	35	900
15 in. matchers	6	50	1140
10 in. moulders	2	35	900
12 in. moulders	2	35	900
15 in. moulders	2	35	900
Sizer	1	75	1200
15 in. matchers	2	35	900
15 in. matcher	1	50	1200
15 in. matcher	1	75	1140
Sizer	1	75	1140
Fans	2	100	600
Fan	1	150	600
Resaw	1	25	680
Band rip saw	1	25	600
Band rip saw	1	25	720
Resaw	1	50	514
Edger	1	25	1200
Cut offs	5	5	1200
Cut offs	2	5	1130
Cut offs	3	5	720
Grinders	2	5	1200
Grinder	1	1	1700
Tool room	1	10	1200
Conveyor	1	10	1200
Conveyor	1	5	720
Fan	1	5	600
Cut off	1	5	1200
9 in. matchers	2	35	900
9 in. matchers	3	50	1200
9 in. matchers	2	35	850
Surfacer			
BOX FACTORY			
Surfacer	1	25	850
Hog	1	55	570
Line shaft	1	40	850
Line shaft	1	20	1140
Rip saw	1	10	1800
Resaw	1	55	514
Resaw	1	50	600
Matcher	1	35	900
Fan	1	75	900
Cut off	1	5	1200
Cut off	2	5	720
Sorter	1	10	1200
Hog chain	1	25	1200
Conveyor	3	10	1200
Grinder	2	1	1700
Transfer	1	10	1130
SAW MILL			
Butt saw	1	50	720
Butt saw	1	50	900
PLANING MILL NO. 2			
6–No. 94 planers and matchers	6	35	900
3–16 in. No. 238 trim saws	3	5	1200
1–Double 70 in. Sturtevant blower	1	150	600

Machinery	MOTORS		
	No.	H.P.	r.p.m.
PLANING MILL ON TIMBER DOCK			
1–72 in. sizer	1	75	1200
1–30 in. by 20 in. No. 1 timber sizer	1	85	900
1–Double Sturtevant blower	1	150	600
1–Planer	1	75	1200
DRY LUMBER SORTER			
1–Dry lumber sorter	1	35	900
LUMBER STACKERS			
8–Lumber stackers	8	25	600
FUEL CONVEYORS			
1–Fuel conveyor	1	35	900
1–Fuel conveyor	1	15	900
CENTRIFUGAL PUMPS			
2–14 in. centrifugal pumps for pumping on to log ponds	2	85	720
RELAY BLOWER STATIONS			
2–Double 70 in. Sturtevant blower	2	150	600
MACHINE SHOP			
1–Upright drill	1	2	
1–Bolt cutter	1	2	
1–Planer	1	7½	
2–Pipe machines	2	2	
1–Shaper	1	3½	
1–Radial drill	1	5	
1–Machine lathe	1	3½	
MISCELLANEOUS			
1–Burner slab chain	1	35	900
1–Green sorter	2	35	900
1–Prime sorter	1	35	900
2–Transfer cars	2	20	1200
1–Transfer car	1	25	1200
6–Transfer cars	6	10	1200



DOUBLE-HEAD PONY PLANER DRIVEN BY THREE 7½ H.P. INDUCTION MOTORS
PAINE LUMBER COMPANY, OSHKOSH, WIS.



4 IN. BAND SAW DRIVEN BY AN INDUCTION MOTOR, SILENT CHAIN DRIVE
PAINE LUMBER COMPANY, OSHKOSH, WIS.

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

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Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
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Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
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Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

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General Electric Company
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SMALL MOTOR DEPARTMENT

June, 1912 *Bulletin No. 4963*

SMALL DIRECT AND ALTERNATING CURRENT MOTORS DRAWN SHELL TYPE

The fractional horse power "drawn shell" motors described in this bulletin have been especially designed and built for application to the diversified forms of small machines which may be driven by electric power.

This line of small motors is complete and includes sizes from 1/50 to 1/4 h.p. inclusive, wound for either direct or alternating current.

ALTERNATING CURRENT MOTOR, TYPE DSS

DIRECT CURRENT MOTOR, TYPE DSD

The mechanical and electrical designs have been worked out with equal care, as shown by the superior performance characteristics, refinement in detail and generally clean cut appearance of both types.

GENERAL DESCRIPTION

The distinguishing feature of drawn shell motors is the field construction which consists of a steel shell or cylinder supporting and clamping together the stator or field punchings. This unique method avoids the use of the usual cast framework outside the active magnetic material, also serving to reduce the temperature of interior parts, as the external shell conducts and radiates the heat generated more effectively and rapidly than is possible with the ordinary cast frame construction.

The following illustrations graphically represent the successive steps employed in building up the field structure of a drawn shell alternating current motor.

A disk (Fig. 1) is first punched or "blanked" out of soft steel; this disk being forced into cup shape (Fig. 2) with one end closed. The open edge of the shell is then trued up and a blank accurately punched out of the cup bottom (Fig. 3). The partly finished field structure is now ready to receive the stator

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

punchings. In the next operation a suitable number of spacing rings (Fig. 4) are forced into the shell and seated against the retaining lip, which may be seen in Fig. 3. The field punchings or laminae (Fig. 5) are now assembled, after which a second and equal set of spacing rings are put into place to center the active field iron. The open edge of the shell is then rolled over the punchings under heavy pressure, thus preparing the field structure for the machinings and fitting of the end heads and base. Fig. 6 shows a section of the competely assembled field structure, the parts being cut away to indicate the relation between field punchings, spacing rings and shell.

Fig. 1

Fig. 2

Fig. 3

BLANKING AND CUPPING PROCESSES

Fig. 4

Fig. 5

Fig. 6

SPACING RING AND LAMINAE ASSEMBLY

BEARING HEADS

After the spacing rings at both frame ends have been turned true and grooved, the bearing heads (Fig. 7) are ready for fastening in place by four fillister-headed screws.

A complete wound field is shown in Fig. 8 with flat base casting attached. This base, if desired, may be removed, leaving the cylindrical frame of the motor free for any special method of support.

The construction of direct current drawn shell motors is essentially the same as for the alternating current types. Fig. 9 illustrates the unwound laminated field of a DSD motor, the complete detail parts being shown in Fig. 26, page 8.

RATING

Prospective customers often fail properly to appreciate that all motor manufacturers do not rate their product on the same basis. Fractional horse power motors in particular are occasionally rated ***on input expressed as horse power,*** while other manufacturers rate them on a basis of ***actual brake horse power developed at the pulley.*** We believe the first, or input basis, to be misleading, since a motor rated for example, 1/8, and having an efficiency of 55 per cent., would actually develop only 1/15 brake horse power.

All General Electric motors are rated on actual tested brake horse power output, and have, in addition, ample reserve capacity to withstand a reasonable percentage of overload. These facts should be kept prominently in mind when making price and size comparisons between General Electric motors and those of other manufacture not employing the same basis for rating.

Fig. 7
BEARING HEAD OF DRAWN SHELL MOTOR

BEARINGS AND LUBRICATION

The bronze bearing linings of all drawn shell motors are of generous size and are lubricated by under-feed oil cups or oil ring bearings, depending on the size of the frame as well as the duty to be performed.

For continuous service, and in sizes rated 1/4 h.p., motors are fitted with oil ring bearing heads. Figs. 24 and 25 (page 7) show respectively the alternating and direct current ring bearing type motors.

SHAFTS AND ARMATURES

All drawn shell motors use special grade steel shafts having ample dimensions and particularly selected for the purpose (see Fig. 10).

SINGLE-PHASE MOTORS

All single-phase drawn shell motors are provided with a simple and reliable form of

Fig. 8
WOUND FIELD, SINGLE-PHASE MOTOR

starting switch assembled within the motor frame. This switch consists essentially of three parts: a rotating member (Fig. 11) mounted on the armature and provided with two spring controlled, pivoted levers in contact with an insulated collector ring. The

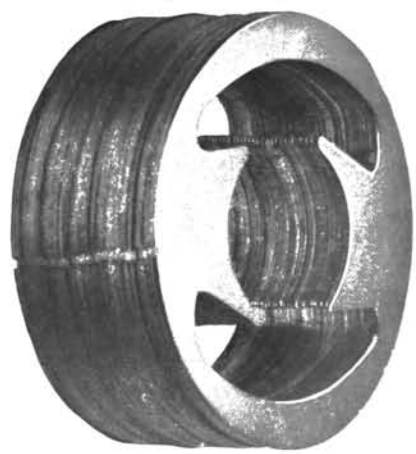


Fig. 9
LAMINATED FIELD, DIRECT CURRENT MOTOR

fixed contact member, insulated from and mounted on the bearing head, is shown in Fig. 12.

4963-4 Small Direct and Alternating Current Motors, Drawn Shell Type

Fig. 10
COMPLETE ARMATURE WITH SHAFT

Fig. 13
BRUSH

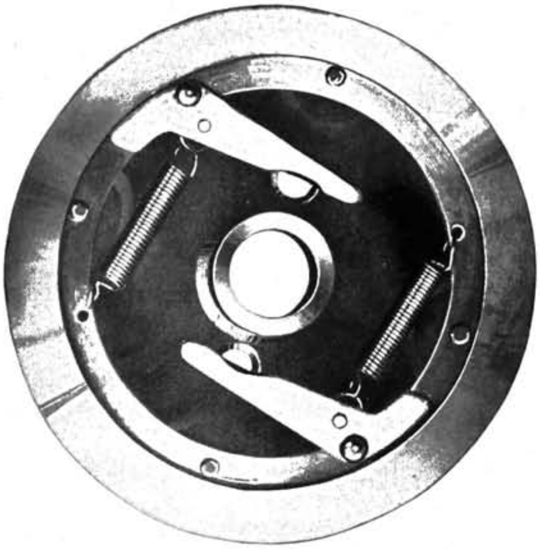


Fig. 11
ROTATING SWITCH MEMBER

Fig. 14
MOTOR CAP

Fig. 15
CLUTCH ARMATURE

Fig. 12
FIXED CONTACT MEMBER

Fig. 16
CLUTCHLESS ARMATURE

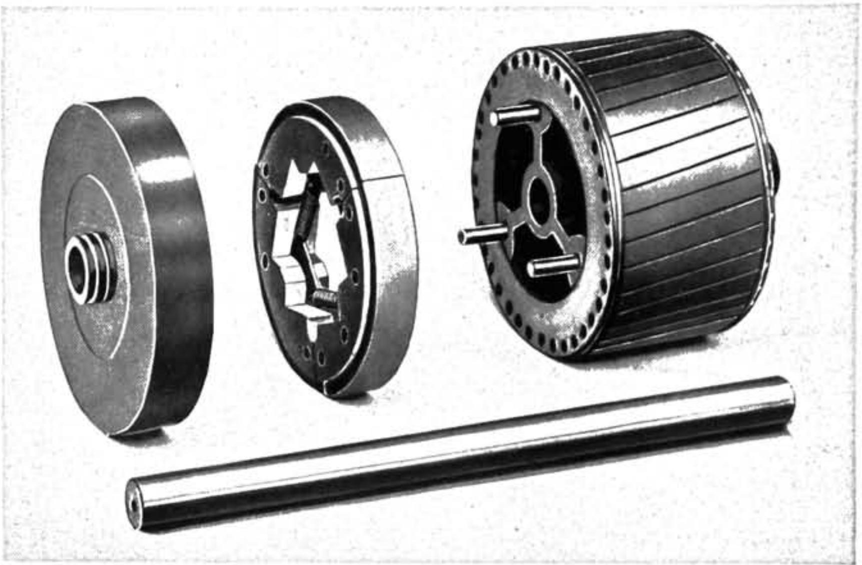


Fig. 17
DETAIL CONSTRUCTION OF SINGLE-PHASE CLUTCH PARTS

A small brush (Fig. 13) carried by an insulated brush-holder mounted on the motor cap and shown in Fig. 14, acts as a switch to open the starting phase of the field winding when the armature reaches a predetermined speed.

SINGLE-PHASE ARMATURES

The armatures of DSS motors are of the squirrel cage design and built either with (Fig. 15) or without (Fig. 16) clutches.

The detail construction of clutch parts is shown above. (Fig. 17).

BASES

All drawn shell alternating and direct current motors up to and including 1/4 h.p. provided with flat base castings, screwed or bolted to the motor frame. These bases have broad slotted supporting feet, filling a double function as holding down screws and belt tighteners (Fig. 18). Sliding bases for 1/8, 1/6 and 1/4 h.p. motors can be furnished on order. (See Fig. 19.)

PULLEYS

Steel pulleys with black oxidized finish and designed with single "V" groove (Fig. 20)

Fig. 18
SLOTTED REMOVABLE BASE

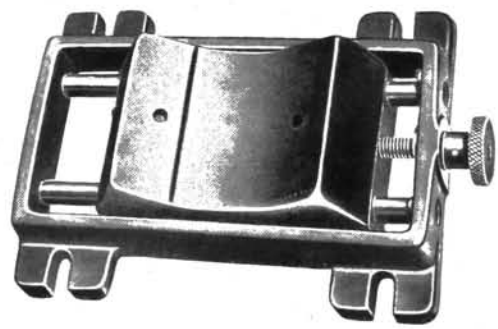


Fig. 19
SLIDING BASE

for use with round belt, are furnished on drawn shell motors of 1/6 h.p. and smaller. On special order, motors may be supplied with three-step "V" or flat grooved cone pulleys.

DSS and DSD 1/4 h.p. motors are fitted with crowned paper pulleys for flat belt (Fig. 20).

INSTALLATION

Unless otherwise ordered, all drawn shell motors are shipped assembled for floor installation. However, as bearing heads and frames are drilled and tapped symmetrically, motors may be readily arranged for side wall or ceiling suspension, by turning the bearing heads 90 or 180 degrees respectively in relation to the frame.

Fig. 20
PULLEYS FOR DRAWN SHELL MOTORS

ENCLOSED MOTORS

On order, the General Electric Company is prepared to furnish totally enclosed drawn shell motors wound for both alternating and direct current circuits, the alternating current type of 1/6 h.p. and smaller (Fig. 21), being built with solid cast bearing caps, while alternating current 1/4 h.p. motors and direct current motors of 1/30 h.p. to 1/4 h.p. are provided with sheet metal enclosing covers (Fig. 22). *Either the cast bearing caps or the sheet metal covers must be applied at the factory.*

ROTATION

All standard drawn shell motors are connected for clockwise rotation when facing the shaft extension end. On Type DSS motors the starting leads are brought out between the binding posts (Fig. 23), thus providing a

Fig. 21
ALTERNATING CURRENT MOTOR—TOTALLY ENCLOSED

ready means of changing the direction of rotation. The rotation of DSD motors may be reversed by exchanging the lead connections at the brush-holders.

HEATING

Standard drawn shell type open motors wound for continuous service will deliver

Fig. 22
SHOWING SHEET IRON ENCLOSING COVER

their rated horse power continuously with a temperature rise by thermometer not exceeding 40 degrees C. on the windings. An overload of 25 per cent., may be maintained for one hour with a temperature rise on the windings not exceeding 55 degrees C.

While totally enclosed motors wound for continuous service will maintain the same normal load ratings as corresponding open motors, the temperature rise will be increased 15 degrees C. Their operation at overloads is not therefore to be generally recommended.

Fig. 23
SWITCH END VIEW—SINGLE-PHASE MOTOR

Type DSS open motors wound for intermittent service are designed for equal periods of operation and rest; operating periods not to exceed one-half hour. Under these restrictions, intermittent service motors will operate with the same temperature rises as the corresponding open and enclosed continuous service motors.

OPERATING VOLTAGES AND SPEEDS

Standard drawn shell motors wound for alternating current will operate satisfactorily on circuits where the variation of either frequency or voltage from normal does not exceed 5 per cent.

When both frequency and voltage vary, the sum of the variation must not exceed 8 per cent.

When the voltage range does not exceed the following limits, satisfactory operation without excessive heating will be secured

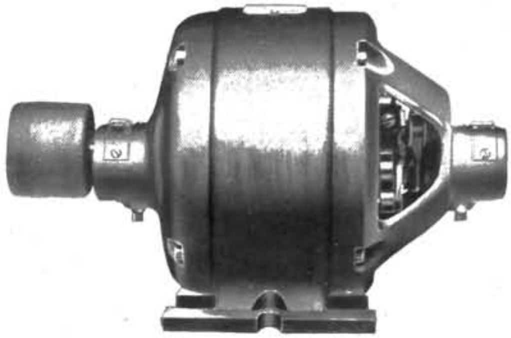


Fig. 24
TYPE DSD MOTOR WITH OIL RING BEARINGS

from standard direct current drawn shell motors.

110 volts, range 100 to 120 volts.
220 volts, range 200 to 240 volts.

SPEED

The full load speed of alternating current motors is approximately 5 per cent. less than the no load (i.e., synchronous) speed. In the

Fig. 25
TYPE DSS MOTOR WITH OIL RING BEARINGS

case of direct current motors, the actual operating speed may be 5 per cent. above or below the rated speed.

MOTOR SELECTION

The nature of the load must be carefully considered when deciding whether a clutch or clutchless motor should be applied. Machines requiring automatic and periodical reversal with considerable inertia to overcome during reversal, should as a rule be driven by clutchless motors. Loads having high inertia at starting, but not calling for reversal after being put in operation, are usually well operated by clutch armature motors. Both the foregoing requirements demand motors with high starting torque. Blowers, fans, etc., can frequently be operated with satisfaction by using clutchless motors having light load starting characteristics. Since no hard and fast rules can be laid down to govern the application of these small motors, each case must be studied very carefully, to determine properly the choice of motor.

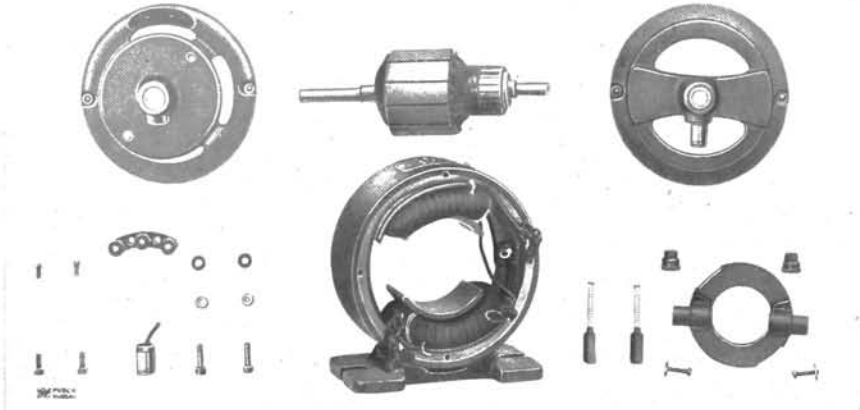


Fig. 26
DETAIL PARTS OF TYPE DSD 1/6 H. P. MOTOR

STARTING TORQUE

Shunt Motors

As the design of direct current motors inherently permits good starting torque, this feature demands less attention than in the case of single-phase motors. Shunt motors give a closer speed regulation than the compound, the former type being applicable where the load may be accelerated slowly and has a reasonably uniform value, i.e., free from violent fluctuations.

Series Motors

Series motors, while not listed in this bulletin, can be furnished on the same frames and with the same ratings as the corresponding shunt motors. Motors with series windings develop inherently heavy torque, guaranteeing ready acceleration on loads having great inertia, or those subject to violent fluctuations.

Compound Motors

Compound wound motors possess the leading characteristics of both the shunt and series types and may be successfully applied to all loads demanding heavy starting torque or subject to violent fluctuations.

NOTE:—The speed of any given direct current motor will vary approximately in proportion to change in impressed voltage. It should be remembered that in general the speed of motors depends on a number of other qualifying factors, e.g., the temperature of the air surrounding the motor as well as changing temperature in the windings due to increased or decreased heating with load; the difficulty in securing iron and steel of absolutely uniform magnetic properties, the variation in the resistance of the relatively fine copper wires used in small motor windings, etc. The belt speed is of really more importance than the number of armature revolutions, and where it is necessary to secure a certain belt speed, this can be effected by the use of a special pulley, entailing less expense and delay than by applying special windings to meet exact load and speed conditions.

The amount of compounding used on Type DSD motors is slight, so that the machines possess sufficiently close regulation to avoid serious fluctuation in speed on change in load.

As before stated, the selection of a motor for a given purpose is largely influenced by the character of the work to be performed both under starting and running conditions. On single-phase alternating current motors it is of particular importance that the starting torque requirements of the driven device be carefully determined if the proper motor is to be applied.

The following tabulation indicates the standard line of drawn shell motors with the percentage of starting to full load torque holding for the speeds as given.

Speed	Per Cent. Starting to Full Load Torque	Armature	Service
1800	150	Clutch	Continuous
1800	150	Clutchless	Continuous
1800	30	Clutchless	Continuous
1200	100	Clutchless	Continuous
3600	100	Clutch	Continuous
1800	100	Clutch	Intermittent
1800	100	Clutchless	Intermittent

The starting currents of the single-phase motors with clutches are approximately three times normal full load values, while the starting currents of motors without clutches (i.e., with solid armatures) are approximately five to six times normal full load rating.

MOTORS ON SPECIAL ORDER

On special order, drawn shell Type DSS single-phase alternating current motors with reduced output and special windings can be furnished at 25, 40 and 133 cycles for a large proportion of the ratings shown, and built in the same frames as the 60 cycle motors.

Drawn shell motors may also be supplied on order wound for operation on two-phase and three-phase circuits. They are designated by type letters DSQ and DST respectively. Direct current motors for 550 volt circuits cannot be furnished in drawn shell frames smaller than O-43-A.

On special order, direct current series shunt or compound wound motors can be wound in standard frames for speed ratings of 1100, 2400 and 3400. Inquiries for all odd frequency and voltage motors of drawn shell type should be taken up with the nearest General Electric office.

TEST DATA

The following tabulation gives approximate operating data applying to drawn shell type motors, both alternating and direct current, for actual full load speeds approximately 1700 r.p.m. Motor on frame W-122-C is built with a solid armature; all the other alternating current motors have clutch armatures. The alternating current motors are wound for 50 per cent. overload start.

Test data on other types and sizes of drawn shell motors not tabulated in this bulletin will be furnished on request to the nearest local office of the General Electric Company.

Series motors have approximately the same full load operating constants as tabulated above for shunt and compound wound motors but no running free figures are given as motors, to avoid excessive speed, cannot be operated without load.

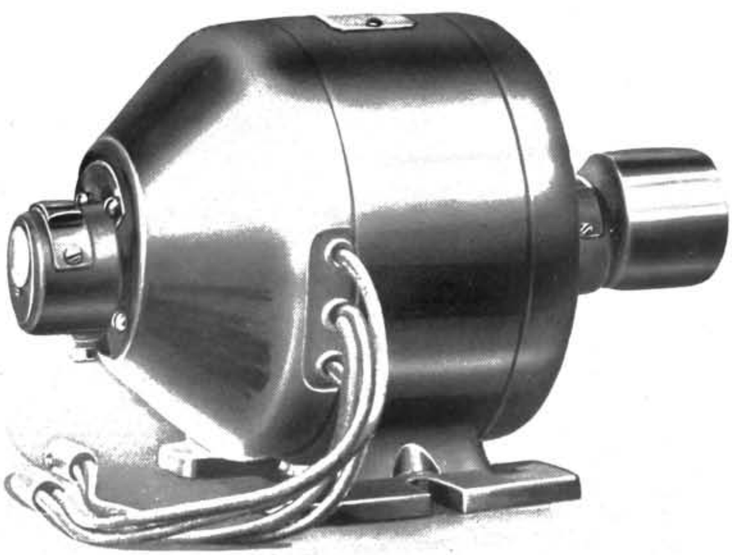
4963–10 Small Direct and Alternating Current Motors, Drawn Shell Type

TESTS AT 60 CYCLES, 110 VOLTS, SINGLE-PHASE

Type	H.P.	Frame Symbol	Running Free			At Full Load		
			Amperes	Watts	Speed	Amperes	Watts	Speed
DSS	1/30	W–122–C	0.67	25	1790	0.75	55	1730
DSS	1/15	W–222–C	1.10	35	1790	1.40	100	1700
DSS	1/10	W–255–C	1.70	50	1790	2.00	140	1700
DSS	1/8	W–333–C	1.95	50	1790	2.20	165	1720
DSS	1/6	W–455–C	2.00	50	1790	2.60	190	1750
DSS	1/4	W–466–C	2.86	70	1790	3.75	275	1740

TESTS AT 110 VOLTS, DIRECT CURRENT 1700 (RATED SPEED)
SHUNT OR COMPOUND WOUND

Type	H.P.	Frame Symbol	Running Free			At Full Load		
			Amperes	Watts	Speed	Amperes	Watts	Speed
DSD	1/30	W–13–A	0.25	27.5	2000	0.45	49.5	1750
DSD	1/15	W–13–A	0.26	28.6	2120	0.78	86.0	1780
DSD	1/10	W–15–A	0.27	29.7	2100	1.25	137.5	1730
DSD	1/10	W–23–A	0.36	40.0	1850	1.20	132.0	1650
DSD	1/8	W–23–A	0.37	41.0	2070	1.38	152.0	1730
DSD	1/6	W–33–A	0.39	43.0	2100	1.88	206.0	1650
DSD	1/4	O–43–A	0.55	60.5	2080	2.45	269.5	1715



TOTALLY ENCLOSED MOTOR, TYPE DSD, ¼ H.P.
WITH OIL RING BEARINGS

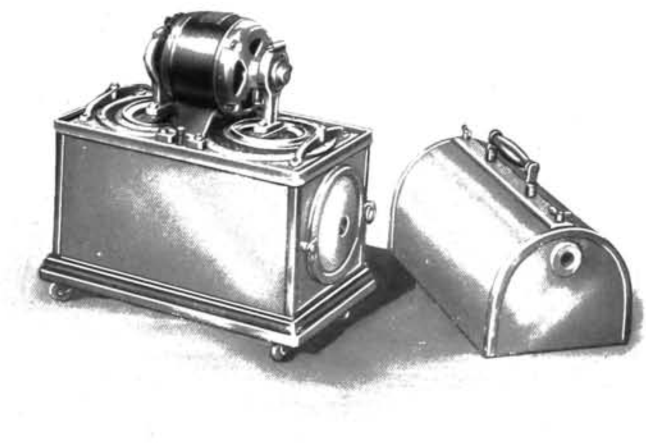
DIMENSIONS

For convenient identification of drawn shell motors, catalogue numbers have been assigned, as tabulated on pages 15 and 16.

All previous lists are herewith rescinded.

On pages 17, 18 and 19, will be found dimension sheets applying to all the drawn shell motor frames listed.

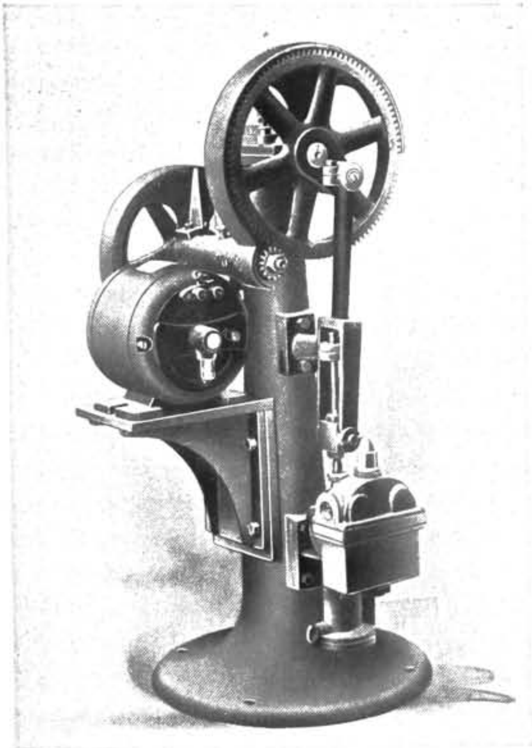
JEWELERS BUFFING AND GRINDING OUTFIT, WITH TYPE DSS 1/8 H.P. MOTOR



VACUUM CLEANER DRIVEN BY TYPE DSS 1/8 H.P. MOTOR

The General Electric Company is prepared to furnish motors in quantities for a wide variety of special applications and to this end offers exceptional advantages through the services of a trained engineering force combined with the highest order of manufacturing facilities.

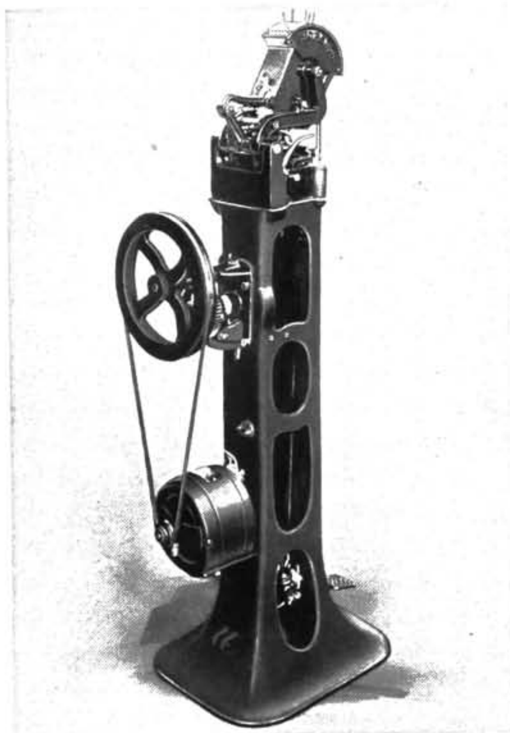
A few typical applications of General Electric drawn shell motors are illustrated herewith and on pages 12, 13 and 14.



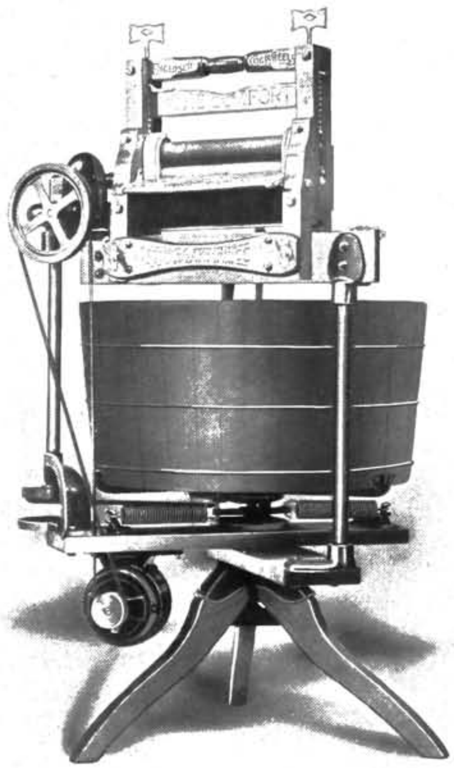
HOUSE PUMP DRIVEN BY TYPE DSS 1/6 H.P. MOTOR

"HIGH ARM" SEWING MACHINE OUTFIT WITH TYPE DSS 1/30 H.P. MOTOR

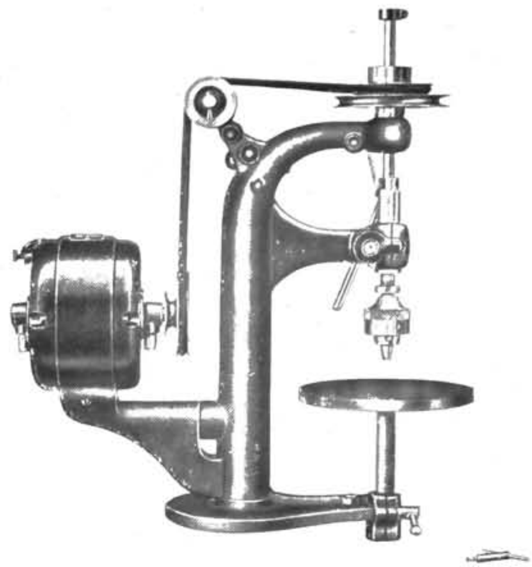
"LOW ARM" SEWING MACHINE OUTFIT WITH TYPE DSS 1/30 H.P. MOTOR



LAUNDRY MARKING MACHINE DRIVEN BY TYPE DSS 1/10 H.P. MOTOR

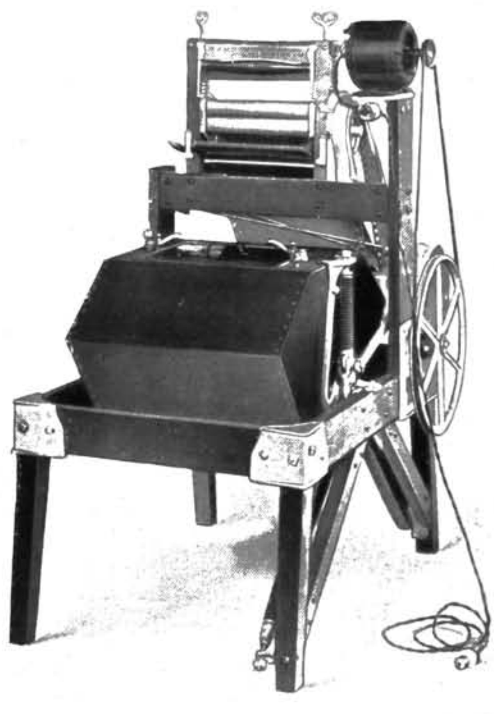


WASHING MACHINE DRIVEN BY TYPE DSS
1/10 H.P. MOTOR



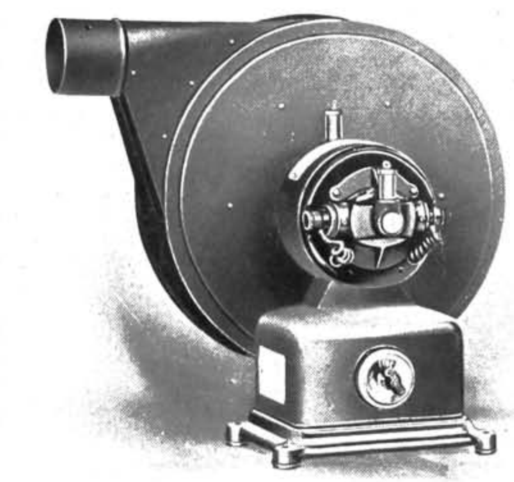
BENCH DRILL DRIVEN BY TYPE DSS-1/6 H.P. MOTOR

HAT CLEANER DRIVEN BY TYPE DSD
1/15 H.P. MOTOR



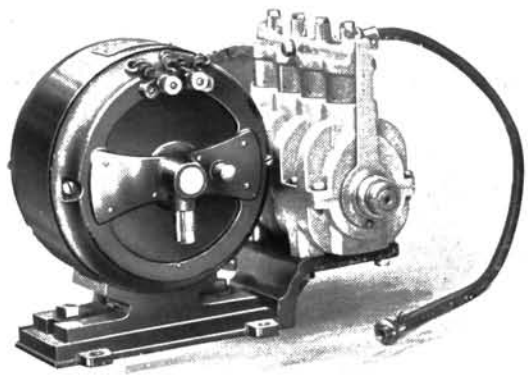
WASHING MACHINE DRIVEN BY TYPE DSS
1/6 H.P. MOTOR

4963-14 Small Direct and Alternating Current Motors, Drawn Shell Type

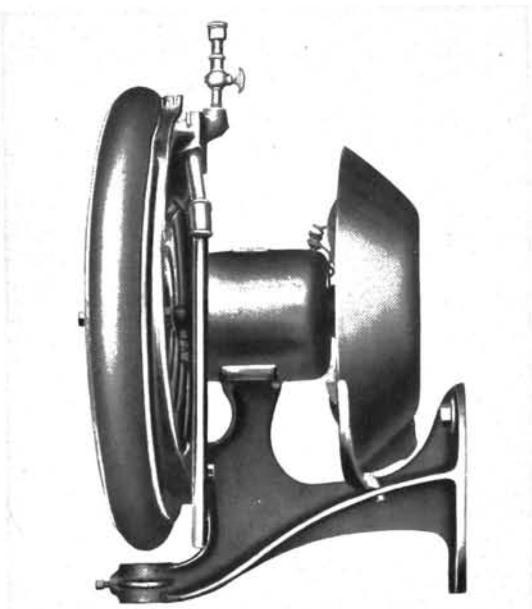


HAIR DRYER DRIVEN BY TYPE DSD 1/15 H.P. MOTOR

"DOMESTIC" BUFFING AND GRINDING OUTFIT
WITH TYPE DSS 1/30 H.P. MOTOR



AIR PUMP DRIVEN BY TYPE DSS 1/4 H.P. MOTOR



HUMIDIFIER WITH TYPE DSD 1/8 H.P. MOTOR

"COMMERCIAL" BUFFING AND GRINDING OUTFIT
WITH TYPE DSS 1/6 H.P. MOTOR

ALTERNATING CURRENT SINGLE-PHASE

TYPE DSS 60 CYCLE FORM CC CONTINUOUS SERVICE, 1800 R.P.M. 50 PER CENT. OVERLOAD START

Cat. No. With Clutch	Cat. No. Without Clutch	Horse Power	Speed (Sync.)	Volts	Frame Symbol
.....	66939	1/30	1800	110	W-122-C
....	66940	1/30	1800	220	W-122-C
66931	112179	1/15	1800	110	W-222-C
66932	112180	1/15	1800	220	W-222-C
66933	112181	1/10	1800	110	W-255-C
66934	112182	1/10	1800	220	W-255-C
66935	112183	1/8	1800	110	W-333-C
66936	112184	1/8	1800	220	W-333-C
36937	112185	1/6	1800	110	W-455-C
66938	112186	1/6	1800	220	W-455-C
129352	......	1/4	1800	110	W-466-C
129353	......	1/4	1800	220	W-466-C
.....	129354	1/4	1800	110	W-466-E
.....	129355	1/4	1800	220	W-466-E
104326	......	1/4	1800	110	O-466-C
104327	......	1/4	1800	220	O-466-C
......	129356	1/4	1800	110	O-466-E
......	129357	1/4	1800	220	O-466-E

TYPE DSS 60 CYCLE FORM CC CONTINUOUS SERVICE, 1800 R.P.M. LIGHT LOAD (30 PER CENT.) START

Cat. No. With Clutch	Cat. No. Without Clutch	Horse Power	Speed (Sync.)	Volts	Frame Symbol
Light load start motors not built with clutch armatures	66941	1/15	1800	110	W-222-C
	66942	1/15	1800	220	W-222-C
	66943	1/10	1800	110	W-255-C
	66944	1/10	1800	220	W-255-C
	66945	1/8	1800	110	W-333-C
	66946	1/8	1800	220	W-333-C
	66947	1/6	1800	110	W-455-C
	66948	1/6	1800	220	W-455-C

TYPE DSS 60 CYCLE FORM CC CONTINUOUS SERVICE, 1200 R.P.M. 50 PER CENT. OVERLOAD START

Cat. No. With Clutch	Cat. No. Without Clutch	Horse Power	Speed (Sync.)	Volts	Frame Symbol
1200 r.p.m. motors not built with clutch armatures	66917	1/50	1200	110	W-122-C
	66918	1/50	1200	220	W-122-C
	66919	1/30	1200	110	W-222-C
	66920	1/30	1200	220	W-222-C
	66921	1/15	1200	110	W-255-C
	66922	1/15	1200	220	W-255-C
	66923	1/12	1200	110	W-333-C
	66924	1/12	1200	220	W-333-C
	66925	1/10	1200	110	W-422-E
	66926	1/10	1200	220	W-422-E
	66927	1/8	1200	110	W-455-E
	66928	1/8	1200	220	W-455-E
	66929	1/6	1200	110	W-466-E
	66930	1/6	1200	220	W-466-E

TYPE DSS 60 CYCLE FORM CC CONTINUOUS SERVICE, 3600 R.P.M. FULL LOAD (100 PER CENT.) START

Cat. No. With Clutch	Cat. No. Without Clutch	Horse Power	Speed (Sync.)	Volts	Frame Symbol
129358	3600 r.p.m. motors not built without clutch armature	1/10	3600	110	W-222-C
129359		1/10	3600	220	W-222-C
129360		1/8	3600	110	W-255-C
129361		1/8	3600	220	W-255-C
129362		1/6	3600	110	W-333-C
129363		1/6	3600	220	W-333-C
129364		1/4	3600	110	W-455-C
129365		1/4	3600	220	W-455-C

ALTERNATING CURRENT SINGLE-PHASE (Continued)

Cat. No. With Clutch	Cat. No. Without Clutch	Horse Power	Speed (Sync.)	Volts	Frame Symbol
TYPE DSS 60 CYCLE FORM CC INTERMITTENT SERVICE, 1800 R.P.M. FULL LOAD (100 PER CENT.) START					
......	100701	1/20	1800	110	W-122-C
......	100702	1/20	1800	220	W-122-C
100693	100703	1/10	1800	110	W-222-C
100694	100704	1/10	1800	220	W-222-C
100695	100705	1/8	1800	110	W-255-C
100696	100706	1/8	1800	220	W-255-C
100697	100707	1/6	1800	110	W-333-C
100698	100708	1/6	1800	220	W-333-C
100699	100709	1/4	1800	110	W-455-C
100700	100710	1/4	1800	220	W-455-C

DIRECT CURRENT—SHUNT AND COMPOUND WOUND

Cat. No. Open	Cat. No. Enclosed	Horse Power	Speed (Sync.)	Volts	Frame Symbol
TYPE DSD 1700 R.P.M. FORM C CONTINUOUS SERVICE, SHUNT WOUND					
67166	67178	1/30	1700	110	W-13-A
67167	67179	1/30	1700	220	W-13-A
67168	67180	1/15	1700	110	W-13-A
67169	67181	1/15	1700	220	W-13-A
67170	67182	1/10	1700	110	W-15-A
67171	67183	1/10	1700	220	W-15-A
67172	67184	1/10	1700	110	W-23-A
67173	67185	1/10	1700	220	W-23-A
104328	129374	* 1/4	1700	110	O-43-A
104329	129375	* 1/4	1700	220	O-43-A

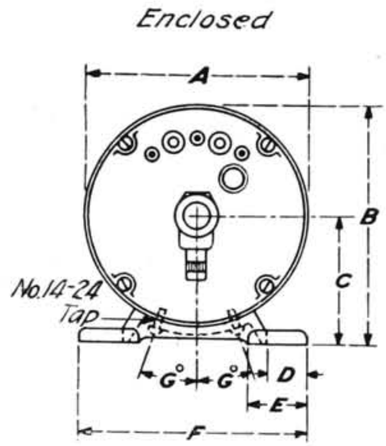
* The DSD ¼ h.p. shunt motor on frame O-43-A requires a starting rheostat. All other shunt and all compound wound motors listed above do not require starting rheostats.

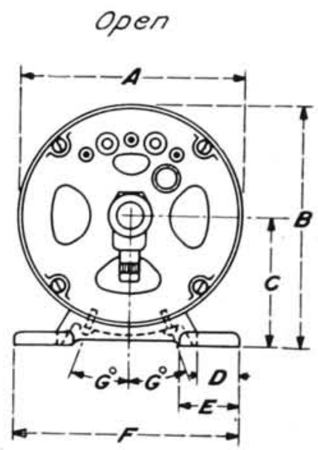
TYPE DSD 1700 R.P.M. FORM C CONTINUOUS SERVICE, COMPOUND WOUND					
67368	67399	1/8	1700	110	W-23-A
67370	67400	1/8	1700	220	W-23-A
67372	67401	1/6	1700	110	W-33-A
67374	67402	1/6	1700	220	W-33-A
104332	129376	1/4	1700	110	O-43-A
104333	129377	1/4	1700	220	O-43-A
TYPE DSD 1100 R.P.M. FORM C CONTINUOUS CURRENT, SHUNT WOUND					
67142	67154	1/50	1100	110	W-13 A
67143	67155	1/50	1100	220	W-13-A
67144	67156	1/30	1100	110	W-13-A
67145	67157	1/30	1100	220	W-13-A
67146	67158	1/15	1100	110	W-15-A
67147	67159	1/15	1100	220	W-15-A
67148	67160	1/15	1100	110	W-23-A
67149	67161	1/15	1100	220	W-23-A
67150	67162	1/10	1100	110	W-23-A
67151	67163	1/10	1100	220	W-23-A
TYPE DSD 1100 R.P.M. FORM C CONTINUOUS SERVICE, COMPOUND WOUND					
67342	67354	1/8	1100	110	W-33-A
67143	67355	1/8	1100	220	W-33-A

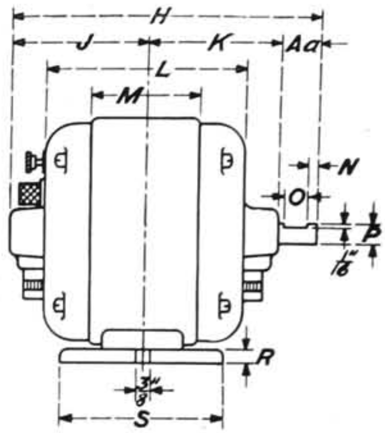
Catalogue numbers quoted above apply to the motors with standard flat bases only; i.e., pulleys are not included. When wanted, pulleys should be specified separately.

All motors with prefix "W" are built with wick oil bearings while those with frame symbol prefix "O" are built with oil ring bearings.

DIMENSIONS OF TYPE DSS MOTORS WITH WICK-OILED BEARINGS



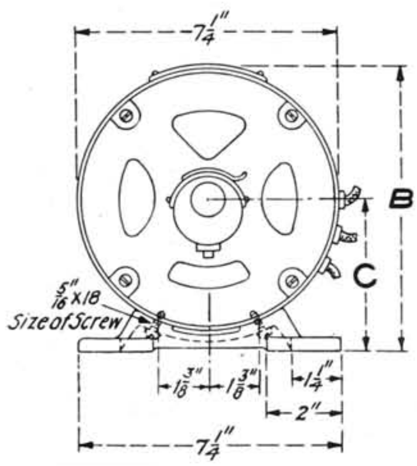


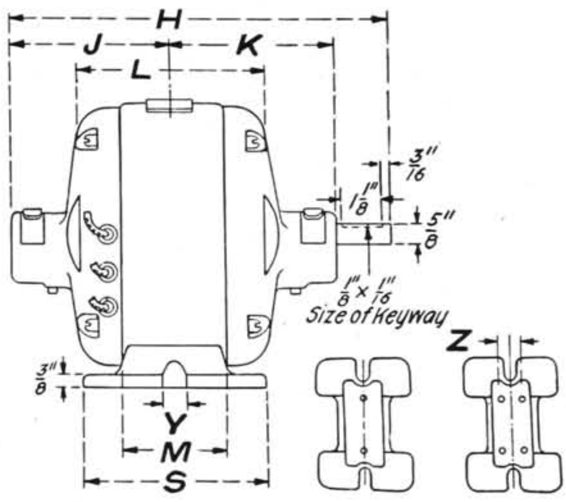


Frame Symbol	Net Wt.	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	R	S	Aa
W-122-C	12	4¾	5⅛	2¾	⅞	1⅜	4¾	20°	6	2⅝	2⅝	4 1/16	2.375	3/16	7/16	⅜	5/16	3½	¾
W-222-C	19	5¾	6⅛	3¼	1	1½	5¾	20° 30′	7⅜	3 3/16	3 3/16	4¾	2.4375	5/16	⅝	½	5/16	4	1
W-255-C(D)	21	5¾	6⅛	3¼	1	1½	5¾	20° 30′	7¾	3⅜	3⅜	5⅛	2.8125	5/16	⅝	½	5/16	4	1
W-333-C	25	6½	6⅞	3⅝	1	1⅝	6½	22° 30′	7⅞	3 7/16	3 7/16	5¼	2.6875	5/16	⅝	½	⅜	4	1
W-422-E	25	7¼	7⅝	4	1¼	2	7¼	22°	6⅝	2 13/16	2 13/16	4¼	2.0625	5/16	⅝	½	⅜	3½	1
W-455-C(E)	30	7¼	7⅝	4	1¼	2	7¼	22°	7¾	3⅜	3⅜	5⅛	2.5625	5/16	⅝	½	⅜	4	1
W-466-C(E)	31	7¼	7⅝	4	1¼	2	7¼	22°	8	3½	3½	5⅜	2.8125	5/16	⅝	½	⅜	4	1

NOTE.—Frame symbols with affixes "C", "D" or "E," have same external dimensions.

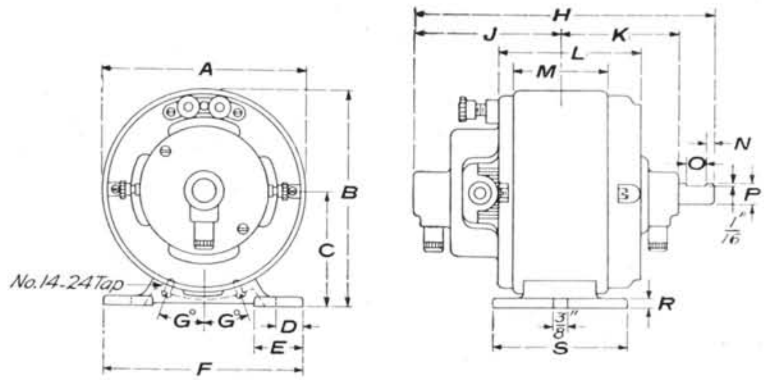
DIMENSIONS OF TYPE DSS MOTORS WITH OIL-RING BEARINGS





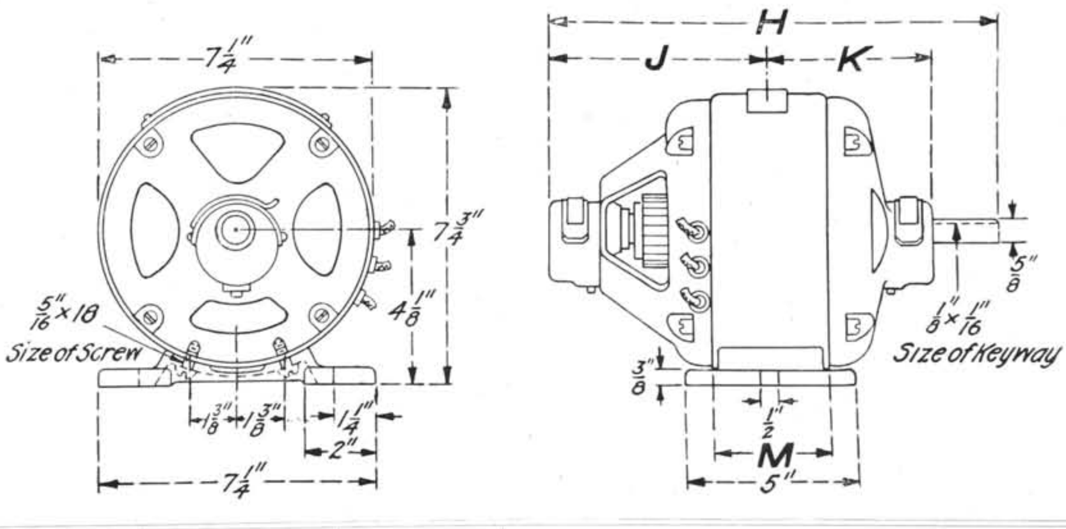
Type	Frame Symbol	Net Weight	DIMENSIONS IN INCHES									
			B	C	H	J	K	L	M	S	Y	Z
DSS	O-455-C(E)	32	7⅝	4	10	4¼	4¼	4 13/16	2 9/16	4	⅜	0
DSS	O-466-C(E)	36	7¾	4⅛	10¼	4⅜	4⅜	5 1/16	2 13/16	5	½	1¼

DIMENSIONS OF TYPE DSD DIRECT CURRENT MOTORS WITH WICK-OILED BEARINGS



Frame Symbol	Net Wt.	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	R	S
W-13-A	12	4¾	5⅛	2¾	⅞	1⅜	4¾	20°	7	3½	2¾	3 15/16	2⅝	3/16	7/16	⅜	5/16	3½
W-15-A	13¾	4¾	5⅛	2¾	⅞	1⅜	4¾	20°	7½	3¾	3	4 7/16	3⅛	3/16	7/16	⅜	5/16	3½
W-23-A	18½	5¾	6⅛	3¼	1	1½	5¾	20½°	8⅝	4¼	3⅜	4 5/16	2 13/16	5/16	⅝	½	5/16	4
W-33-A	24	6½	6⅞	3⅝	1	1⅝	6½	22½°	8⅞	4 7/16	3 7/16	4½	2 11/16	5/16	⅝	½	⅜	4

DIMENSIONS OF TYPE DSD MOTORS WITH OIL RING BEARINGS



Type	Frame Symbol	Net Weight	DIMENSIONS IN INCHES			
			H	J	K	M
DSD	043-A	33	11 21/32	5¾	4 13/32	2⅞
DSD	045-A	37½	12 5/32	6	4 21/32	3⅜

ADDENDA

To Accompany Bulletin No. 4963

SMALL DIRECT AND ALTERNATING CURRENT MOTORS—DRAWN SHELL TYPE

½ H.P. and ¾ H.P. Motors—Shunt, Series, or Compound Wound, 1700 r.p.m. at 115/230 volts, 2000 r.p.m. at 550 volts

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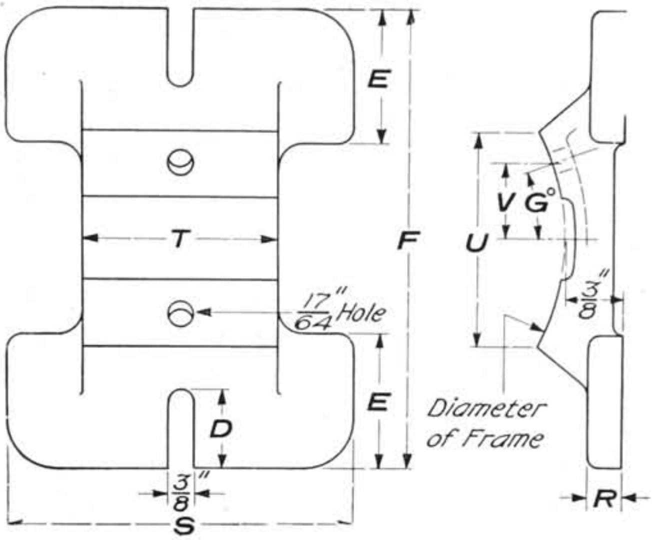
This bulletin, covering Drawn Shell Motors from 1/50 h.p. to ¼ h.p., inclusive, will be followed by a bulletin describing exclusively the ½ h.p. and ¾ h.p. sizes recently added to complete the standard line of motors available in "Drawn Shell" construction.

For immediate uses, data relating to the ½ h.p. and ¾ h.p. sizes may be obtained on application to the nearest office of the General Electric Company.

DIMENSIONS OF BASES AND PULLEYS FOR TYPES DSS AND DSD MOTORS



Frame Symbol	Weight Lb.	Diam. of Frame	D	E	F	G	R	S	T	U	V
W-122-C, W-13-A, W-15-A	1¼	4¾	⅞	1⅜	4¾	20°	5/16	3½	2	2⅜	13/16
W-222-C, W-23-A, W-255-C	1½	5¾	1	1½	5¾	20½°	5/16	4	2 13/16	2⅞	1
W-333-C, W-33-A	2	6½	1	1⅝	6½	22½°	⅜	4	2½	3⅜	1¼
W-422-C(E)	1¾	7¼	1¼	2	7¼	22°	⅜	3½	1¾	3¾	1⅜
W-455-C(E) W-466-C(E)	2½	7¼	1¼	2	7¼	22°	⅜	4	2⅛	3¾	1⅜

DIMENSIONS OF STANDARD SINGLE GROOVE PULLEYS

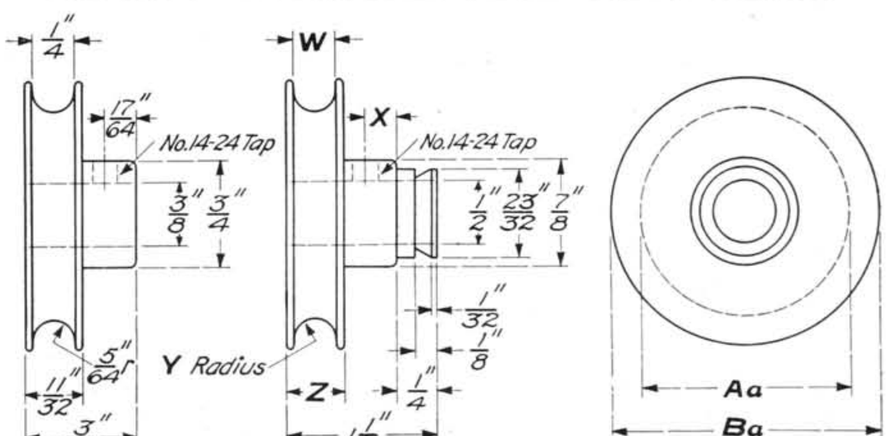


Fig. 1 Fig. 2

Frame Symbol	Wt. Lb.	Diam. of Belt	W	X	Y	Z	Aa	Ba	Fig.
W-122-C, W-13-A, W- 15-A	⅜	3/16	..	..	..	..	1½	2	1
W-222-C, W-23-A, W-255-C	½	¼	5/16	¼	7/64	7/16	1¾	2¼	2
W-333-C, W-33-A, W-422-C(E), W-455-C(E), W-466-C(E	¾	⅜	7/16	5/32	11/64	9/16	2	2¾	2

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

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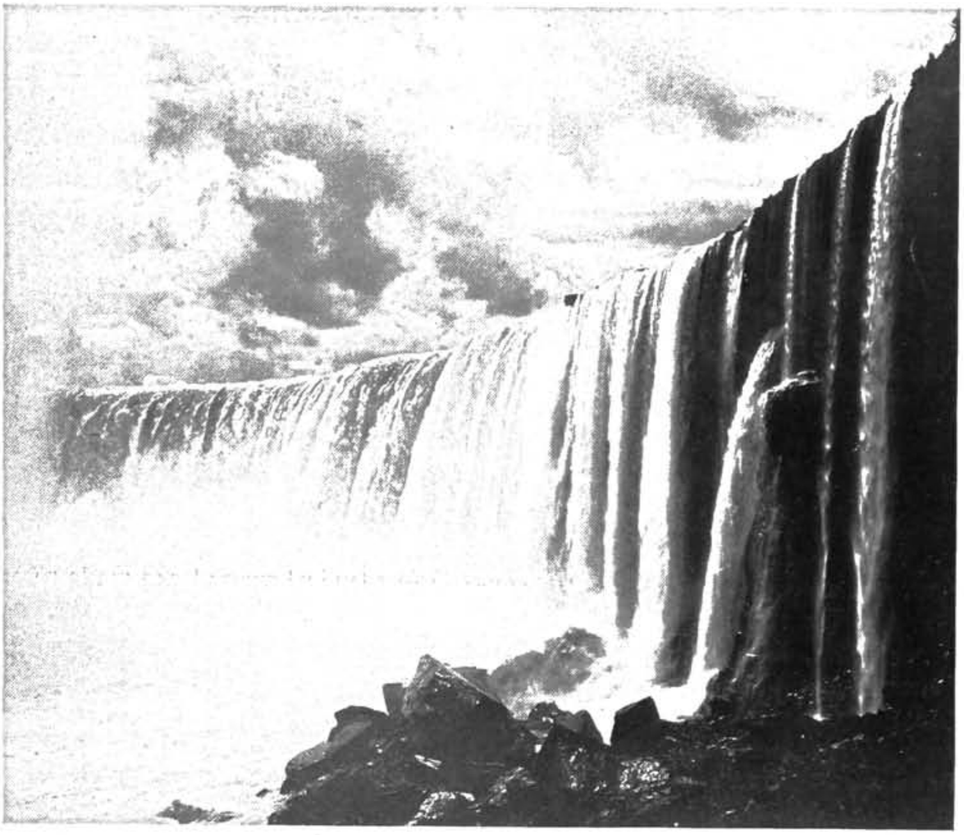
July, 1912 *Bulletin No. 4966

HYDRO-ELECTRIC POWER DEVELOPMENTS



NIAGARA

During the past few years, great advances have been made in the development of hydro-electric powers and in the construction of long distance transmission systems. Ten years ago the maximum capacity of generators and transformers was rarely more than 1000 kw., while today these units are being built in capacities as large as 14,000 kw. The transmission pressure of 50,000 volts was then looked upon with more wonder than the 140,000 volt transmission of today.

The General Electric Company has always taken a leading part in the manufacture of electrical equipments for hydro-electric power systems and the apparatus of largest capacity and highest voltage in existence was built by this company.

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

The first installation of three-phase generators in this country for the transmission of power was put into operation September

TY GENERATORS IN THE FIRST THREE-PHASE TRANSMISSION PLANT

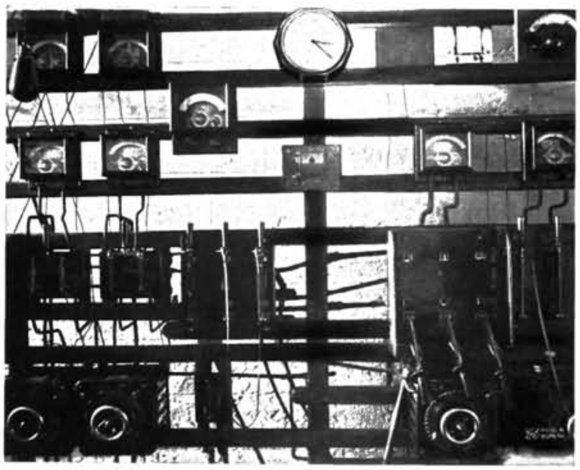
7, 1893, by the Redlands Electric Light and Power Company. The power station, which was known as Mill Creek No. 1, contained at this time two 250 kw. three-phase revolving armature generators direct connected to Pelton waterwheels. These machines were the first of their kind ever constructed in the United States and were known under the General Electric symbols as "TY" generators. Three-phase current was generated at 2500 volts and transmitted to Metone, four and one-half miles distant, where it was used for operating a 150 horse power synchronous motor; and also to Redlands seven and one-half miles distant where it was used for light and power. The synchronous motor at Metone replaced a steam engine which was driving apparatus for an artificial ice plant.

The switchboard which is shown in the illustration was constructed on the premises by the power company and is an example of the type of construction prevailing at that time. Besides the necessary meters, switches and rheostats the board also contained an audible synchronizer or "growler" as it was then called, for paralleling the two machines.

The merits of the three-phase system were quickly recognized and other installations were soon made to various parts of country, the transmission voltages and the distances being rapidly increased. Ten years later this same system, then a part of what is now known as the Southern California Edison Company, began to transmit power at 60,000 volts, a distance of eighty-two miles, to Los Angeles.

During the last decade even greater progress has been made in transmission of energy of our great water powers to large industrial centers. The General Electric Company has always maintained its lead in the development of these systems and has recently furnished the equipment for a 140,000 volt transmission (Eastern Michigan Power Company) which is the highest voltage yet commercially employed.

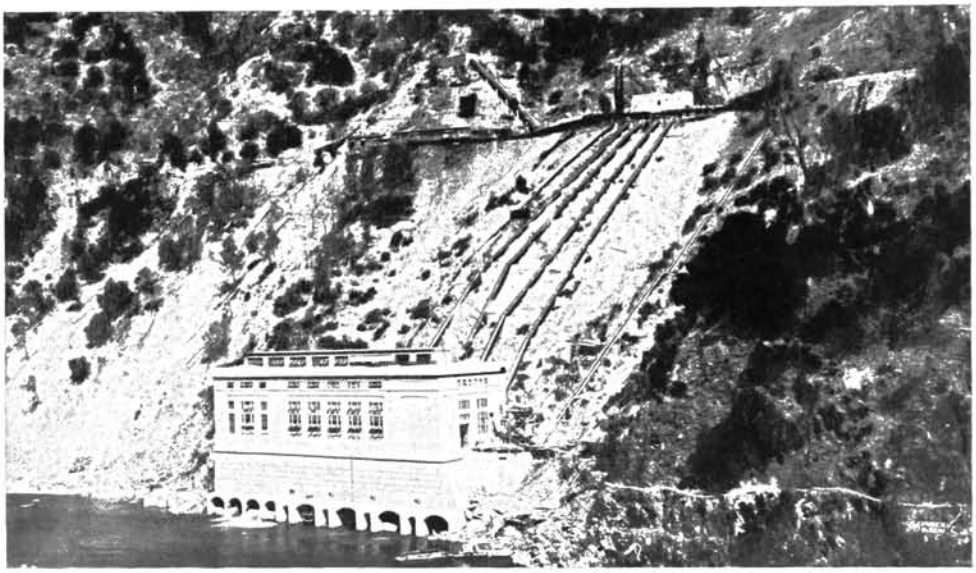
The illustrations in this publication include a few typical examples of modern hydro-electric stations and transmission systems representing some of the most important developments in various sections of the country.



WOODEN FRAME SWITCHBOARD FOR CONTROLLING TY GENERATORS

GREAT WESTERN POWER COMPANY

The Great Western Power Company's system is an excellent example of a modern installation. The main generating station of this company is located on the Feather River, one hundred and fifty-four miles north of Oakland, California. The water supply is received through a tunnel nearly three miles in length which diverts the water which normally flows around the big bend of the Feather River. A heavy concrete dam was erected at the intake point which will ultimately have a height of 140 feet. When the installation is complete the available water head will be 535 feet.



BIG BEND STATION, GREAT WESTERN POWER COMPANY, FEATHER RIVER, CALIFORNIA
FOUR 10,000 KW., 11,000 VOLT GENERATORS

Waterwheels

The four main waterwheels now installed are inward flow Francis type turbines and in point of output are among the largest of any now in service, being rated at 18,000 h.p. each. The water for each unit is carried through a separate steel feeder pipe 450 feet in length from the mouth of the tunnel to the power house and controlled by a motor-operated gate-valve at the head of the steel pipe. The vertical shaft carrying the turbine and the revolving field of the generator is supported on an oil disk step bearing located between the wheel and the generator. A triplex pump in the turbine chamber supplies oil to the step bearings under 215 pounds pressure and a second pump, operated by an electric motor, supplies oil at the same pressure for operating the governor cylinders. These governors are placed on the main floor and are of special design, known as the double float lever type.

Generators

The main generators at the time of installation were the largest of their kind ever constructed. They are of the vertical shaft revolving field type rated at 10,000 kw. delivering three-phase 60 cycle current at 11,000 volts. The stationary armature is supported directly on the main floor structure.

The rotating element is supported by two guide bearings, one above and one below the revolving field. The rotor was especially designed for this installation and before shipment was tested at double its normal speed of 400 r.p.m. As the diameter of this rotor is over 9 ft. the peripheral velocity during this test was 23,000 feet per minute. In order to withstand this severe test the revolving field is of unusually substantial design.

Two exciter sets are provided each of 250 kw. capacity at 250 volts. These machines are of the horizontal type direct connected to 350 h.p. waterwheels.

Switchboard

The generator circuits and the outgoing transmission lines are controlled from the main switchboard in the balcony. This switchboard is of the standard bench board type with panels for each generator and its transformer and for the outgoing transmission lines. Mounted on the panels are all instruments necessary for the operation of the circuits according to the requirements of the best modern practice. This board is installed to control eight generators but is equipped only for the present installation. A synchronizer with 3 ft. dial is mounted on a pivot at the edge of the balcony in such a manner that it may be turned for observation from any part of the building.

INTERIOR OF POWER HOUSE, GREAT WESTERN POWER COMPANY

Transformers

Each generator feeds directly through cables in the ducts under the main floor and the remote control oil switches on the second floor, to a three-phase transformer having a normal capacity of 10,000 kv-a. stepping up from 11,000 to 110,000 volts delta. The full load efficiency of these units is 98.6 per cent.

After leaving the transformer the conductor passes through an oil switch to a disconnecting switch and then to bus-lines. From the bus-line the current is carried through oil switches, series transformers and disconnecting switch to the transmission line. Mounted on the roof of the power-house are two sets of aluminum cell electrolytic lightning arresters. These are connected to the transmission line wires in the usual manner through spark gaps.

Transmission System

The transmission line from the Big Bend Power House to Oakland contains an average of seven steel towers per mile, the spaces varying according to natural conditions. There are three cross-arms of equal length placed one above another and ten feet apart. These arms carry two three-wire circuits of No. 000 seven strand copper cable and one ground wire, the total length of transmission to the Oakland substation being 153½ miles. The full load loss, if the entire load of 40,000 kw. were delivered to the Oakland substation, would be about 15 per cent. and the regulation drop, depending on the power-factor, about 24 per cent.

Substations

There are three substations, the first at Brighton, a suburb of Sacramento, the second at Cowell's Portland Cement plant near Concord, and the third at the terminus of the transmission line in the city of Oakland. The Brighton substation contains six 1250 kv-a. transformers stepping down to 22,000 volts, the Concord station contains four 1250 kv-a. transformers transforming to 440 volts; the Oakland substation contains two 10,000 kv-a. three-phase transformers similar to those at the power-house and three 5000 kv-a. three-phase transformers, the high tension side being wound for 90,000 and the low tension for 55,000 volts. At the latter potential current is delivered to the Ridge substation of the Pacific Gas & Electric Company with whom the Great Western Power Company has a contract for power. A second feeder transmits energy at 11,000 volts to the steam turbine substation operated by this company at Oakland tide water.

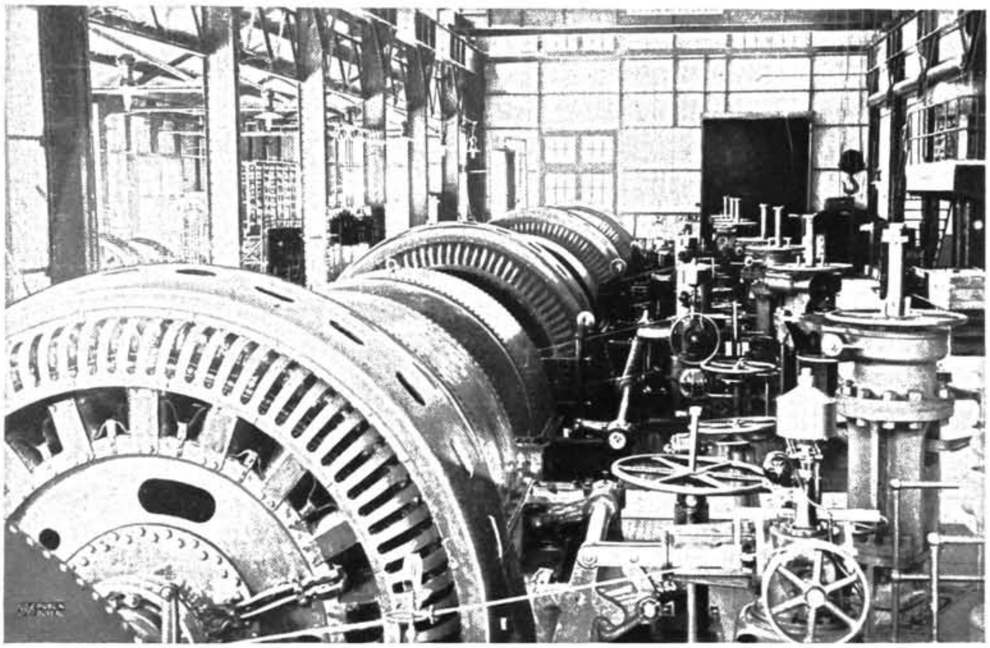
OAKLAND SUBSTATION, GREAT WESTERN POWER COMPANY

STANISLAUS POWER DEVELOPMENT

One of the most difficult water power developments in the west is the Stanislaus plant of the Sierra and San Francisco Power Company. The remarkable feature is the high head obtained by the construction of a fifteen mile flume, 9 by 6 ft. in cross section and carrying the water a distance of 78,000 feet along the canyon of the Stanislaus River. At the end of the flume occupying a valley in the high hills above the power-house is a forebay reservoir of sufficient capacity to operate the plant at full load for fifteen hours. From the forebay the water is carried to the power-house through a vertical distance of 1500 ft. by two 31 in. riveted steel pipes. At the power-house header each pipe is branched into three 22 in. pipes which furnish water to three Pelton units each of 15,000 h.p. tested capacity. These wheels are the double overhung type, one being placed on either side of the generator. The three generators are rated 8500 kw. at 400 r.p.m. and deliver 60 cycle 4000 volt current. Exciting current is furnished by two waterwheel and induction motor-driven General Electric machines rated 300 kw. at 250 volts, and controlled by automatic voltage regulators. Nine water-cooled 2333 kv-a. single-phase transformers are used, stepping the voltage up to 114,000Y.

Energy is delivered at the main substation in San Francisco, a distance of approximately 130 miles at about 100,000 volts. The transmission line is carried on galvanized steel towers, without ground wires, resting on a specially designed steel base and is composed of No. 00 stranded copper cable.

This station supplies a large part of the current for the operation of the United Railways of San Francisco. As is the case in many of the hydro-electric power developments in the west, steam turbine units are operated in parallel with this supply and are well suited to take care of load fluctuations and to control the frequency.



STANISLAUS STATION, SIERRA AND SAN FRANCISCO POWER COMPANY
FOUR 8500 KW., 4000 VOLT GENERATORS

WASHINGTON WATER POWER COMPANY

The Washington Water Power Company is rapidly developing new hydro-electric properties in the vicinity of Spokane and will shortly have two new stations in operation at Little Falls and Long Lake, about thirty-five miles northwest of the city of Spokane. The latter plant when completed will be equipped with the largest hydro-electric units in existence. Four 22,500 horse power turbines will be installed, each direct connected to a *13,900 kv-a. 4000 volt generator. These turbines will operate under a 140 foot head receiving water through four separate pen-stocks.

At the Little Falls station, three 5000 kw. and one 6125 kw. generators are installed, each driven by a pair of horizontal turbines operating under a 67 foot head. On account of the liberal rating of these generators, the station will be able to supply 25,000 kw. continuously.

The Post Falls development is some twenty-five miles east of the city up the river from Spokane. This station is designed for six 2250 kw. 2300 volt 60 cycle generating units, six three-phase 2200 kv-a. step-up transformers and outgoing feeders for 60,000, 22,500 and 2300 volt lines. Five of these units have been in operation since 1908. Each generator is driven by a horizontal Francis type turbine capable of delivering 3260 horse power at 80 per cent. efficiency when operating under an effective head of 50 feet.

POST FALLS STATION, WASHINGTON WATER POWER COMPANY
FIVE 2250 KW., 4000 VOLT GENERATORS

This company has now in operation 450 miles of transmission lines at a pressure of 60,000 volts supplying power not only for Spokane but also to the Idaho mining district 100 miles away. Two entirely separate lines connect the Spokane plant to the Post Falls station and with those at Little Falls and Long Lake. Both copper and aluminum are employed for transmission wires.

In the city of Spokane there are several hydro-electric developments operating in parallel with this system and with a 13,000 kw. Curtis turbine station. In addition to

* Maximum rating, 17,400 kv-a.

the industrial and lighting load this system supplies power for the operation of more than 300 miles of electric railways. Among the consumers of energy from these lines are the Great Northern and Northern Pacific Railway shops, Coeur d' Alene Silver Lead Mines, flour mills, iron works and numerous factories.

WASHINGTON WATER POWER CO., LITTLE FALLS PLANT
20,000 KW. CAPACITY

MISSISSIPPI RIVER POWER COMPANY

One of the largest if not the largest single hydro-electric project ever attempted is the development of the Des Moines Rapids in the Mississippi River near Keokuk, Iowa. When the full equipment is installed this plant will have a normal rating of 270,000 kv-a. The first part of this station, however, only contemplates an installation of half this capacity.

The initial equipment totaling approximately one half the ultimate development is expected to be in operation by July, 1913. The generating units, each rated at 9000 kv-a., will deliver 11,000 volt 25 cycle current to an equal number of 9000 kv-a. three-phase transformers for transmission at 110,000 volts Y. Each alternator will be provided with a 100 kw. 250 volt exciter driven by a 440 volt induction motor. For driving the exciting units two 2000 kv-a. 460 volt 25 cycle auxiliary waterwheel-driven generators will be installed.

Power will be supplied to nearby towns and cities but at present the principal market will be at St. Louis, 140 miles distant. The transmission line will consist of two circuits of 300,000 c.m. copper carried on a single line of steel towers spaced approximately seven per mile. At the top of the towers will be a three-quarter inch steel ground wire for lightning protection. The vertical spacing of the conductors will be ten feet and the height of the lowest insulator 55 feet from the ground. Owing to the unfinished condition of this development further description is deferred until the plant is in actual operation.

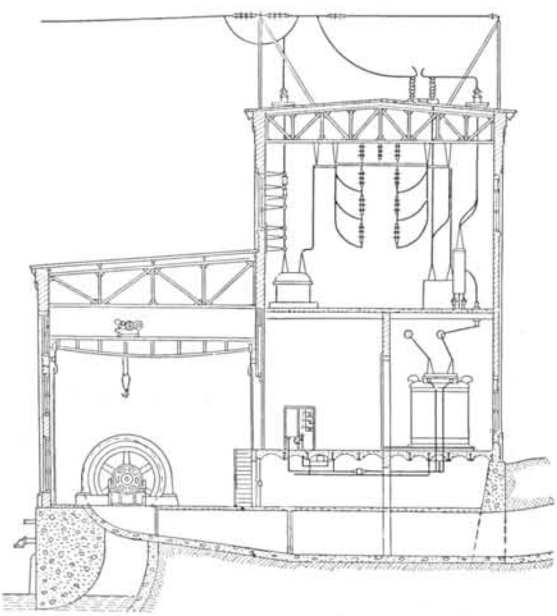
GREAT FALLS WATER POWER AND TOWNSITE COMPANY

The Rainbow Falls development at Great Falls, Montana, on the Missouri River was completed in July, 1910. At this time, six generating units with a total rated capacity of 21,000 kw. were placed in service. Each of the 3500 kw. generators is direct connected to a 6000 h.p. turbine of the inward flow Francis type operating under a 105 foot head. The output of two of these units is utilized in the vicinity of Great Falls and is transmitted at the generator voltage of 6600. The power from the other four units is stepped up to 102,000 volts delta through four banks of single-phase transformers rated at 3600 kv-a. per bank. Energy is transmitted at this voltage to Butte, a distance of 130 miles, over two separate parallel lines constructed on the same right of way. The transmission towers, which are shown on page 31, carry two ground wires besides the high voltage lines. At the Butte substation four 3600 kv-a. banks of transformers are installed stepping down to 2500 volts for the synchronous and induction motor load.

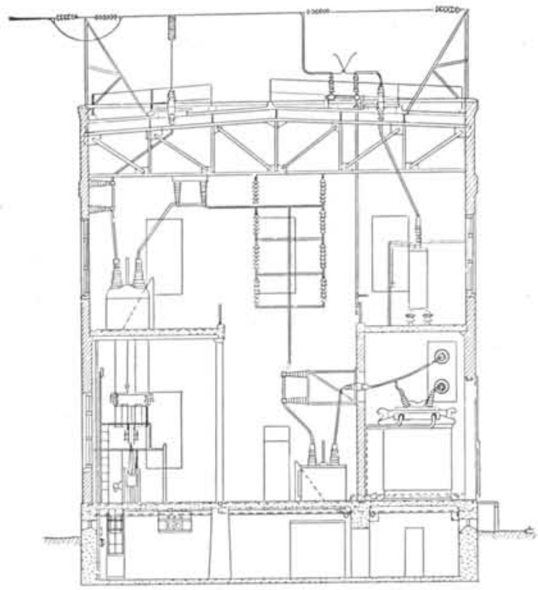
An extension of the transmission line 22 miles beyond the Butte substation supplies power at 102,000 volts to Anaconda where it is used for the operation of the Washoe Smelter. The present equipment of the Anaconda substation includes three 1200 kv-a. transformers controlled by a K-15, 100,000 volt oil switch and protected by an electrolytic lightning arrester. This equipment will be increased in the near future to six transformers, making two complete banks with a total capacity of 7200 kv-a.

All transformers and switching apparatus, as well as generators, were manufactured by the General Electric Company. Forms K-10 and K-15 oil switches are used for interrupting the 100,000 volt circuits and Form H-3 switches for the 6600 volt lines.

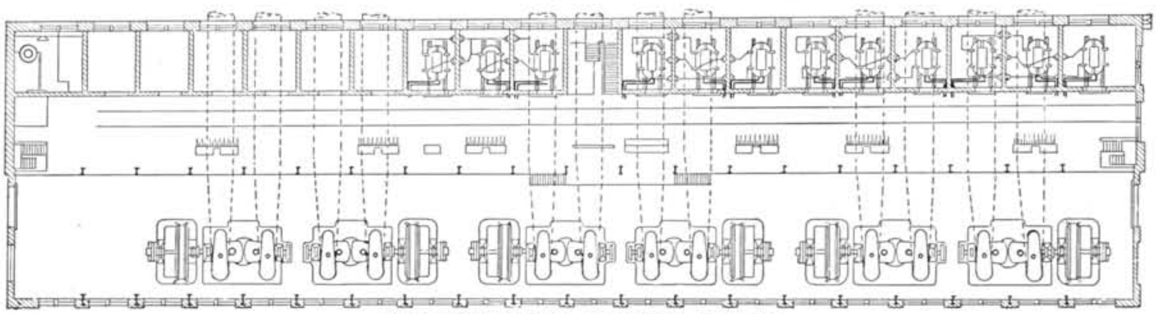
GENERATOR ROOM IN RAINBOW STATION, SHOWING SIX 6000 H.P. GENERATING UNITS



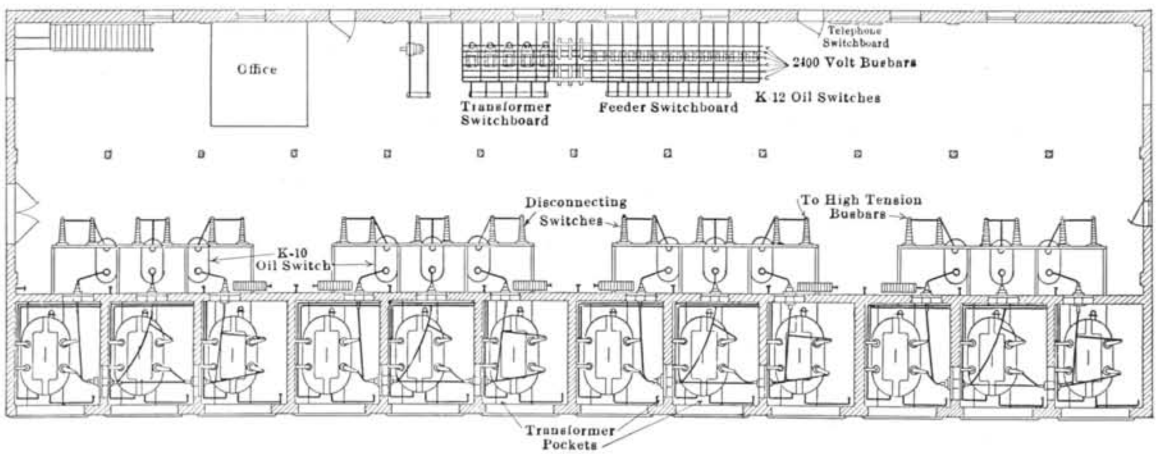
CROSS SECTION RAINBOW STATION



CROSS SECTION BUTTE SUBSTATION



PLAN FIRST FLOOR, RAINBOW STATION



PLAN FIRST FLOOR, BUTTE SUBSTATION

PENNSYLVANIA WATER AND POWER COMPANY

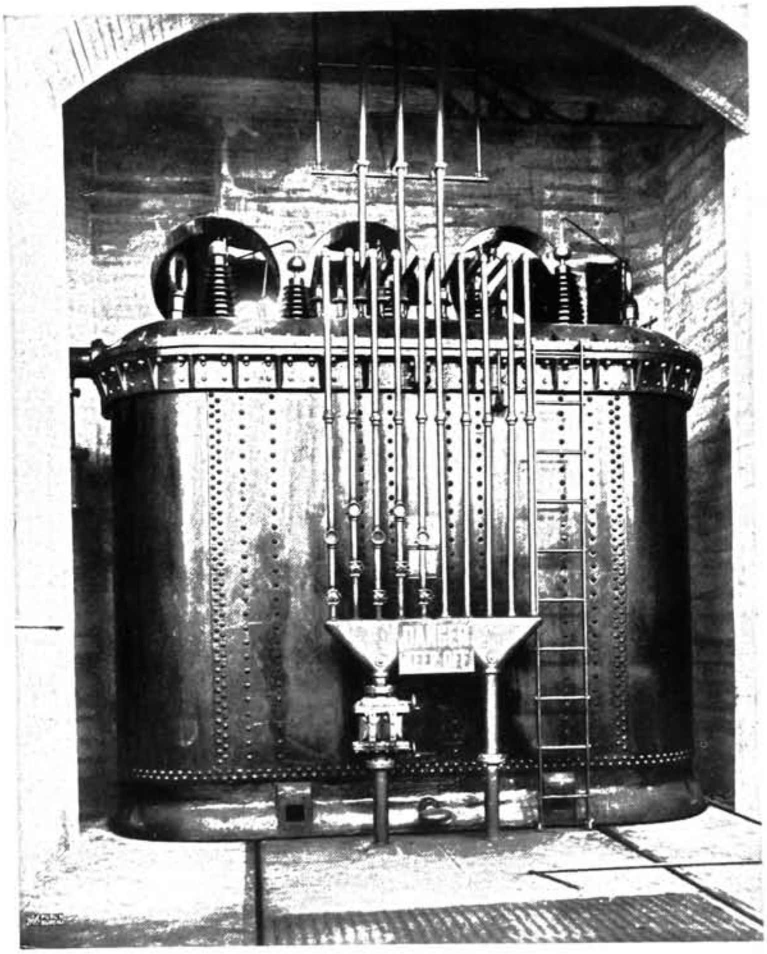
The development at McCall Ferry, Pennsylvania, on the Susquehanna river will be, when completed, one of the largest hydraulic stations in the east, being second only to Niagara in capacity. This plant is designed for ten vertical units, five of which are already installed. Three of these machines are rated at 7500 kw. and the remaining two at 10,000 kw. each. Each generator is driven by a Francis type turbine operating at a maximum head of 65 feet low water. Under these conditions the wheels for the 10,000 kw. generators will develop 13,500 horse power with an 80 per cent. gate opening. During periods of high water the effective head is reduced to a minimum of 53 feet necessitating the full gate opening in order to develop full rated horse power.

10,000 AND 7500 KW. GENERATORS AND 400 KW. EXCITERS IN THE PENNSYLVANIA WATER AND POWER CO'S STATION, MC CALL FERRY, PA.

The generators operate at 94 revolutions per minute delivering three-phase 25 cycle current at 11,000 volts. Two vertical water-wheel driven exciters are installed each rated 400 kw. at 250 volts. The present installation comprises four 7500 kv-a. three-phase transformers and two of 10,000 kv-a. rating, stepping up the generator voltage to 70,000 Y.

All oil switches are of the General Electric H-3 motor-operated type provided with automatic devices for opening the circuits on overloads and to protect the apparatus. All transmission lines are protected by aluminum lightning arresters. The station is laid out for six 70,000 volt 300 ampere outgoing lines, three of which are now installed. Two of these lines now furnishing power to Baltimore, a distance of forty miles, consist of substantial steel towers carrying aluminum conductors and constructed over a private right of way for the entire distance. Provision is also made in the station layout for six outgoing 11,000 volt 800 ampere local feeders. The control of the plant is centered in a bench-board located on the south gallery of the generator room. This board consists of ten sets of panels for the generators and transformers, all apparatus being remote controlled and provided with green and red lamps indicating the position of the switches.

For the purpose of testing insulation of the various types of apparatus a special testing transformer has been installed, having a capacity of 300 kw. and a maximum primary voltage of 300,000. The secondary of this transformer is excited by a step down transformer of 200 kw. capacity taking current from the 11,000 volt circuits and stepping it down to 2200, 1100 and 550 volts. A loading rheostat is also provided which is designed for carrying 15,000 kw. continuous load.



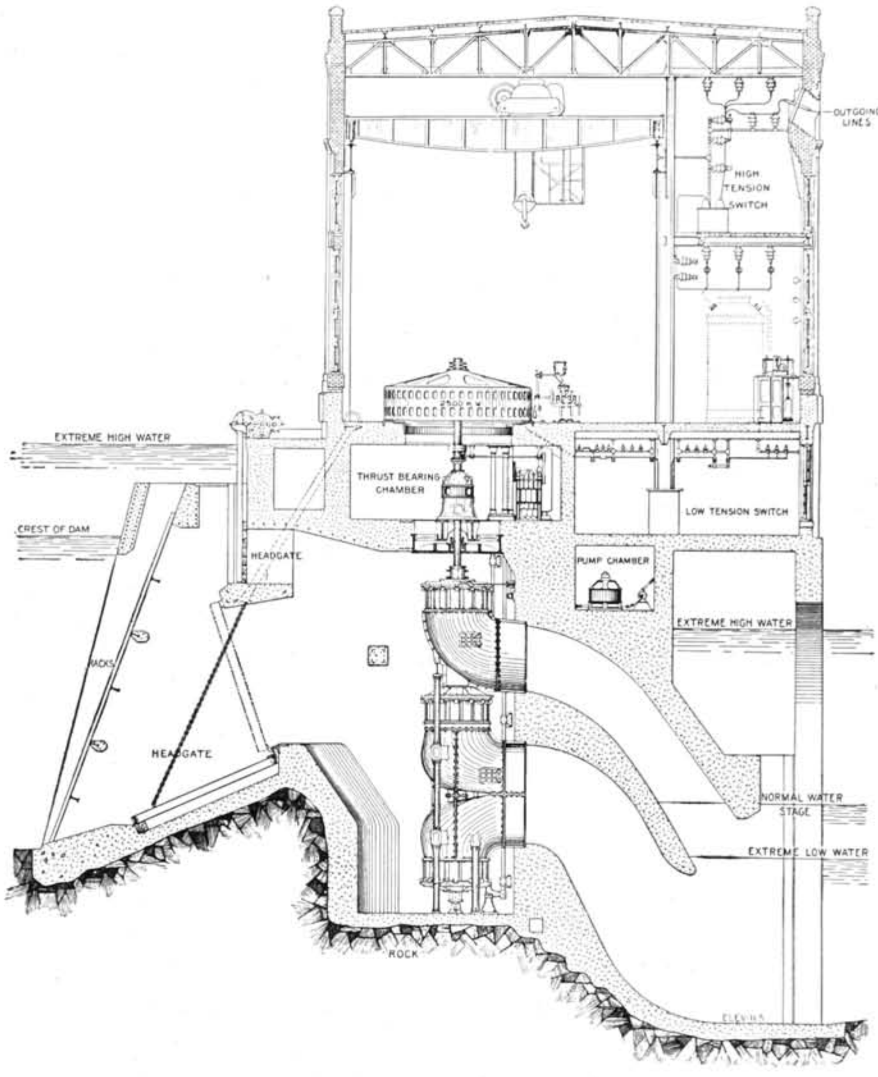
PENNSYLVANIA WATER AND POWER COMPANY. 10,000 KV-A., THREE-PHASE, 70,000/11,000 VOLT WATER-COOLED TRANSFORMER

CONNECTICUT RIVER POWER COMPANY

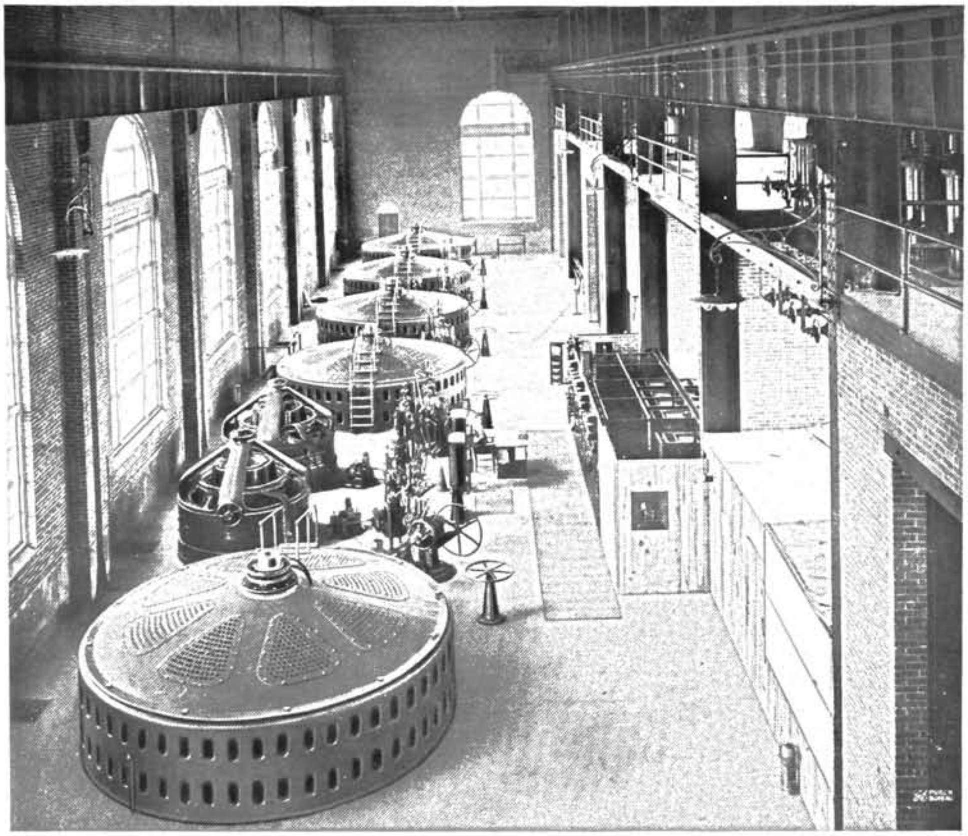
A typical low head development which is probably the largest single hydraulic station in New England is located on the Connecticut River at Vernon, six miles below Brattleboro, Vermont. The generating equipment of this station comprises eight 2500 kw. generators driven by specially designed vertical turbines operating under a head of from 32 to 34 feet.

These wheels consist of two 60 inch runners for normal operation and a 57 inch runner which ordinarily runs idle but can be utilized under high water conditions.

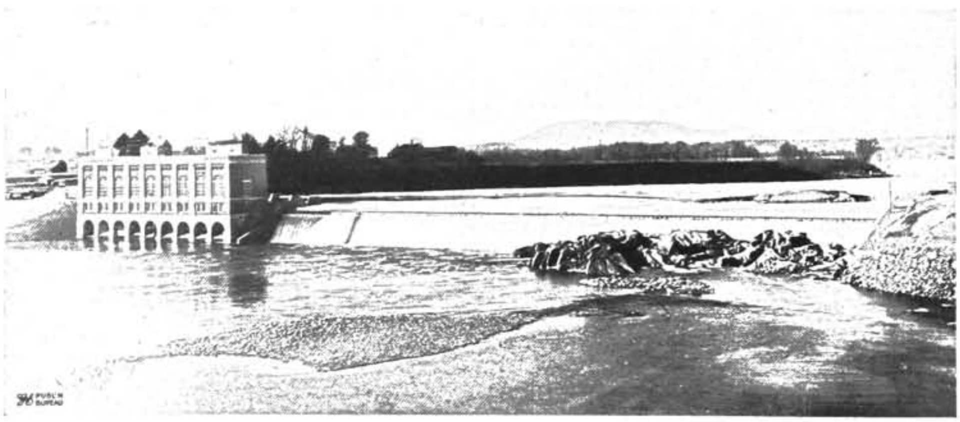
Current is generated at 2300 volts 60 cycles and is stepped up through three-phase transformers to the transmission voltage. Four 5000 kv-a. oil-cooled transformers raise the voltage from 2300 to 66,000 volts Y for transmission over two independent lines to Worcester and intermediate towns, a distance of 66 miles. A 2500 kv-a. three-phase trans-



SECTION OF CONNECTICUT RIVER POWER STATION, VERNON, VT.



2500 KW., 60 CYCLE, THREE-PHASE, 2300 VOLT, 133 R.P.M. WATERWHEEL-DRIVEN ALTERNATORS AND EXCITERS, CONNECTICUT RIVER POWER CO., VERNON, VT.

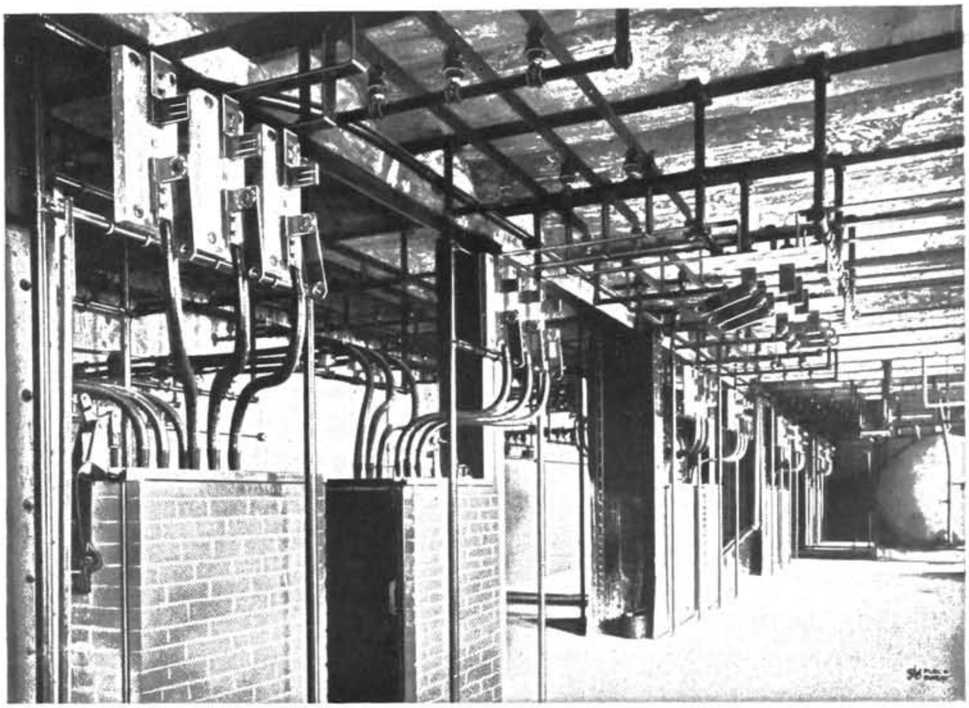


CONNECTICUT RIVER POWER COMPANY, POWER HOUSE AND DAM former wound for 2300/31,500 volts supplies current to a 20 mile transmission into Keene, New Hampshire, and to the city of Brattleboro, Vermont. These two lines are at present supplied at 19,100 volts. A fifth feeder supplies the town of Vernon with power and lights at 2300 volts.

The switchboard is of the remote control type and consists of 19 marine finished slate panels. On the front of this board is mounted a dummy busbar giving in miniature all of the station connections. A Type TA voltage regulator is installed on one end of the board and a storage battery panel on the other. The storage battery is used for the switch signal lights and for operating the remote controlled oil switches. An emergency connection from the exciters is also provided for this purpose.

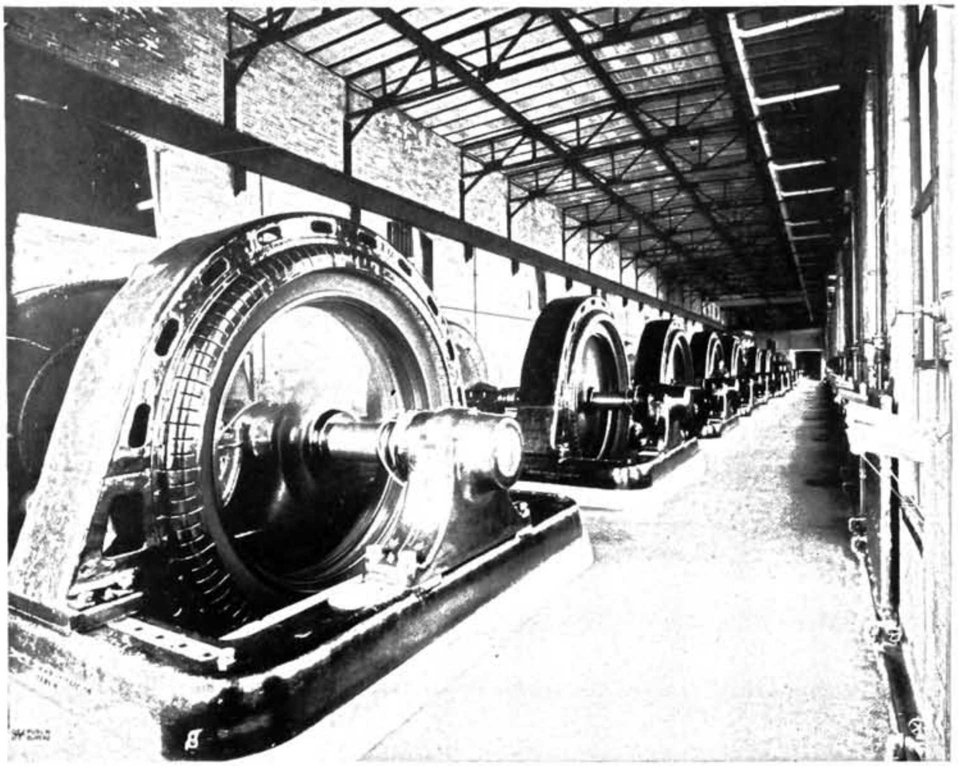
The general scheme of wiring is sufficiently flexible to permit of all desired combinations. Two generators and one 5000 kv-a. transformer comprise one complete unit capable of being isolated on any line or busbar or of being operated in parallel with other units. This arrangement also permits of any generator being connected through any transformer.

General Electric apparatus is used throughout, including generators, transformers, K-4, K-10 and H-3 oil switches and other switch gear.

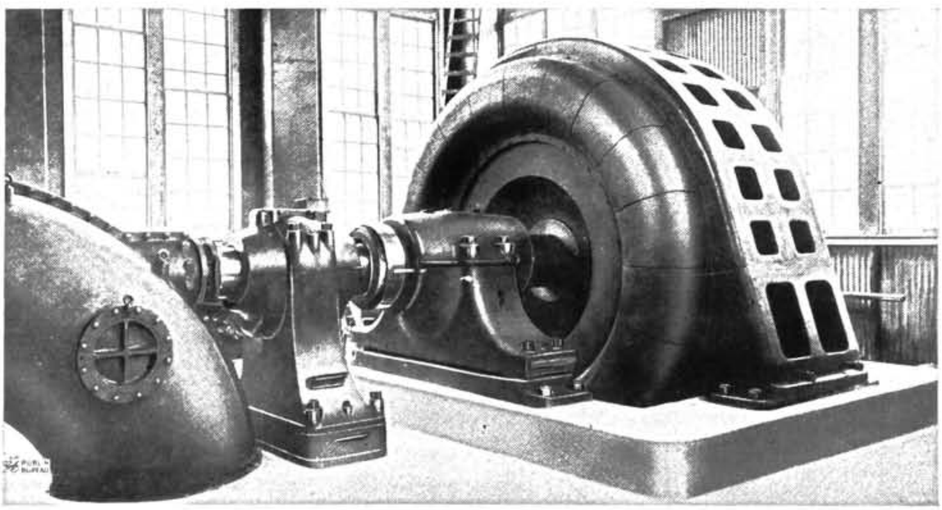


CONNECTICUT RIVER POWER COMPANY, LOW TENSION GALLERY

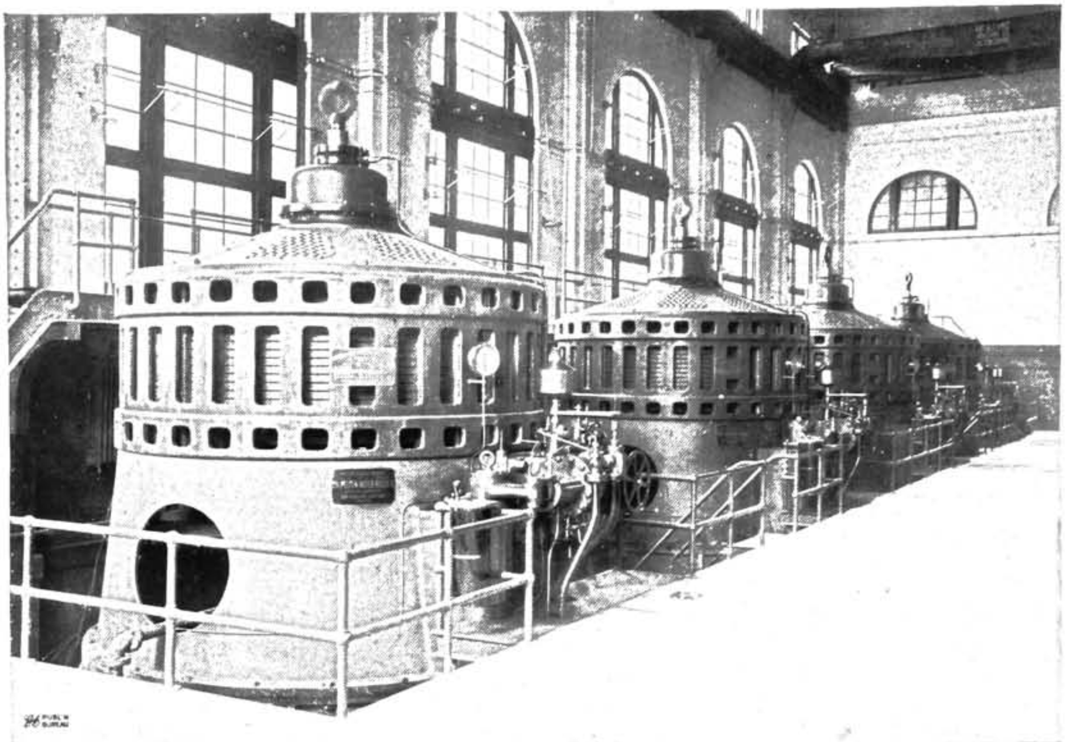
Substations along the main 66,000 volt transmission and at the Worcester terminal contain step-down transformers with a combined rating of 24,000 kv-a. These stations supply energy for the operation of cotton and paper mills and many other industrial plants as well as for local power and traction companies. With many of these customers reciprocal contracts are maintained providing for the purchase of power from isolated steam plants in case of low water at the generating station.



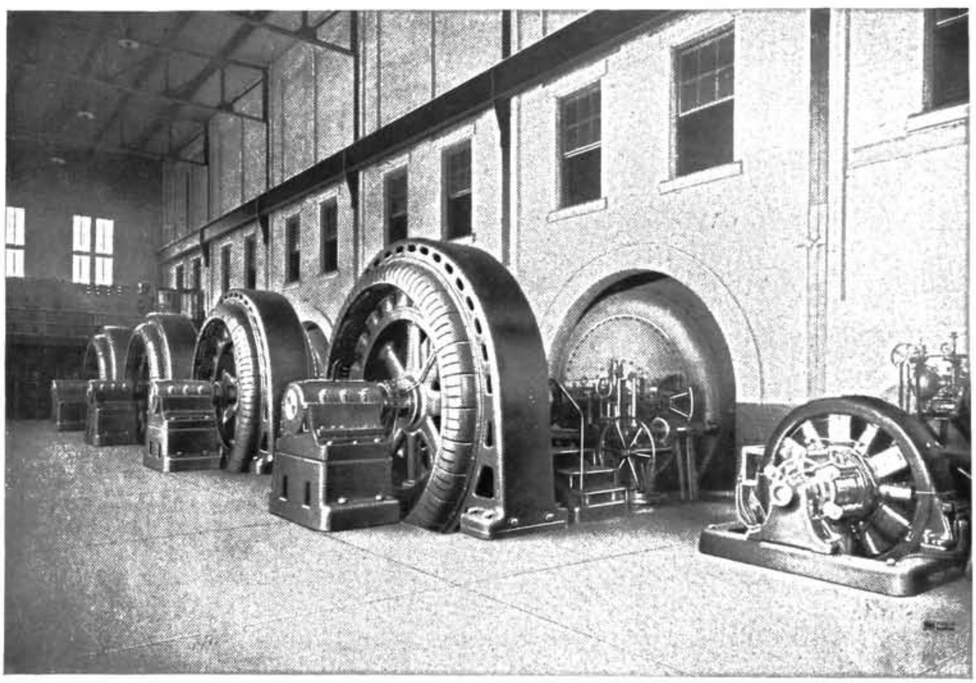
LAC DU BONNET STATION, WINNIPEG ELECTRIC RAILWAY COMPANY
1500 AND 1000 KW. GENERATORS



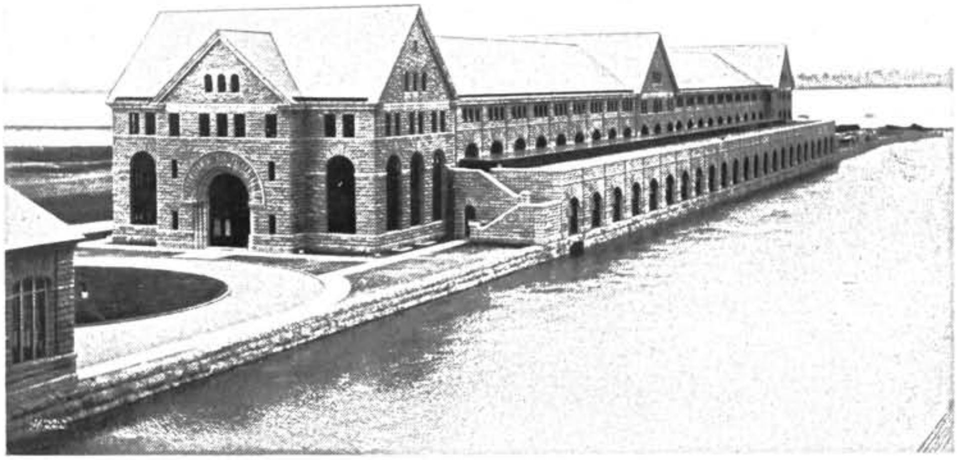
SNOQUALMIE FALLS STATION, SEATTLE-TACOMA POWER COMPANY
8750 KW., 6900 VOLT GENERATOR



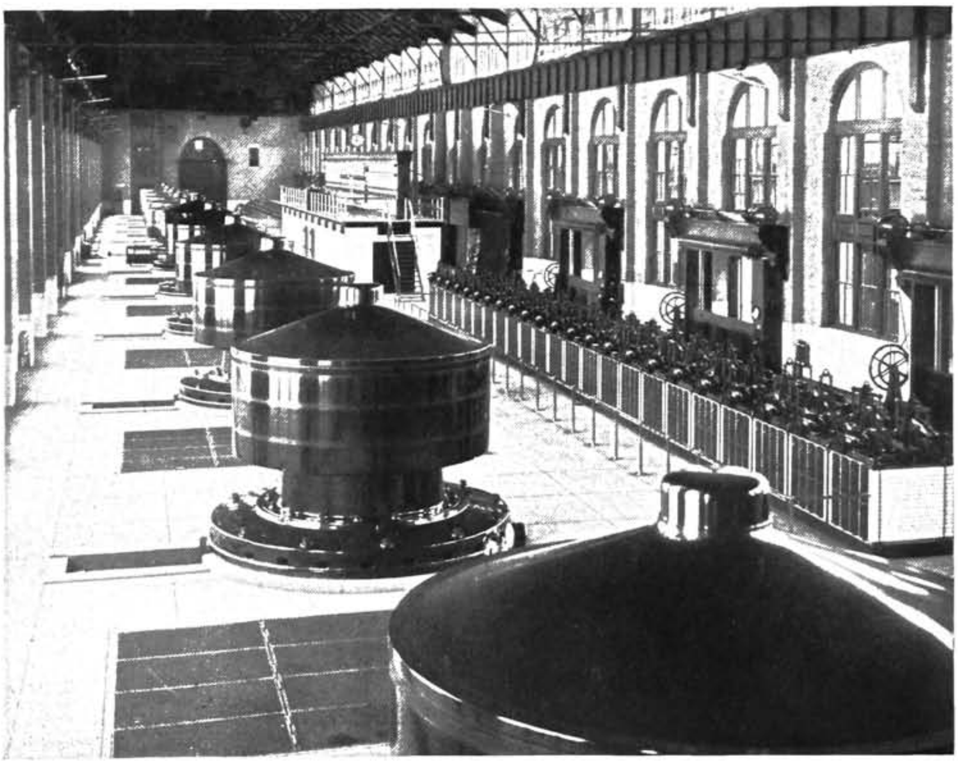
3000 KW., 40 CYCLE, 3-PHASE, 4400 VOLT, 300 R.P.M. WATERWHEEL-DRIVEN ALTERNATORS
SCHENECTADY POWER CO., SCHAGHTICOKE, N. Y.



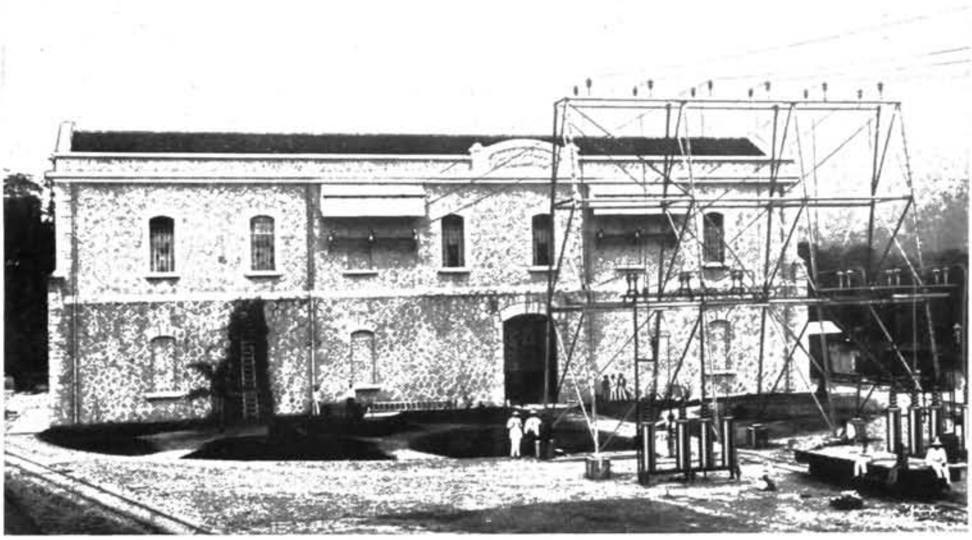
HENNEPIN ISLAND POWER STATION, TWIN CITY RAPID TRANSIT CO.
FOUR 2250 KW., 13,200 VOLT GENERATORS



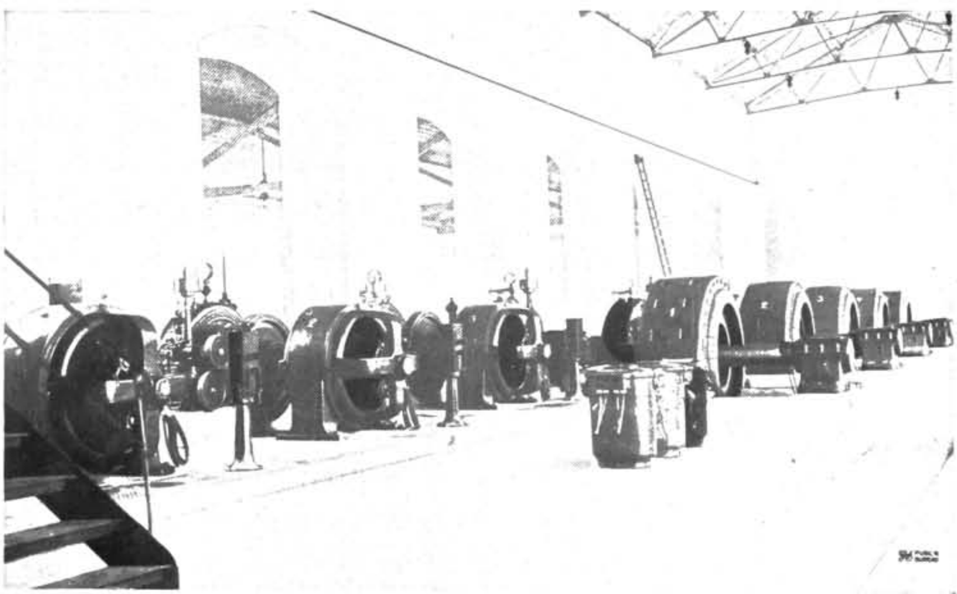
NIAGARA FALLS POWER COMPANY, POWER HOUSE NO. 2



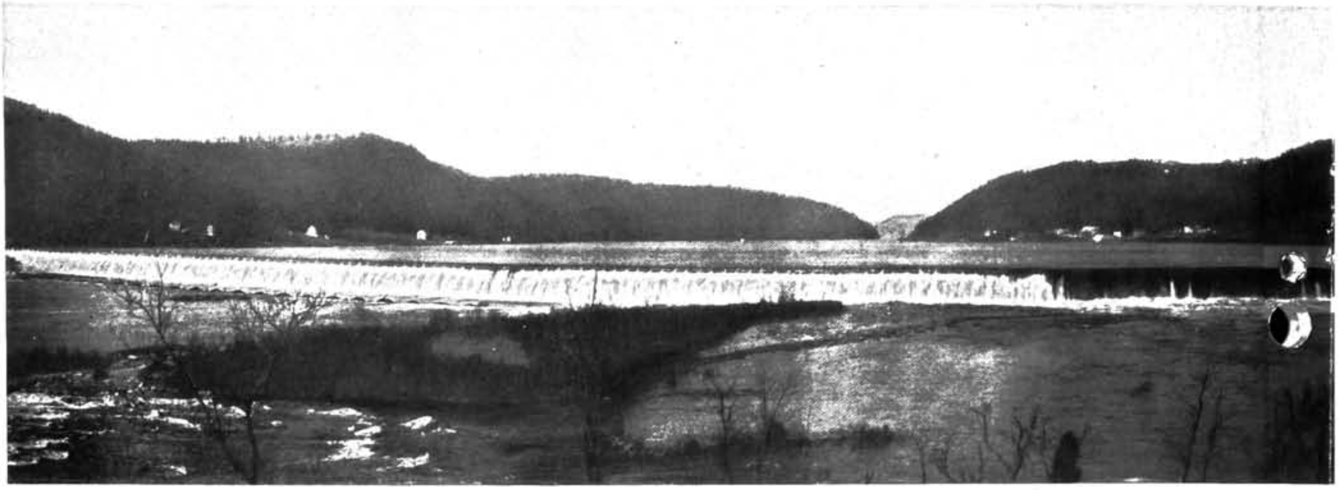
POWER HOUSE NO. 2, NIAGARA FALLS POWER COMPANY
ELEVEN 4000 KW., 2200 VOLT GENERATORS



CIA DOCAS DE SANTOS, BRAZIL, MAIN GENERATING STATION SHOWING OUTDOOR TYPE ALUMINUM LIGHTNING ARRESTER

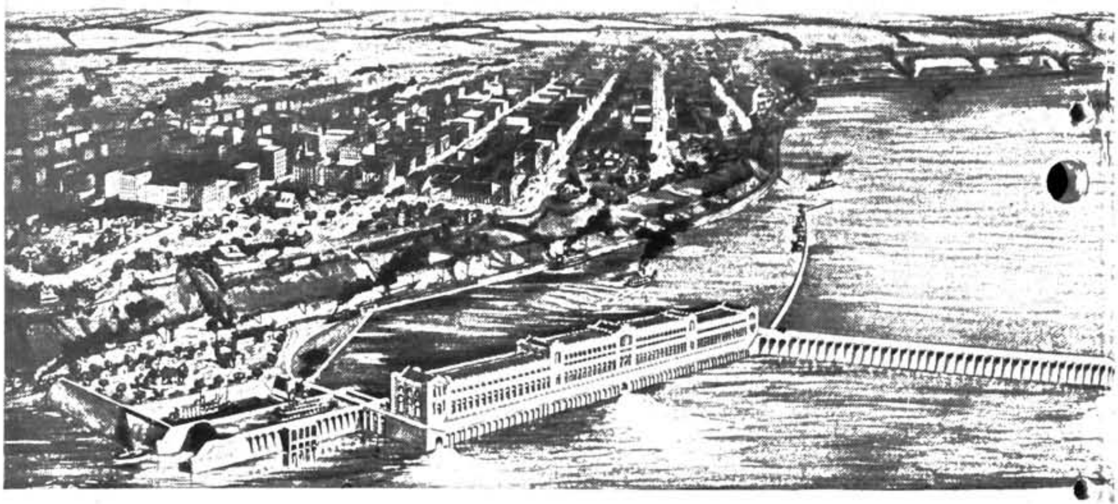


INTERIOR OF CIA DOCAS DE SANTOS STATION. FIVE 3000 KW., 2300 VOLT GENERATORS

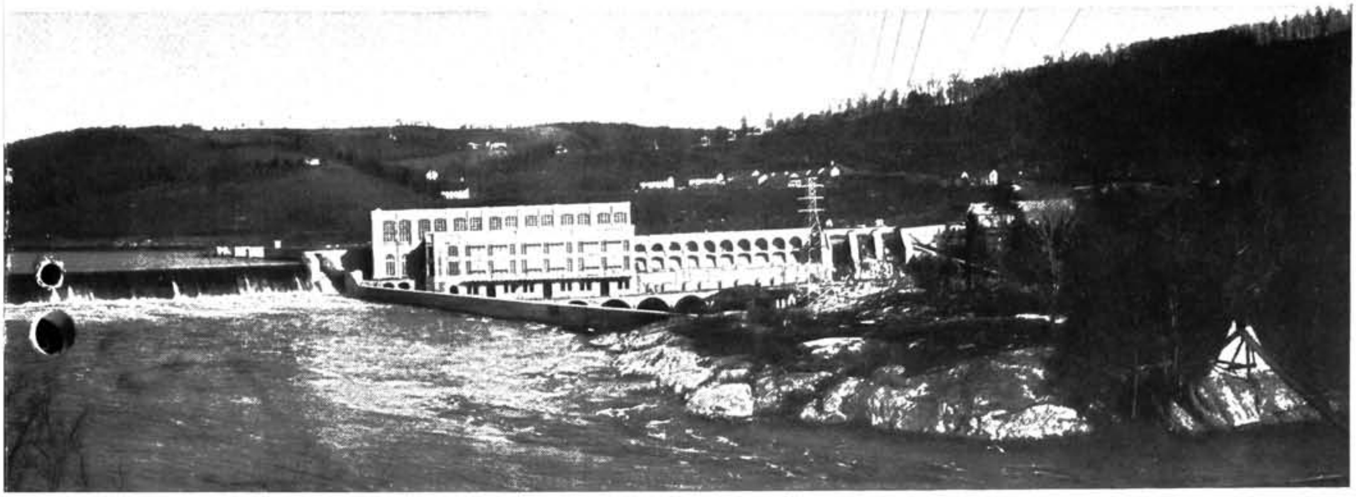


POWER HOUSE AND DAM AT MC CALL FERRY, PENNSYLVANI

RAINBOW FALLS DEVELOPMENT ON THE MISSOU

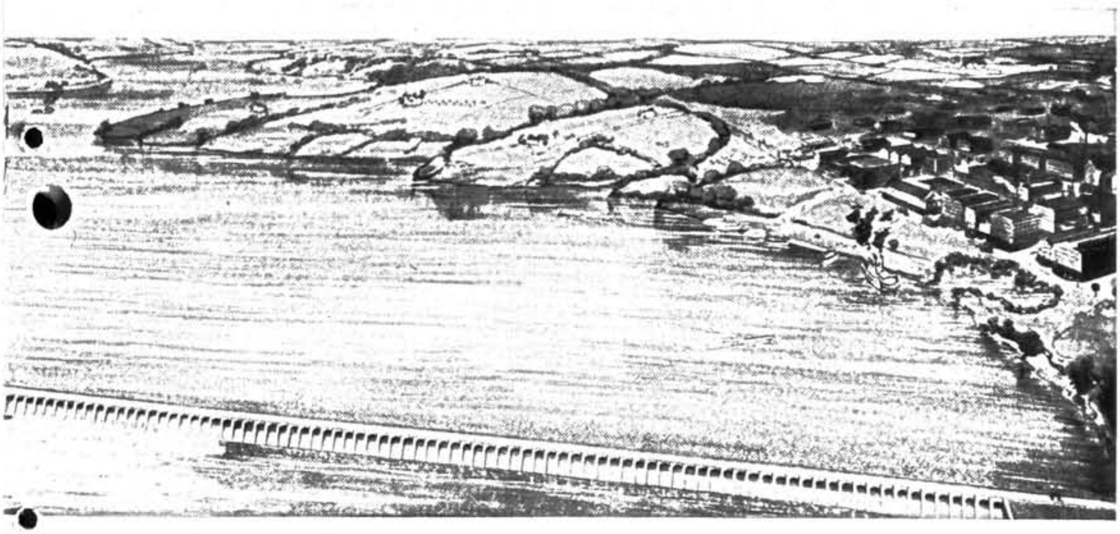


MISSISSIPPI RIVER DEVELOPMENT, DES MO

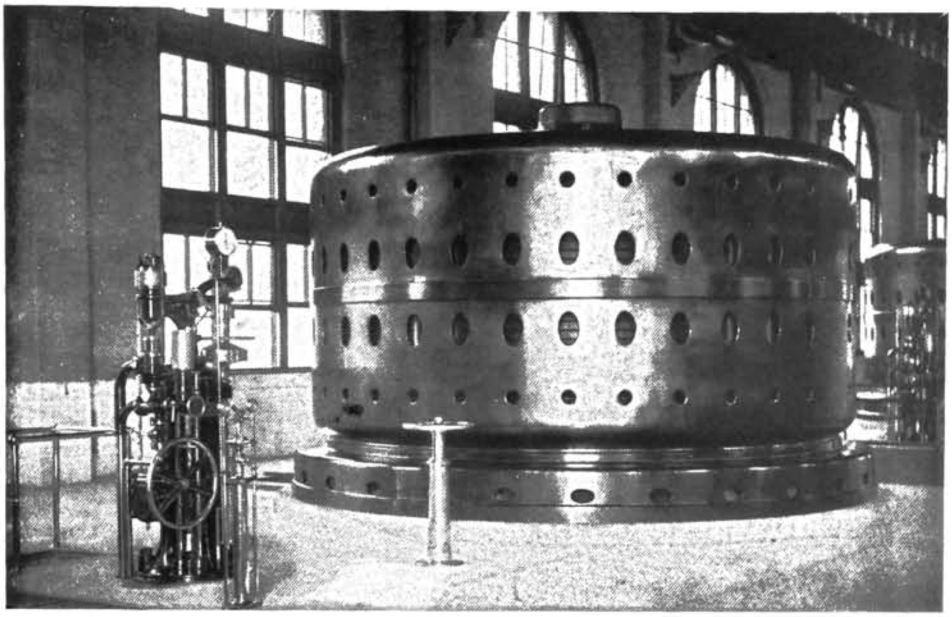


A WATER AND POWER CO. (FOR DESCRIPTION SEE PAGE 11)

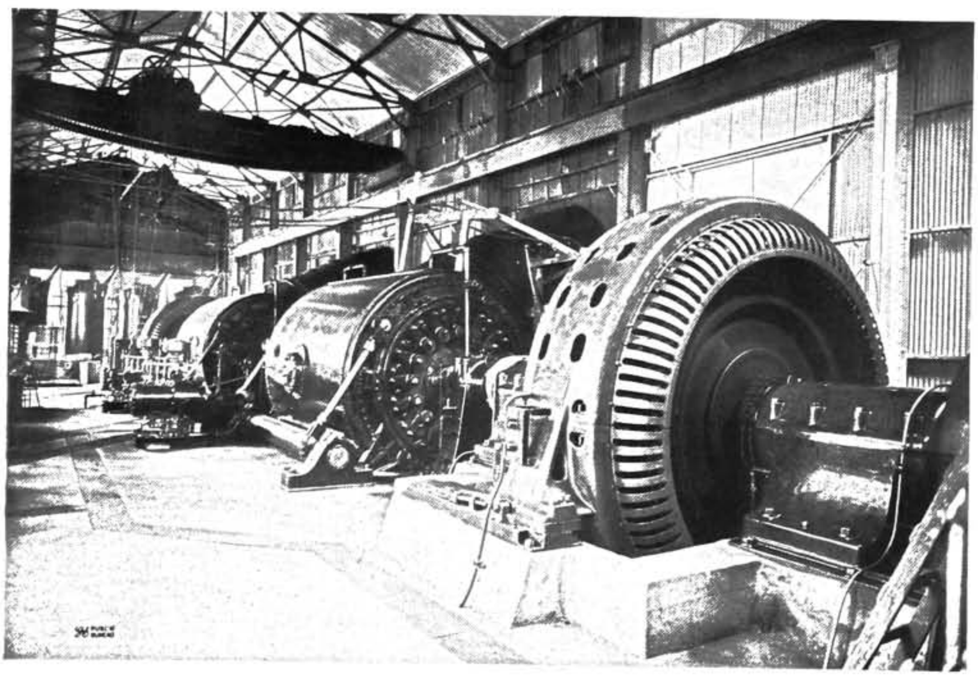
RI RIVER, GREAT FALLS, MONTANA (SEE PAGE 9)



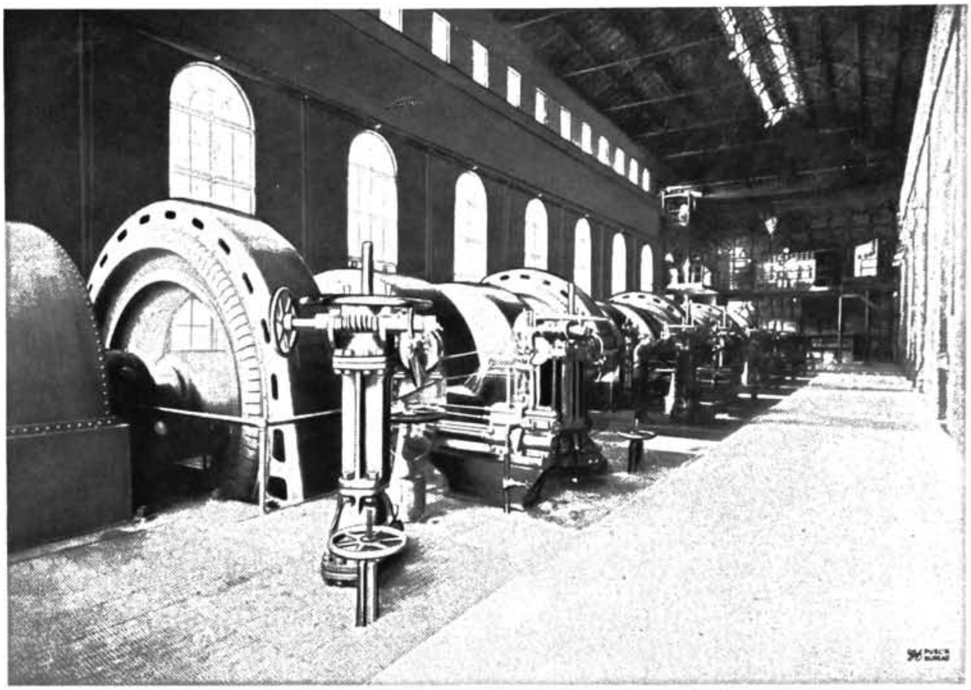
INES RAPIDS, KEOKUK, IOWA (SEE PAGE 8)



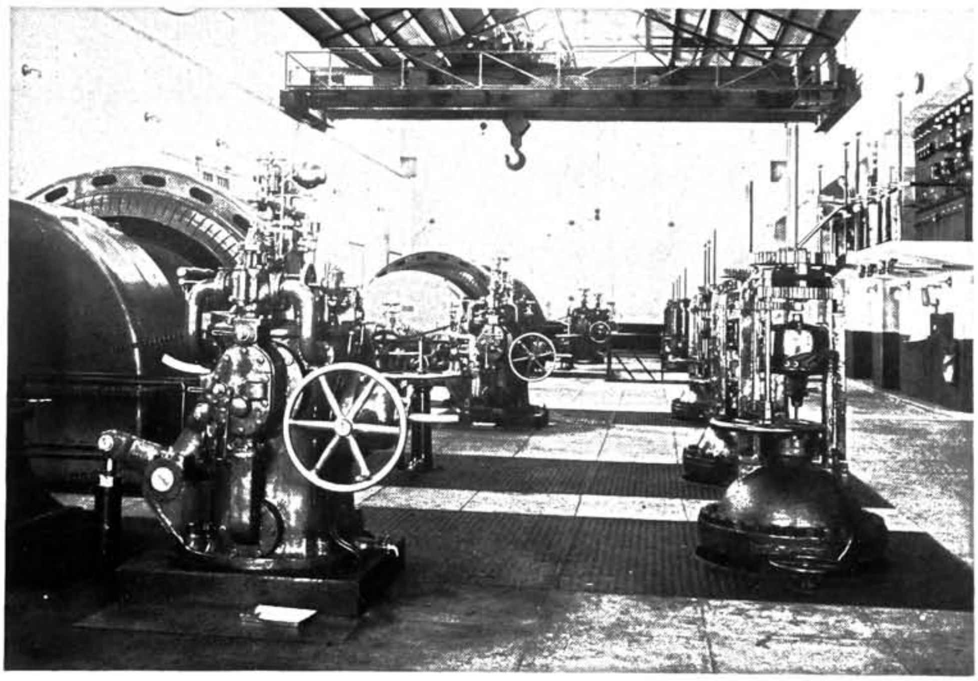
CANADIAN NIAGARA FALLS POWER COMPANY
7500 KW., 12,000 VOLT GENERATOR



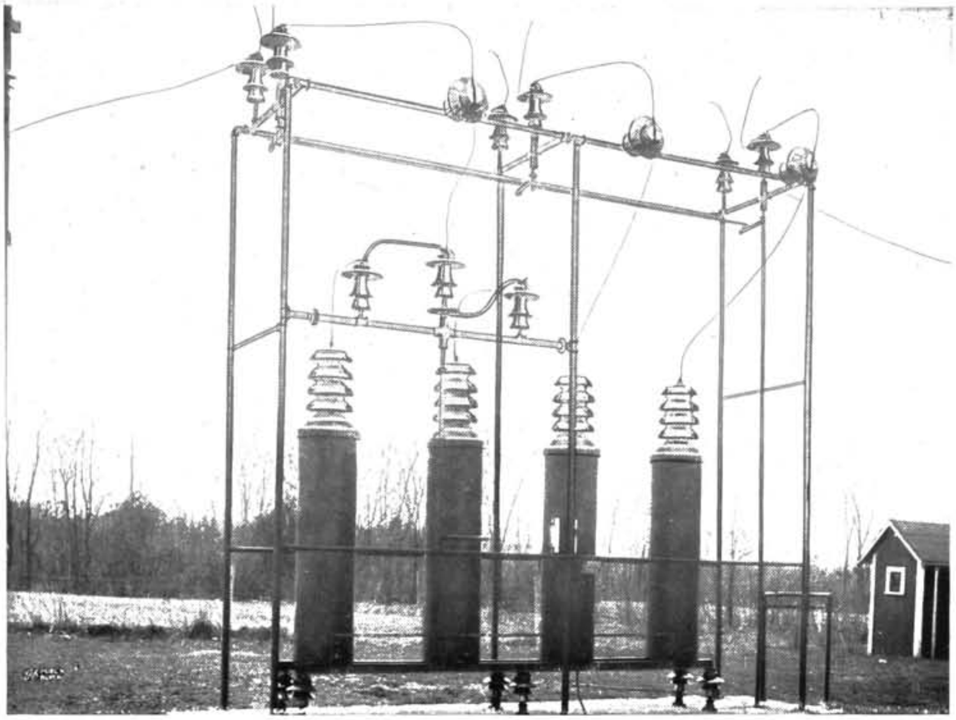
SHOSHONE POWER HOUSE, CENTRAL COLORADO POWER CO.
TWO 5000 KW., 4000 VOLT GENERATORS



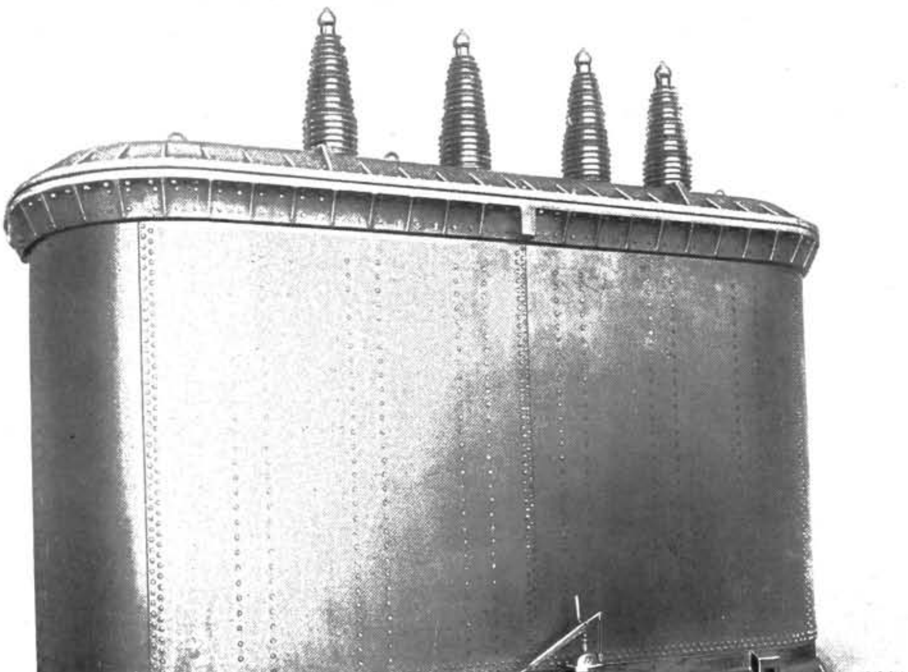
PUYALLUP RIVER STATION, PUGET SOUND POWER COMPANY
FOUR 3500 KW., 2300 VOLT GENERATORS



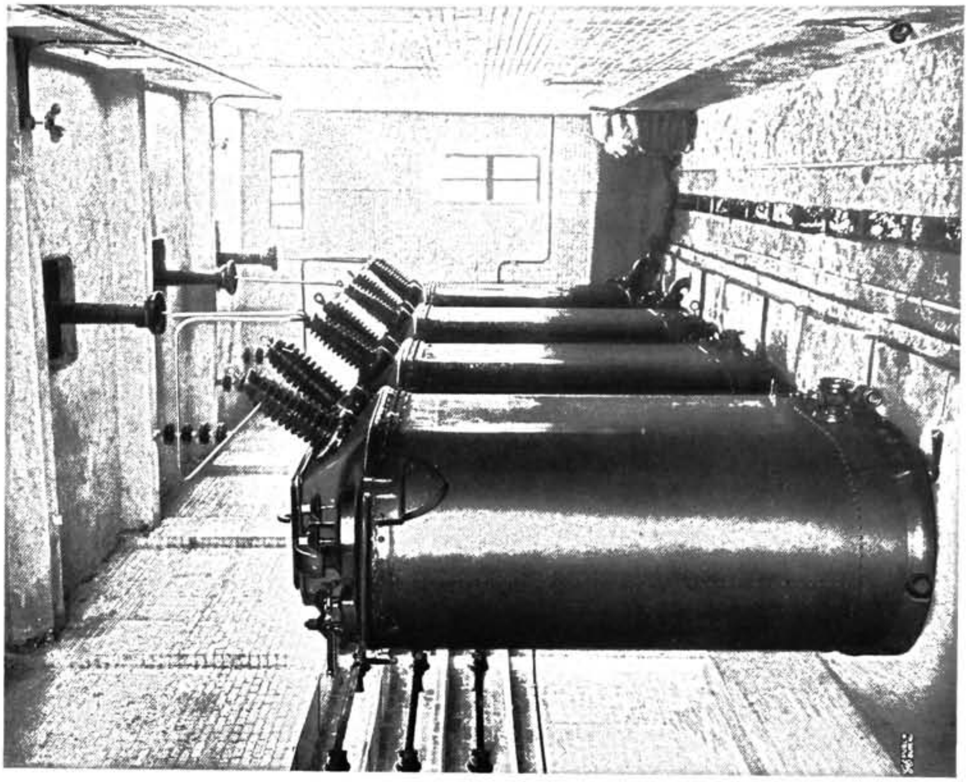
KERN RIVER STATION NO. 1, SOUTHERN CALIFORNIA EDISON COMPANY
FOUR 5000 KW., 2300 VOLT GENERATORS



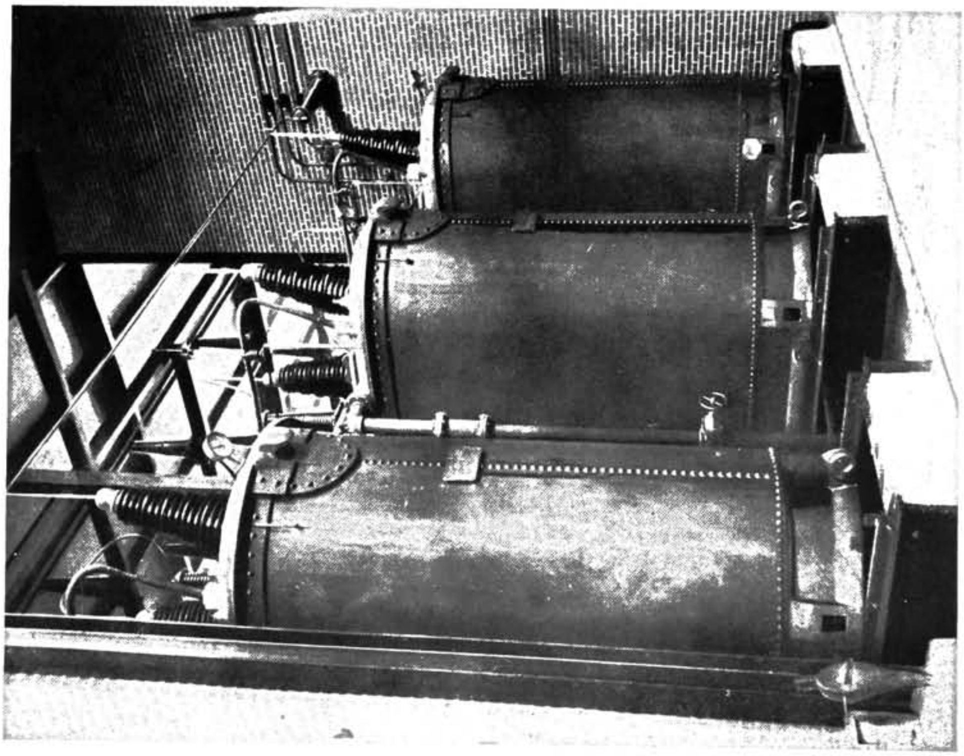
OUTDOOR TYPE 60,000 VOLT ALUMINUM LIGHTNING ARRESTER
BUFFALO, LOCKPORT & ROCHESTER RAILWAY CO.



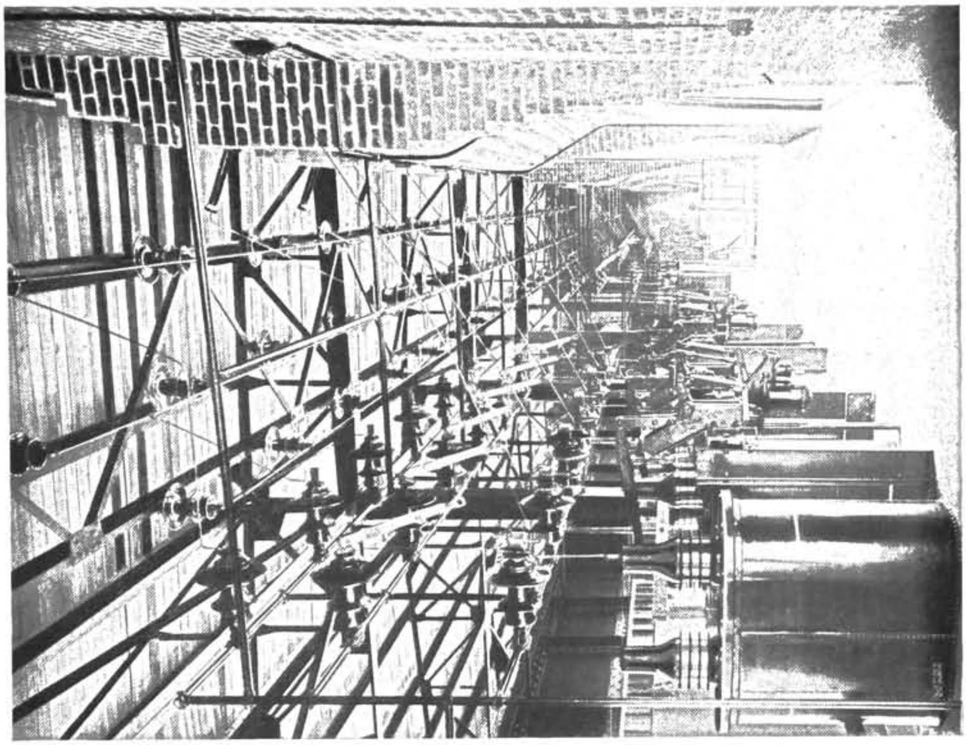
SHAWINIGAN POWER COMPANY, SHAWINIGAN FALLS, CANADA
14,000 KW., 100,000/6600 VOLT, THREE-PHASE TRANSFORMER



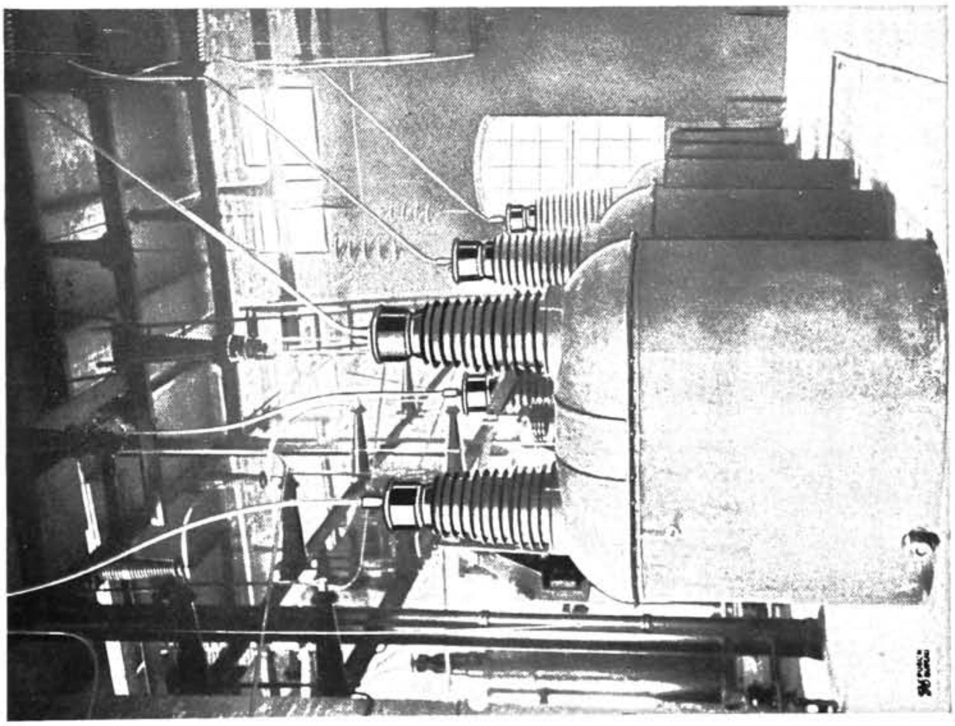
DENVER SUBSTATION, CENTRAL COLORADO POWER COMPANY
TYPE WC 1250 KV-A., 90,000/22,000 VOLT TRANSFORMERS



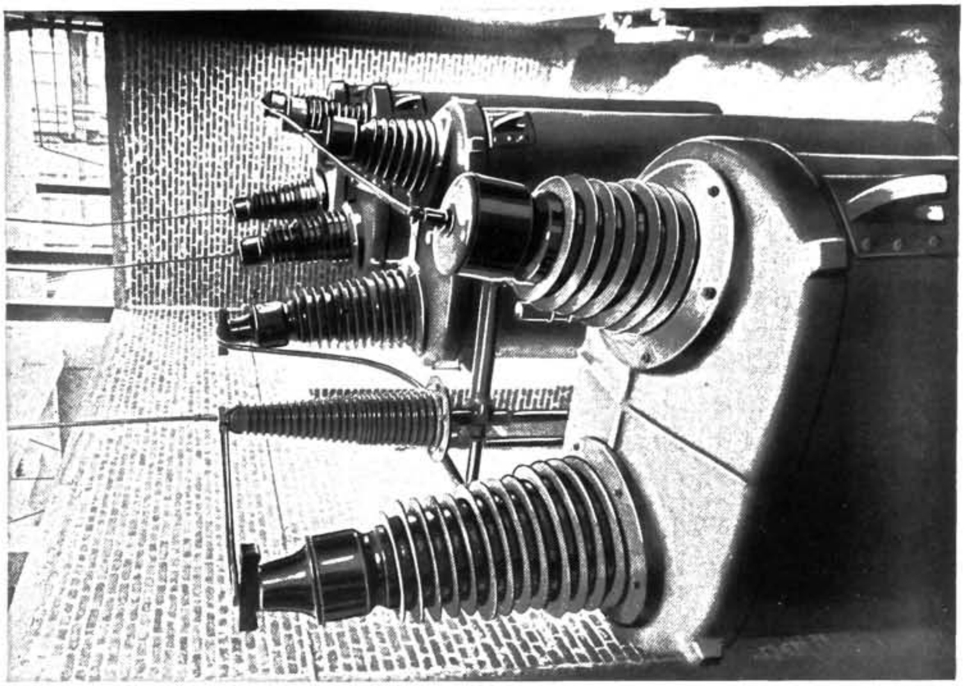
HYDRO-ELECTRIC POWER COMMISSION, ONTARIO, CANADA. THREE
TYPE WC 3750 KV-A., 110,000/13,200 VOLT TRANSFORMERS



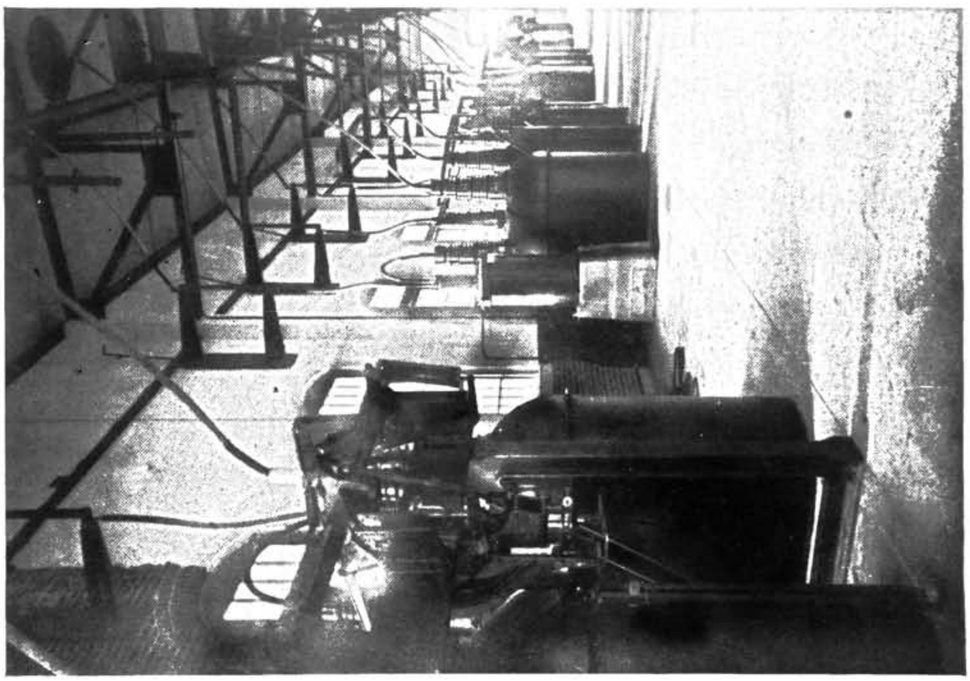
CONNECTICUT RIVER POWER COMPANY, HIGH TENSION GALLERY
60,000 VOLT, K-10 OIL SWITCHES



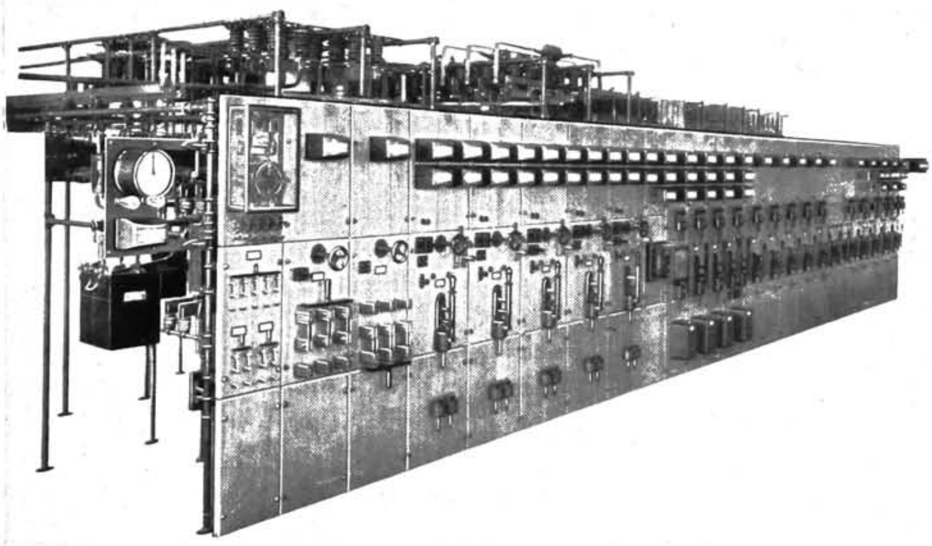
HYDRO-ELECTRIC POWER COMMISSION, ONTARIO, CANADA
110,000 VOLT REMOTE CONTROL OIL SWITCHES



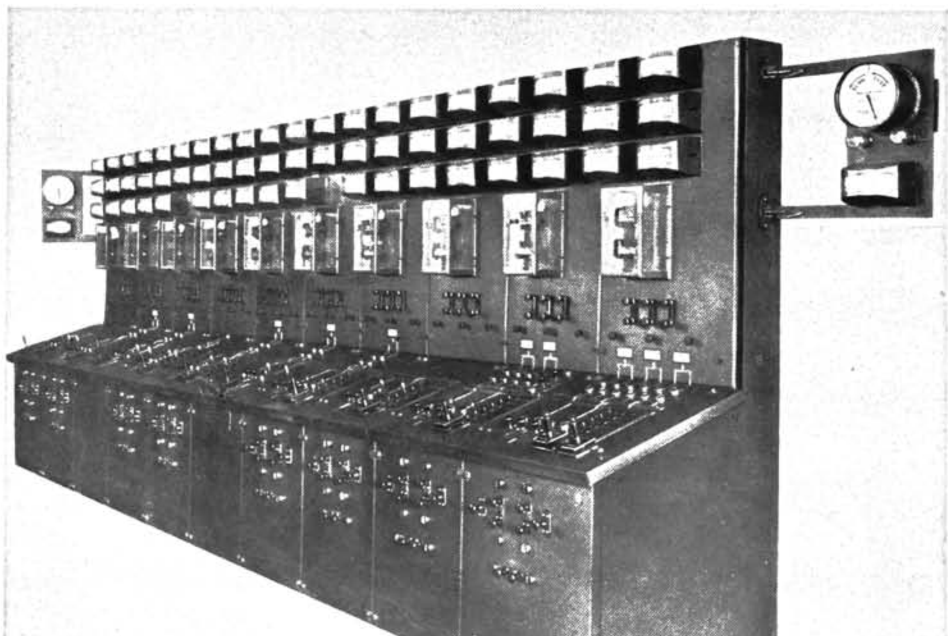
MONTREAL SUBSTATION, SHAWINIGAN POWER CO.
100,000 VOLT ALUMINUM LIGHTNING ARRESTER



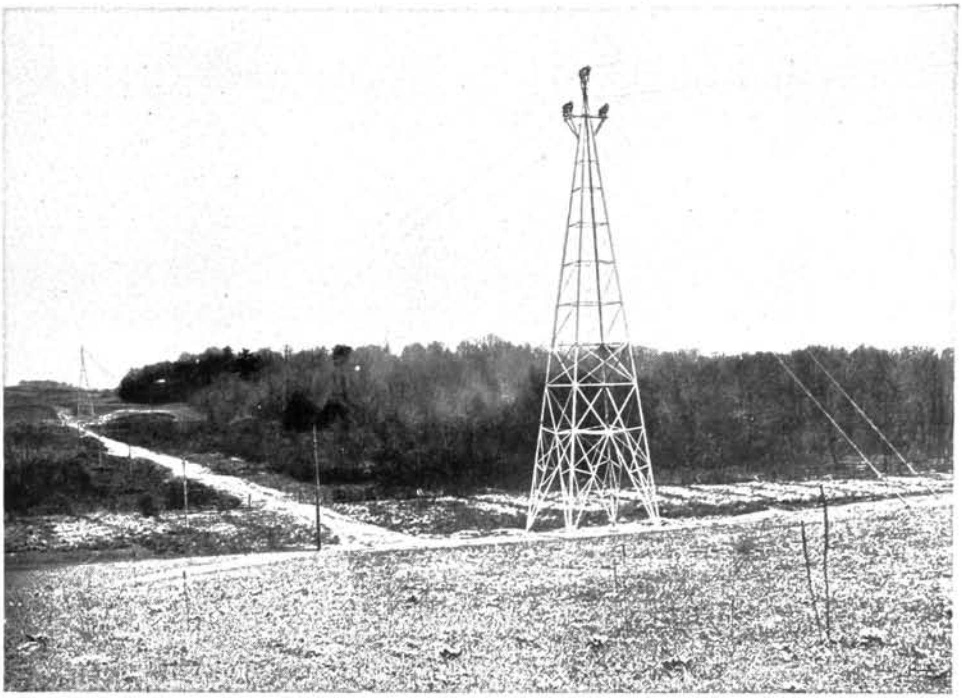
BUTTE SUBSTATION, GREAT FALLS WATER POWER AND TOWNSITE CO.
100,000 VOLT, TYPE K-15 OIL SWITCHES



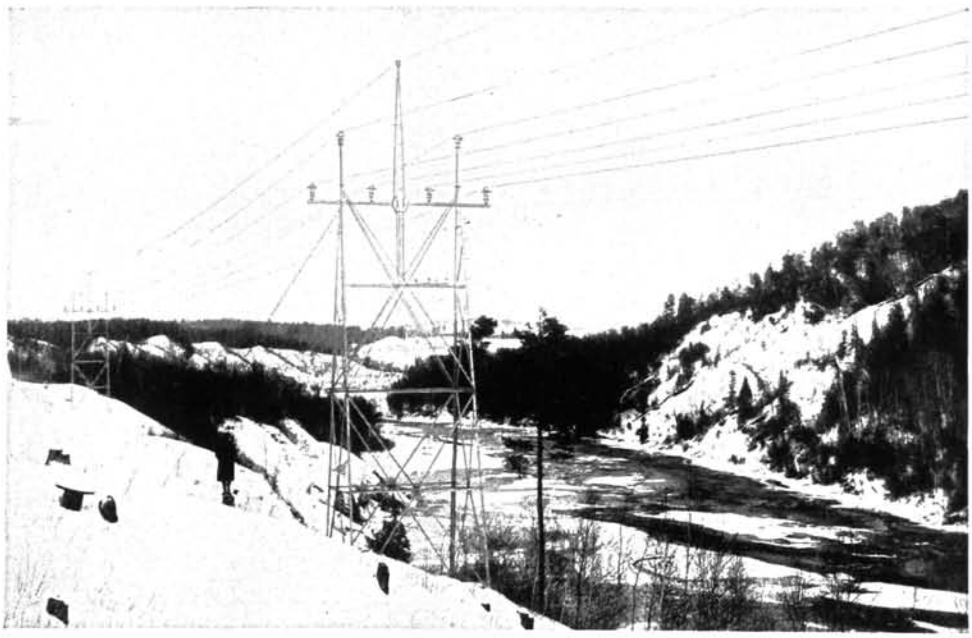
KYOTO ELECTRIC COMPANY, JAPAN. 6600 AND 3500 VOLT VERTICAL SWITCHBOARD



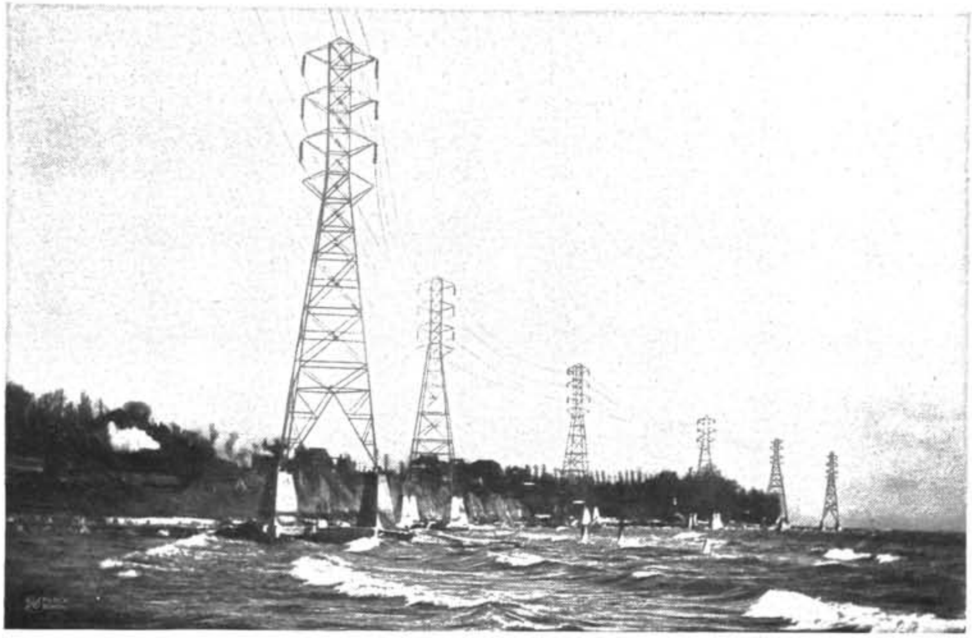
TEN PANEL BENCHBOARD CONTROLLING 49,000 KW., 13,200 VOLT STATION



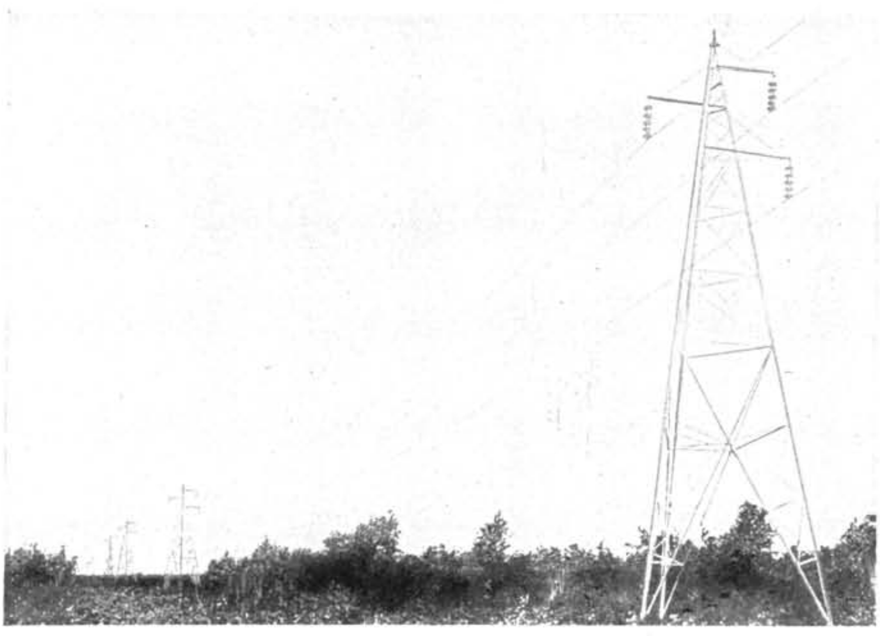
1250 FOOT SPAN, NIAGARA, LOCKPORT AND ONTARIO TRANSMISSION



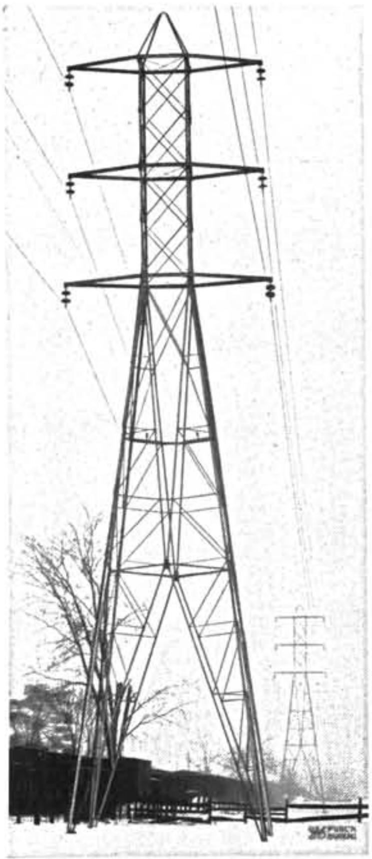
STANDARD TOWERS OF GREAT NORTHERN POWER CO.



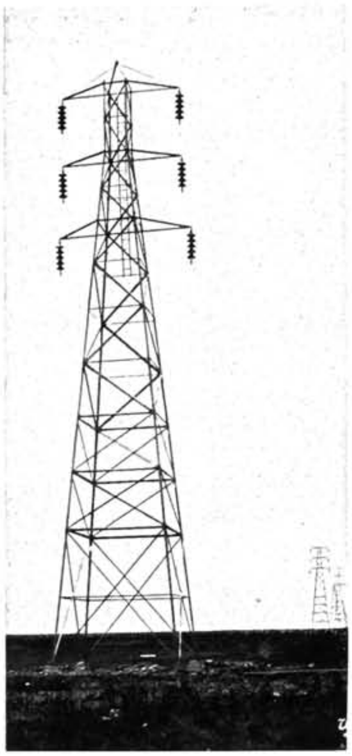
HYDRO-ELECTRIC POWER COMMISSION, ENTRANCE TO TORONTO



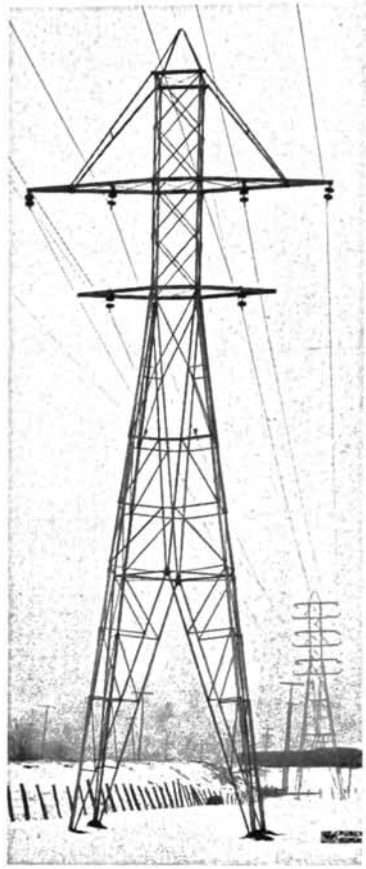
STANDARD TOWERS, MUSKEGON AND GRAND RAPIDS POWER COMPANY



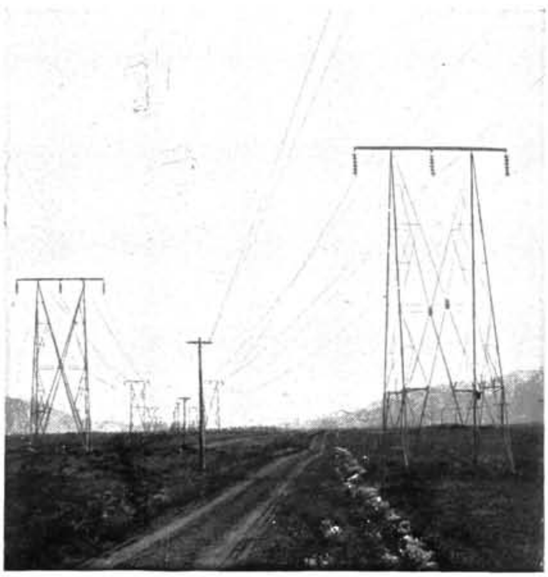
STANDARD TOWER, SCHENECTADY POWER CO.



GREAT WESTERN POWER CO.

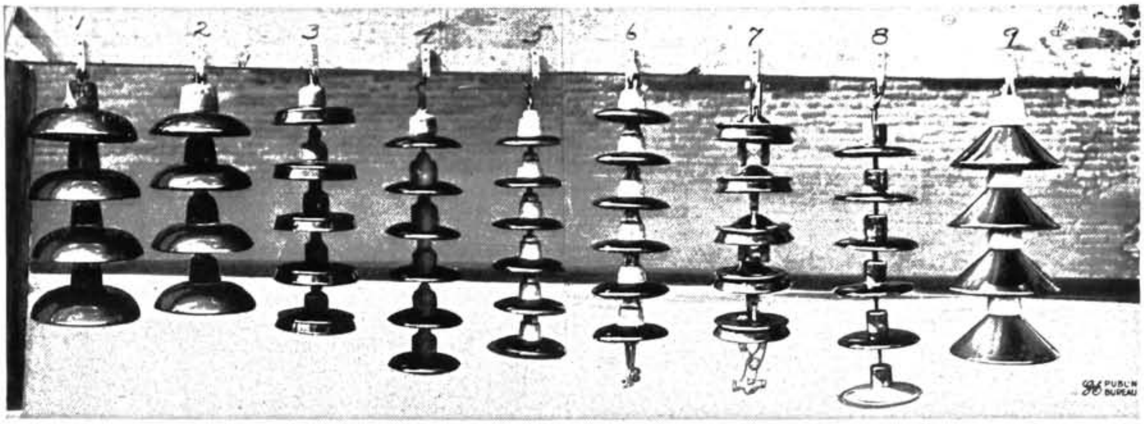


TRANSPOSITION TOWER SCHENECTADY POWER CO.



GREAT FALLS WATER POWER AND TOWNSITE CO.

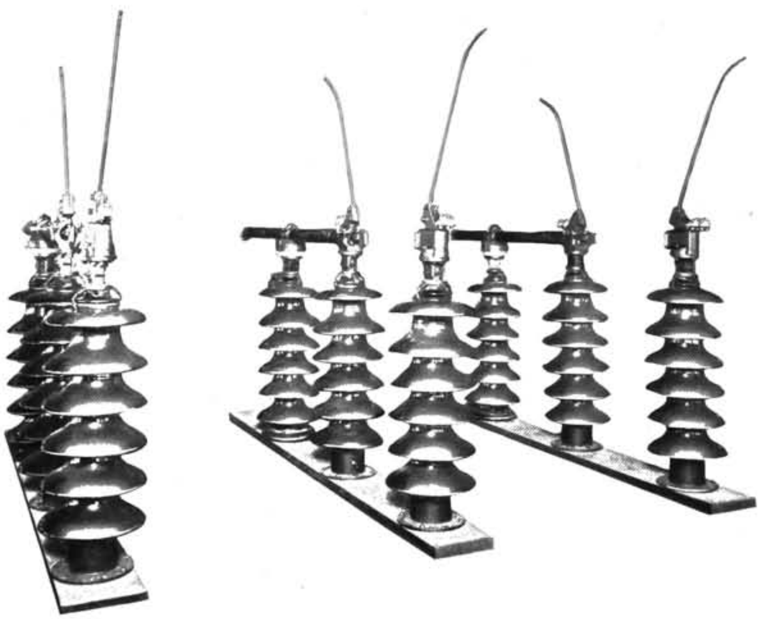
ROCHESTER AND SODUS BAY TRANSMISSION



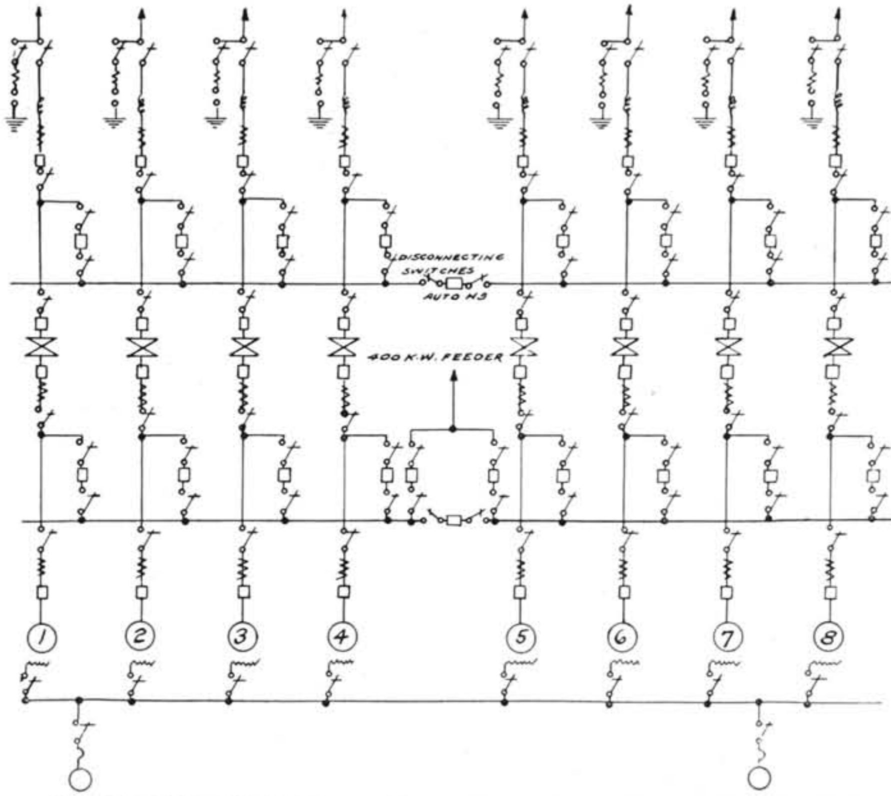
SUSPENSION TYPE INSULATORS

The General Electric Company has issued the following bulletins descriptive of apparatus designed for large hydro-electric developments:

Waterwheel Driven Alternators	4799
Large Shell Type Transformers	4953
Core Type Transformers	4896
Aluminum Lightning Arresters for Alternating Current Circuits	4828
Automatic Voltage Regulators, Type TA, for A-C. Generators	4601
Oil Break Switches, Type F, Form K-12	4821
Oil Break Switches, Type F, Forms K-10 and K-15	4823
Switchboard and High Tension Relays	4857

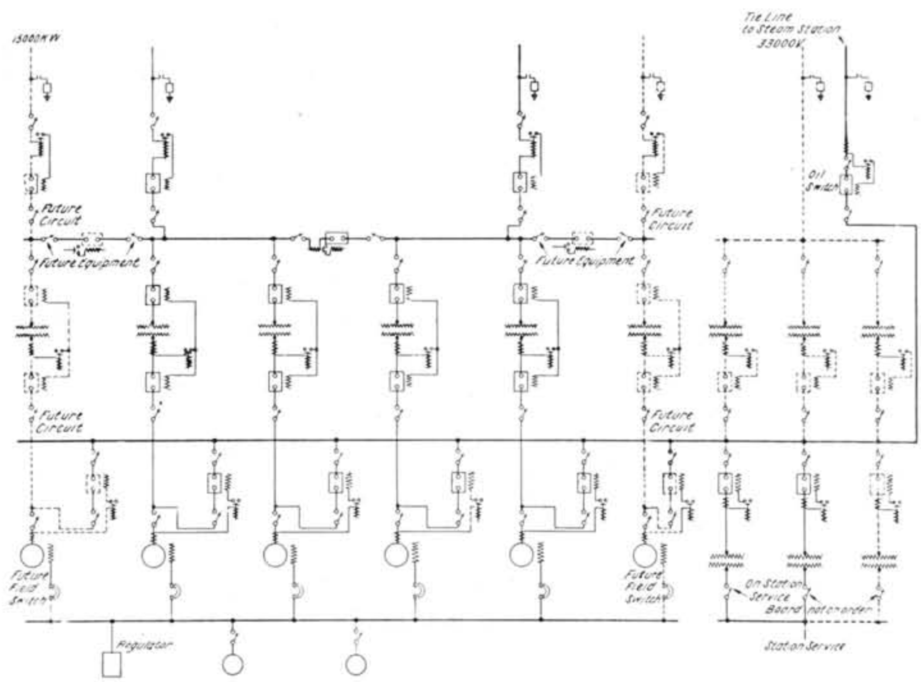


OUTDOOR TYPE DISCONNECTING SWITCH



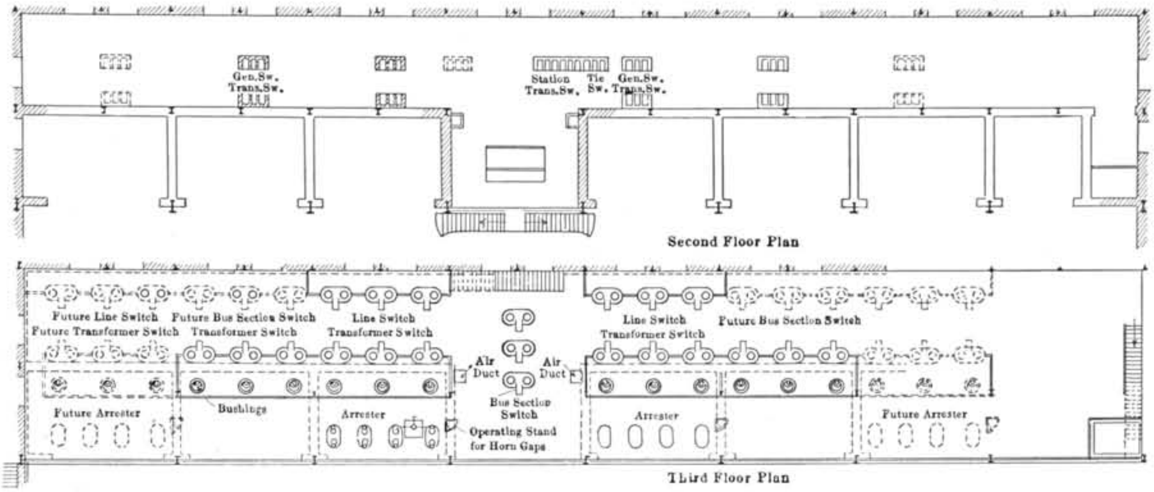
Feeders
Disconnecting switches
Lightning arresters
Kicking coils
Current transformers
Auto. H-3 switches with definite time limit relays
Disconnecting switches
Disconnecting switches
Auto. H-3 switches
Disconnecting switches
60,000 volt buses
Disconnecting switches
Non-automatic H-3 switches
7500 kv-a. transformers, 60,000 volts primary
Auto. H-3 switches definite time limit relays
Current transformers
Disconnecting switches
Disconnecting switches
Auto. H-3 switches with inverse time limit relays
Disconnecting switches
6600 volt buses
Disconnecting switches
Current transformers
Non-automatic H-3 switches
Generators 7500 kw., 6600 volt, 25 cycle.
Disconnecting switches
Disconnecting switches
Fuses
250 kw. exciters

SWITCHBOARD CONNECTIONS, GREAT NORTHERN POWER CO., DULUTH, MINN.

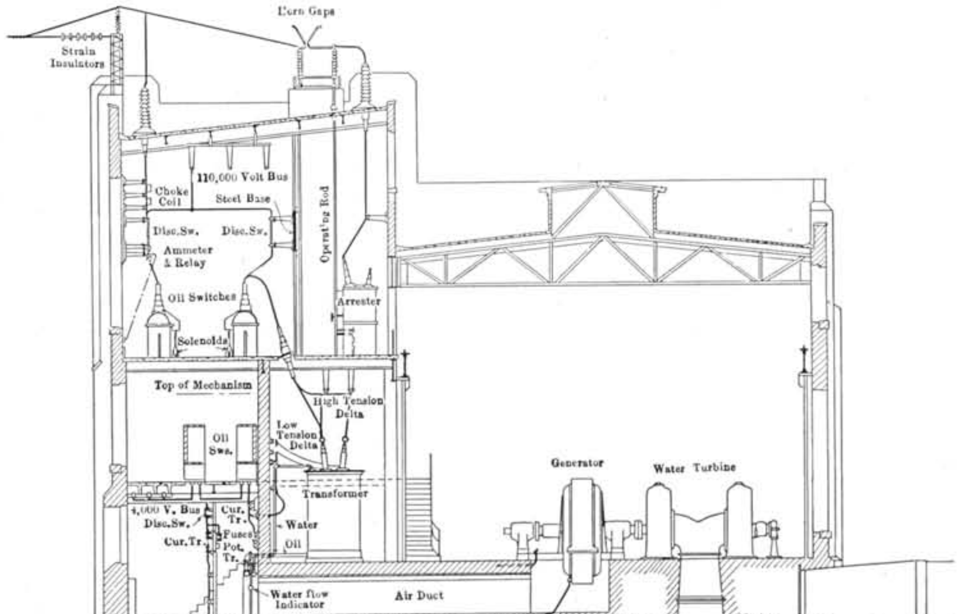


Horn gap
Lightning arrester
Disconnecting switch
Series relay
Oil switch K-15
Trip coil
Disconnecting switch
100,000 volt bus
Disconnecting switch
Oil switch K-15
Trip coil
Power transformer
Current transformer
Relay
Oil switch H-3
Trip coil
Disconnecting switch
Auxiliary bus 4000 volt
Disconnecting switch
Oil switch with trip coil
Current transformer
Relay
Disconnecting switch
Current transformer
7800 kw. generator
Power transformer
Disconnecting switch
250 volt exciting bus
Disconnecting switch
Exciters, 300 kw.

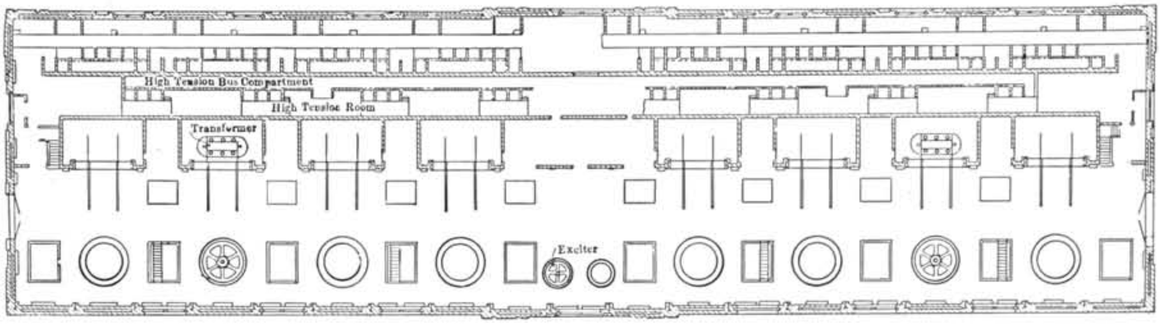
SWITCHBOARD CONNECTIONS, MEXICAN NORTHERN POWER COMPANY



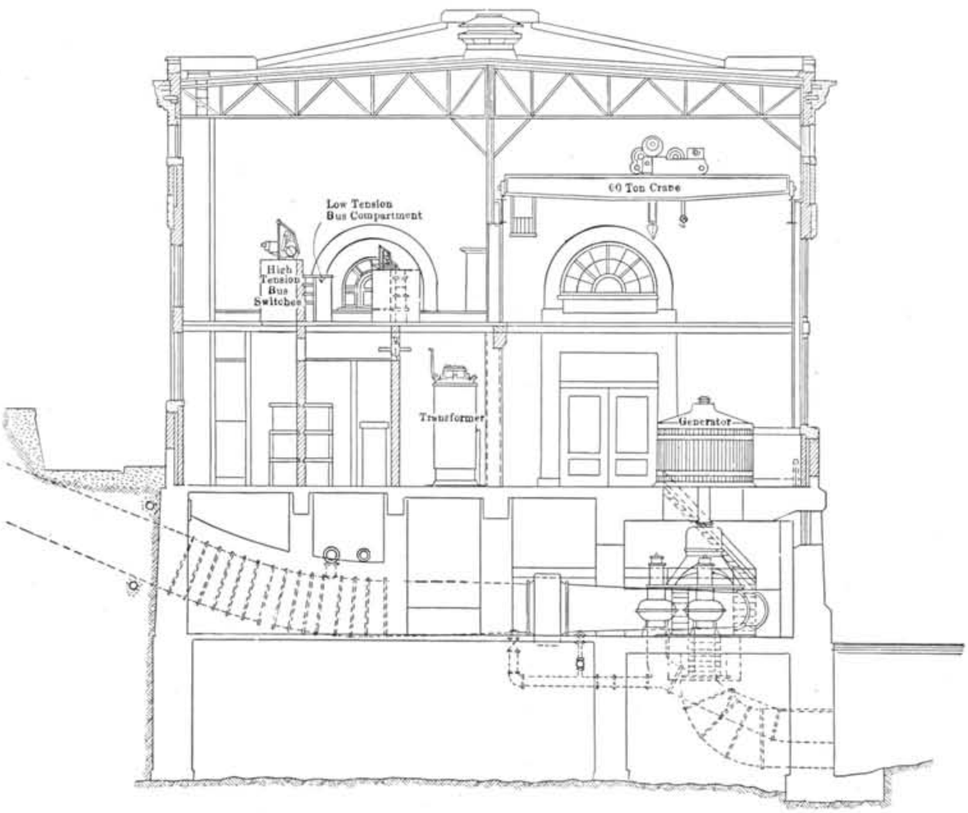
MEXICAN NORTHERN POWER COMPANY, SECOND AND THIRD FLOOR PLAN MAIN GENERATING STATION



MEXICAN NORTHERN POWER COMPANY, SECTION GENERATING STATION



GREAT NORTHERN POWER COMPANY, DULUTH, MINN. PLAN VIEW OF GENERATING STATION



GREAT NORTHERN POWER COMPANY, SECTION OF GENERATING STATION

4966-36 Hydro-Electric Power Developments

PARTIAL LIST OF LARGE THREE-PHASE WATERWHEEL DRIVEN GENERATORS BUILT BY GENERAL ELECTRIC COMPANY

Name and Location	Kv-a.	R.P.M.	Volts	Frequency	Vert. or Horiz.	No.	Year Installed
Washington Water Pr. Co., Spokane Dev.	13,900	200	4000	60	H.	2	1911
Mexican Light & Power Co., Mexico	12,500	300	4400	50	V.	2	1910
Georgia Power Co., Tallulah Falls, Ga.	10,000	514	6600	60	V.	3	1911
Great Western Power Co., California	10,000	400	11,000	60	V.	4	1909
Pacific Coast Power Co., White River, Wash.	10,000	360	6600	60	H.	2	1911
Electrical Development Co., Niagara Falls, Canada	10,000	250	12,000	25	V.	3	1911
Pennsylvania Water & Power Co., McCall Ferry, Pa.	10,000	94	11,000	25	V.	2	1911
Mississippi River Pr. Co., Keokuk, Iowa	9000	57.7	11,000	25	V.	15	Not Complete
Western Canada Power Co., Canada	8825	225	4400	60	H.	2	1911
Seattle-Tacoma Power Co., Snoqualmie Falls	8750	360	6900	60	H.	1	1910
Sierra and San Francisco Pr. Co., Stanislaus, Cal.	8500	400	4000	60	H.	4	1910
Electrical Development Co., Niagara Falls, Canada	8000	250	12,000	25	V.	4	1906
Mexican Northern Power Co., Mexico	7800	360	4000	60	H.	4	1912
Great Northern Power Co., Duluth, Minn.	7500	375	6600	25	V.	3	1906
Katsura-Gawa Hydro-Elec. Co., Japan	7500	500	11,000	60	H.	4	1912
Canadian Niagara Falls Pr. Co., Niagara Falls	7500	250	12,000	25	V.	5	1905-6
Ontario Power Co., Niagara Falls, Canada	7500	187	12,000	25	H.	3	1911
Pennsylvania Water & Power Co., McCall Ferry, Pa.	7500	94	11,000	25	V.	3	1910
Washington Water Power Co., Little Falls Station	6125	150	4000	60	H.	1	1911
Yadkin River Power Co., Raleigh, N. C.	6000	164	2300	60	H.	3	1912
West Kootenay Light & Power Co., Canada	5625	180	2300	60	V.	2	1905
Central Colorado Power Co., Colorado	5000	400	4000	60	H.	4	1908
So. California Edison Co., California	5000	250	2300	50	H.	4	1906
Vancouver Pr. Co., British Columbia	5000	200	2200	60	H.	1	1903
Washington Water Power Co., Little Falls Station	5000	170	4000	60	H.	3	1909
Rogue River Electric Co., Oregon	4700	514	2300	60	H.	1	1911
San Joaquin Lt. & Pr. Co., Fresno, Cal.	4000	400	2300	60	H.	4	1911
Appalachian Power Co., Fries, Va.	4000	116	13,200	60	V.	4	1912
Niagara Falls Power Co.	4000	250	2200 (2-Ph.)	25	V.	11	1902-4
Portland Ry., Light & Pr. Co., East Portland, Oregon	3667	240	11,000	60	H.	3	1911
Telluride Power Co., Provo, Utah	3600	225	11,000	60	H.	1	1907
Michoacan Power Co., Mexico	3500	514	2300	60	H.	2	1910
Great Falls Wt. Pr. & Townsite Co., Montana	3500	225	6600	60	H.	6	1910
Puget Sound Pr. Co., Puyallup River, Washington	3500	225	2300	60	H.	4	1903
Eastern Michigan Pr. Co., Michigan	3333	180	2300	60	H.	3	1912
Chattanooga & Tennessee River Power Co., Tennessee	3133	112	6600	60	V.	10	1912
Nagoya Electric Pr. Co., Japan	3125	360	6600	60	H.	4	1908
Oji Paper Co., Japan	3125	300	3450	60	H.	4	1907
Hitachi Copper Mines, Japan	3000	600	3450	60	H.	1	1911
Cia Docas de Santos, Brazil	3000	514	2300	60	H.	5	1906
Nictheroy Pr. Transmission Co., Brazil	3000	514	2300	60	H.	3	1906
Great Northern Railway Co., Cascade Tunnel	3000	375	6600	25	H.	3	1910
Schenectady Power Co., Schaghticoke	3000	300	4400	40	V.	4	1908
Truckee River General Elec. Co., Reno, Nev.	3000	277	2300	60	H.	1	1911
Yadkin River Power Co., Raleigh, N. C.	3000	164	4000	60	H.	3	1912
East Creek Electric Lt. & Pr. Co., Inghams Mills, N. Y.	2800	300	2300	25	V.	2	1911
La Crosse Water Power Co., Wisconsin	2600	300	2300	60	H.	3	1910
Minneapolis Gen. Elec. Co., Taylor Falls, Wisconsin	2500	277	2300	60	H.	2	1910
Hudson River Power Co., Spiers Falls, N. Y.	2500	240	2000	40	H.	6	1905
Commonwealth Power Co., Michigan	2500	164	6900	60	H.	1	1906
Chippewa Valley Lt. & Ry. Co., Wisconsin	2500	200	2300	60	H.	2	1911
Connecticut River Power Co., Vernon, Vt.	2500	133	2300	60	V.	8	1910
Appalachian Power Co., Fries, Va.	2300	97	13,200	60	V.	3	1912
Animas Canal, Reservoir, Water Pr. and Improvement Co., Colorado	2250	300	4000	60	H.	2	1905
Washington Water Power Co., Spokane	2250	300	4000	60	H.	5	1902
Madison River Power Co., Meadow Creek, Mont.	2250	300	4000	60	H.	4	1907
Hakone Water Power Co., Japan	2000	375	3450	50	H.	2	1907
Union Bag & Paper Co., Sandy Hill, N. Y.	2000	266	6600	40	H.	1	1907
New England Power Co., Shelburne Falls, Vt.	2000	257	2300	60	H.	9	1912
Amoskeag Mfg. Co., Manchester, N. H.	2000	225	2300	60	H.	1	1911
Arizona Power Co., Prescott, Arizona	1800	400	2300	60	H.	3	1908
Cumberland Lt. & Power Co., Bonny Eagle, Maine	1500	180	2300	60	H.	6	1911

PARTIAL LIST OF LARGE TRANSFORMERS BUILT BY GENERAL ELECTRIC COMPANY

Name and Location	Kv-a.	Primary Volts	Secondary Volts	Frequency	Type	No.	Year Installed
Eastern Michigan Pr. Co., Michigan	3000	140,000	44000/370	60	WC	13	1912
Sierra and San Francisco Pr. Co., California	3750	138,000	12,000	60	WC	7	1908
Hydro-Electric Pr. Comm., Canada	750	110,000	13,200	25	WC	34	1910
	1250	110,000	13,200	25	WC	14	1909
Georgia Power Co., Georgia	3333	110,000	11,000	60	WC	6	1912
	3333	110,000	6600	60	WC	9	1912
	1000	110,000	11,000/22,000	60	OC	12	1912
Mexican Northern Pr. Co., Mexico	2500	110,000	4000	60	WC	12	1912
Mississippi River Pr. Co.	9000	110,000	11,000	25	WCT	12	1912
Sierra and San Francisco Pr. Co., California	2233	104,000	4000	60	WC	12	1908
	400	104,000	29,400	60	WC	3	1910
Truckee River Gen. Elec. Co., Reno, Nev.	1000	104,000	2300	60	WC	4	1911
Yadkin River Power Co., North Carolina	6250	103,900	4000	60	WCT	5	1912
Great Falls Water Pr. and Townsite Co., Montana	2400	102,000	2500	60	WC	6	1912
	1200	102,000	6800	60	WC	13	1909
	1200	102,000	2500	60	WC	16	1910
Southern Pr. Co., N. Carolina	3000	101,200	2300	60	WC	9	1910
	1000	101,200	2600	60	WC	3	1910
	1000	101,200	2300	60	WC	15	1910
Yadkin River Power Co., North Carolina	2500	100,000	22,000	60	WC	4	1912
No. State Hydro-Electric Co., Raleigh, N. C.	2750	100,000	63,000	60	WC	4	1911
Tata Hydro-El. Pr. & Supply Co., Bombay, India	3333	100,000	5000	50	WC	12	1912
Shawinigan Power Co, Canada	14,000	100,000	6600	60	WCT	2	1912
Great Western Power Co., California	10,000	100,000	12,100	60	WCT	6	1909
Central Colorado Pr. Co., Colorado	3333	100,000	4200	60	WC	8	1908
	3330	100,000	4200	60	WC	6	1908
Great Western Power Co., California	5000	95,000	55,000	60	WCT	4	1909
	1250	95,000	24,200	60	WC	12	1909
	1250	95,000	480	60	WC	4	1909
Central Colorado Pr. Co., Colorado	1500	90,000	13,800	60	WC	8	1909
	2500	90,000	13,800	60	WC	5	1908
	1250	90,000	22,000	60	WC	7	1908
	750	90,000	11,000	60	WC	3	1908
	400	90,000	13,800	60	WC	4	1908
Appalachian Power Co., Virginia	6000	88,000	13,000	60	WCT	4	1912
Toronto Power Co., Canada	6000	86,500	24,000	25	WC	3	1912
Tata Hydro Elec. Co., India	3120	85,800	6750	50	WC	12	1912
Shawinigan Power Co., Canada	12,500	85,500	12,800	60	WCT	2	1912
Appalachian Power Co., Virginia	1500	85,000	13,200/2200	60	WC	9	1912
Mexican Lt. & Pr. Co., Mexico	6000	85,000	4200	50	WC	6	1912
	5600	80,900	18,900	50	WC	6	1912
	1800	80,900	3988	50	WC	5	1912
	1800	80,900	6900	50	WC	13	1912
Madison River Pr. Co., Mont.	900	80,000	4000	60	WC	12	1908
	750	80,000	1500	60	WC	3	1908
	600	80,000	600	60	WC	3	1908
Utah Lt. & Pr. Co., Utah	333	80,000	16,000	60	WC	5	1910
Butte Elec. Lt. & Pr. Co., Mont.	333	80,000	2200	60	WC	7	1910
Katsura-Gawa Hydro-Elec. Co., Japan	3500	77,000	11,000	50	WC	9	1912
Southern California Edison Co., California	1667	75,000	2300	50	FO	13	1905
Katsura-Gawa Hydro-Elec. Co., Japan	2000	70,000	11,400	50	WC	9	1912
Pennsylvania Wt. & Pr. Co., McCall Ferry, Pa.	10,000	70,000	11,000	25	WCT	2	1911
	7500	70,000	11,000	25	FOT	4	1907
Kern River Power Co., California	750	67,500	2200	50	WC	15	1902
Northern California Power Co., California	4000	66,000	6600	60	WCT	4	1910
	1500	66,000	6600	60	WC	3	1908
	750	66,000	2400	60	WC	2	1910
Yakima Valley Pr. Co., Yakima, Washington	1000	66,000	2500	60	WC	4	1910
Southern California Edison Co., California	1500	64,000	32,000	50	FO	13	1905
Nagoya Electric Pr. Co., Yokohama, Japan	1000	60,000	6600	60	WC	12	1907
Washington Water Pr. Co., Washington	2200	60,000	2300	60	WC	6	1905
Mexican Light & Pr. Co., Mexico	2000	60,000	4200	50	WC	15	1903
East Creek El. Lt. & Pr. Co., Ingham Mills, N. Y.	2800	60,000	2300	25	WCT	2	1911
	2500	60,000	13,200	25	WCT	2	1911
Canadian Niagara Power Co., Canada	1250	57,000	11,000	25	WC	12	1903
Portland Ry. Light & Power Co.	3367	57,000	11,000	60	WCT	6	1911
Pacific Coast Power Co., Seattle, Washington	3333	55,000	6600	60	WC	7	1911
Winnipeg General Pr. Co., Canada	1800	55,000	2400	60	WC	3	1905
Mexican Light & Power Co., Mexico	1800	55,000	3300	50	WC	16	1907
Seattle Electric Co., Washington	10,000	50,000	13,800	60	WCT	2	1911

4966-38 Hydro-Electric Power Developments

SOME HYDRO-ELECTRIC INSTALLATIONS FOR WHICH THE ELECTRICAL EQUIPMENT HAS BEEN FURNISHED BY THE GENERAL ELECTRIC COMPANY

Name and Location	Transmission Voltage	Present Capacity of Plant	Ultimate Capacity of Plant	Kv-a. Capacity of Each Generator	Kv-a. Capacity of Each Transformer	Frequency	Total Length of Transmission in Miles	Date of Completion
Eastern Michigan Pr. Co., Michigan	140,000 △	10,000	75,000	3333	3000 S-ph.	60	150	1912
Mexican Northern Pr. Co.	110,000 Y	31,200	46,800	7800	2500 S-ph.	60	125	Not complete
Mississippi River Power Co.	110,000 Y	135,000	270,000	9000	9000 3-ph.	25	150	Not complete
Georgia Power Co., Tallulah Falls	110,000 Y	30,000	60,000	10,000	3330 S-ph.	60	160	1912
Sierra and San Francisco Pr.Co.	104,000 Y	34,000	34,000	8500	2233 S-ph.	60	100	1910
Yadkin River Pr. Co., Raleigh, N.C.	103,900 Y	27,000	27,000	6000 & 3000	6250 3-ph.	60	150	1912
Gt. Falls Water Pr. & Townsite Co., Mont.	102,000 △	21,000	21,000	3500	1200 & 2400 S-ph.	60	135	1910
Gt. Western Power Co., Calif.	100,000 △	40,000	80,000	10,000	10,000 3-ph.	60	157	1909
Cent. Colo. Pr. Co., Boulder Dev.	100,000 △	10,000	10,000	5000	3300 S-ph.	60	30	1908
Cent. Colo Pr. Co., Glenwood Dev.	100,000 △	10,000	10,000	5000	3300 S-ph.	60	153	1908
Appalachian Pr. Co., Fries, Va.	88,000 △	23,000	75,000	4000 2600	6000 3-ph.	60	180	1912
Mexican Lt. & Pr. Co.	85,000 Y	55,000	Unknown	12,500	1800 S-ph.& 6000 S-ph.	50	94	1910
Katsura-Gawa Hydro-Electric Co. Japan	77,000 Y	30,000	56,000	7500	3500 S-ph.	50	65	1912
So. Calif. Edison Co.	75,000 Y	20,000	20,000	5000	1667 S-ph.	50	120	1906
Pennsylvania Wt. & Pr. Co., McCall Ferry	70,000 Y	42,500	92,500	7500 & 10,000	7500 3-ph. & 10,000	25	40	1911
San Joaquin Lt. & Pr. Co., Fresno, Calif.	69,500 Y	16,000	16,000	4000	1500 S-ph.	60	75	1910
Connecticut River Pr. Co., Vernon, Vt.	66,000 Y	20,000	20,000	2500	5000 3-ph.	60	60	1910
Power Construction Co., Shelbourne Falls, Vt.	66,000 Y	18,000	24,000	2000	3000 S-ph.	60	30	1912
Canadian Niagara Falls Pr. Co. Canada	62,500 Y	45,000	82,500	7500	1250 S-ph.	25	15	1903
East Creek Electric Lt. & Pr. Co., Ingham Mills, N. Y.	60,000 △	8400	8400	2800	2800 3-ph.	25	25	1912
Winnepeg General Pr. Co., Canada	60,000 △	22,500	22,500	1000 & 2000	830 S-ph. & 1800 S-ph.	60	65	1906
Washington Wt. Pr. Co., Post Falls, Wash.	60,000 Y	13,500	13,500	2250	2200 3-ph.	60	260	1907
Washington Wt. Pr. Co., Little Falls, Wash.	60,000 Y	21,125	21,125	5000 & 6125	5000 3-ph.	60	260	1911
Michoacan Pr. Co., Mexico	60,000 Y	10,000	Unknown	1500 & 3500	600 S-ph. & 2300 S-ph.	60	75	1910
Jhelum River Hydro-Electric Scheme, Kashmir, India	60,000 △	4000	12,000	1000	1000 S-ph.	25	50	1908
Guanajuato Pr. & Elec. Co., Mexico	60,000 Y	6750	6750	1250 & 3000	1080 S-ph.	60	101	1904
Great No. Pr. Co., Duluth, Minn.	60,000 △	22,500	60,000	7500	7500 3-ph.	25	14	1906
Electrical Dev. Co., Niagara Falls, Can.	60,000 △	62,000	95,000	8000 & 10,000	2670	25	80	1911
Puget Sound Pr. Co. (Puyallup River Dev.) Washington	58,000 Y	14,000	28,000	3500	2333 S-ph.	60	46	1907
California Gas & Electric Co., De Sabla	55,000 Y	14,000	14,000	2000 & 5000	840 S-ph.	60	142	1903
Animas Canal, Reservoir, Water Pr. and Improvement Co., Colorado	50,000 △	9000	9000	2250	750 S-ph.	60	25	1905
Chattanooga-Tenn. River Pr. Co.	45,000 △	22,500	22,500	2250	2250 S-ph.	60	33	Not complete
Hudson River Pr. Co., Spiers Falls, N. Y.	30,000 △	20,250	20,250	2500 750	833 S-ph. 670 S-ph.	40	40	1903
Schenectady Pr. Co., Schaghticoke, N. Y.	30,000 △	15,600	15,600	4000 1800	4000 & 1800 3-ph.	40	27	1908
Mohawk Hydro-Elec. Co. Ephratah, N. Y.	22,000 Y	3750	5000	1250	500 S-ph.	60	11	1911

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E. C., England, 83 Cannon St.

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

General Electric Company

Schenectady, N.Y.

SUPPLY DEPARTMENT

July, 1912 *Bulletin No. 4967*

SWITCHBOARD STRUCTURAL DEVICES

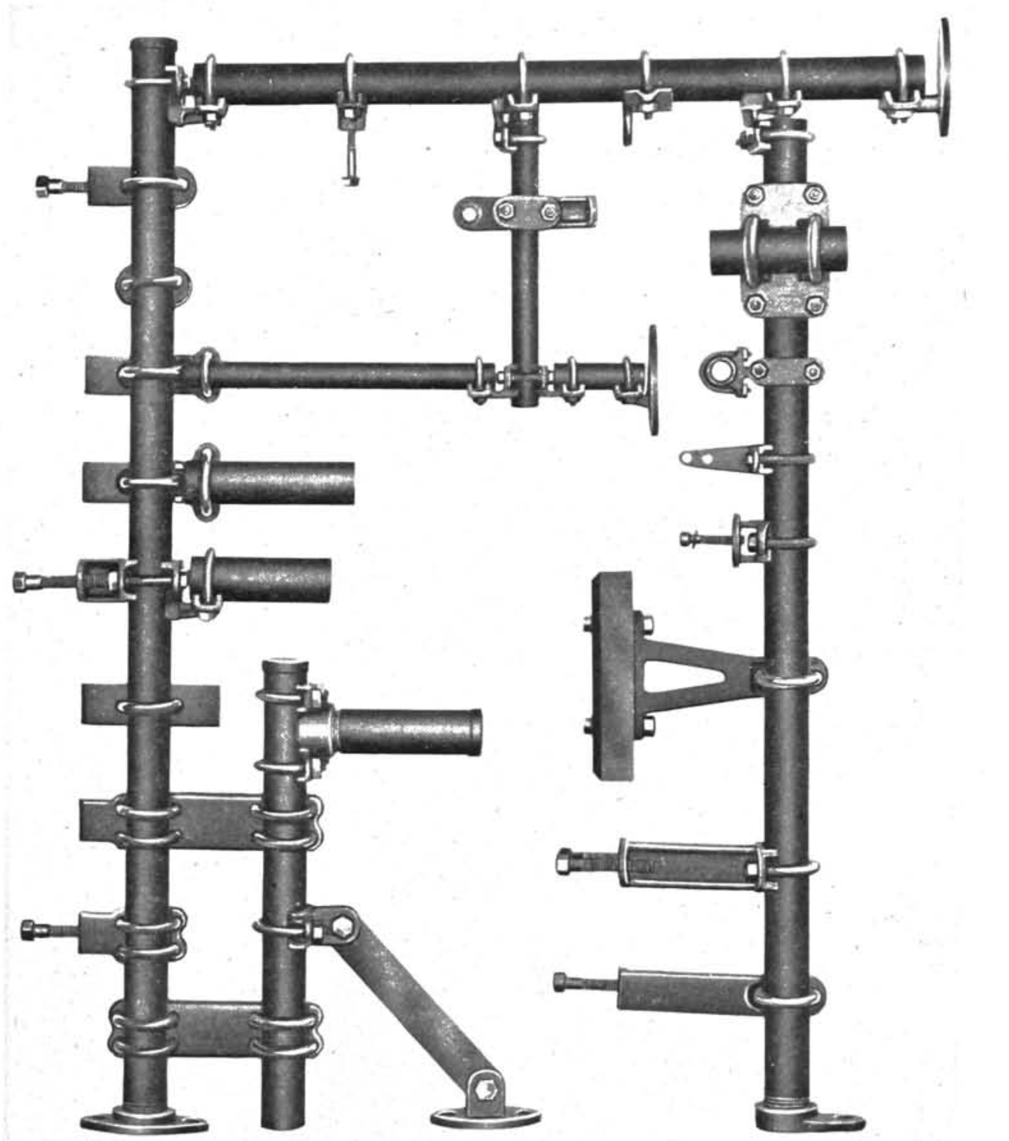


PLATE I

The data contained in the following pages are intended to assist customers in the ordering of fittings for use in connection with switchboard work. All fittings should be ordered by catalogue number, where possible. An index to catalogue numbers, together with prices, will be found in the supplement accompanying the bulletin.

MISCELLANEOUS FITTINGS FOR SWITCHBOARDS

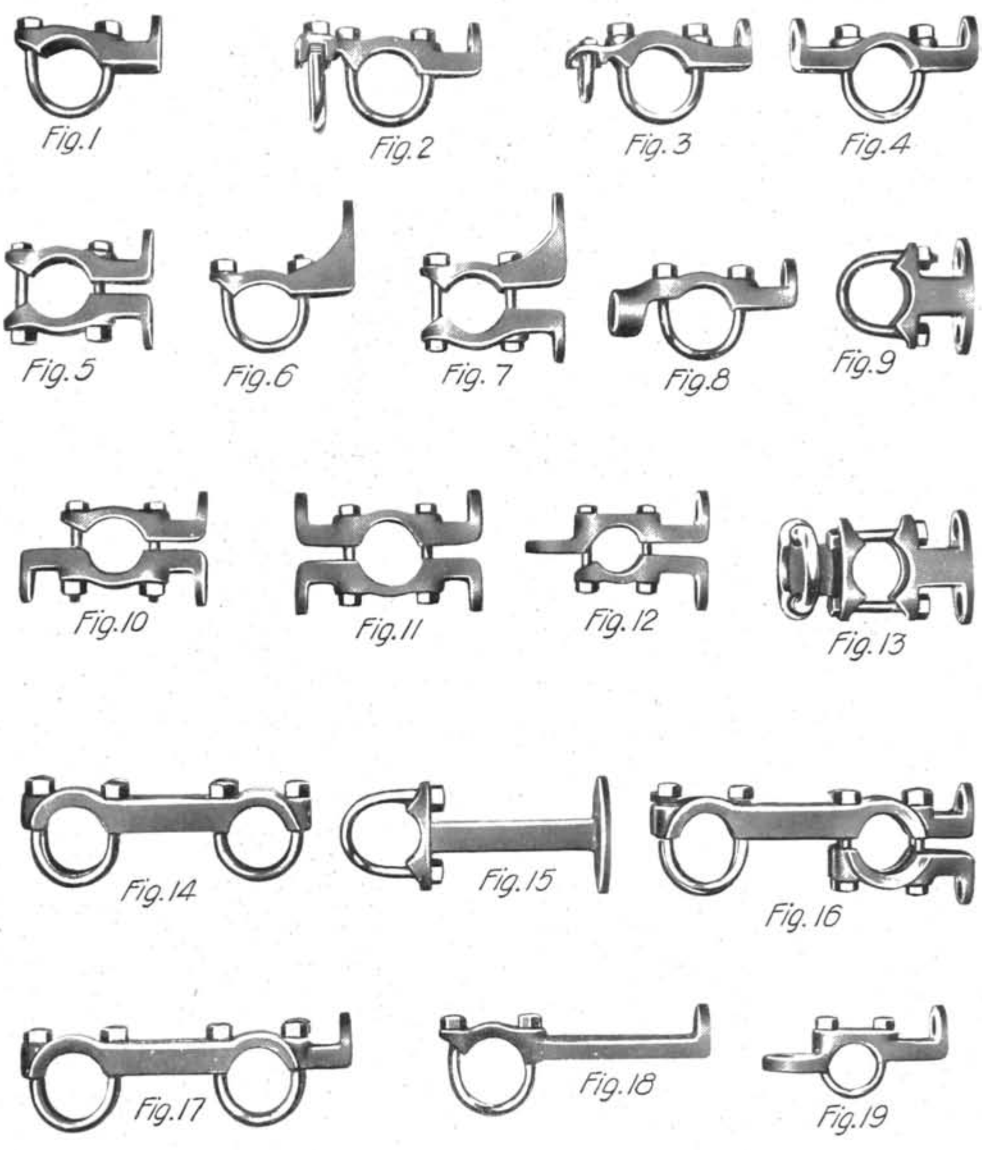


PLATE II

Cat. No.	Description	Fig. No. Plate II
132388	* For panel and 1¼ in. vertical pipe, 2½ in. from panel	1
132389	* For panel, and 1 in. vertical pipe 2½ in. from panel	1
132390	* For panel and ¾ in. vertical pipe, 2½ in. from panel	1
132391	π For two panels and 1 in. vertical pipe	5
132392	△ For panel, 1¼ in. vertical and 1¼ in. horizontal pipe	2

* Complete with yoke and nuts. π Complete with bolts and nuts. △ Complete with yokes and nuts.

Cat. No.	Description	Fig. No. Plate II
132393	△ For panel, 1¼ in. vertical and ¾ in. horizontal pipe	3
132394	△ For panel, 1 in. vertical and ¾ in. horizontal pipe	3
132395	* For panel, 1¼ in. vertical pipe and panel	4
132396	π For two panels, 1¼ in. vertical pipe and two panels	11
132397	π For two panels, ¾ in. vertical pipe	5
132398	* For two panels, 1¼ in. vertical pipe	9
132399	π For two panels, 1¼ in. vertical pipe and one panel	10
132400	§ For two panels, 1¼ in. vertical pipe and 1¼ in. horizontal pipe	13
132401	§ For two panels, 1¼ in. vertical pipe and ¾ in. horizontal pipe	13
132402	† For two panels and two 1¼ in. vertical pipes	16
132403	π For two panels, 1 in. vertical pipe and floor brace	12
132404	* For one panel, 1¼ in. vertical pipe and ¾ in. horizontal pipe	8
132405	π For one panel, 1¼ in. vertical pipe and TA regulator panel	7
132406	* For TA regulator panel and 1¼ in. vertical pipe	6
132407	* For panel, 1 in. vertical pipe and pipe brace	19
132408	△ For panel and two 1¼ in. vertical pipes	17
132409	△ For two 1¼ in. vertical pipes, 5 in. apart	14
132410	* For panel and 1¼ in. vertical pipe, 6 in. from panel	18
132411	* For two panels and 1¼ in. vertical pipe, 6 in. from panel	15
		Plate III
132412	Floor clevis for panel brace	1
132413	Oval floor flange for 1¼ in. pipe	2
132414	Oval floor flange for 1 in. pipe	2
132415	Oval floor flange for ¾ in. pipe	2
132416	Half oval floor flange for 1¼ in. pipe	3
132417	Floor angle	4
132418	* Barrier support for 1¼ in. pipe	5
132419	* Pipe fitting for 1¼ in. pipe and floor brace	6
132420	* Pipe fitting for 1 in. pipe and floor brace	6
132421	* Pipe fitting for ¾ in. pipe and floor brace	6
132422	* Pipe clamp, 1¼ in. pipe and resistance supporting rods	7
132423	* Pipe clamp, 1 in. pipe and resistance supporting rods	7
132424	* Pipe clamp, 1¼ in. pipe, ⅝ in.–11 tap	8
132425	* Pipe clamp, 1¼ in. pipe, ½ in.–13 tap	8
132426	* Pipe clamp, 1¼ in. pipe, ⅜ in.–16 tap	8
132427	* Pipe clamp, 1 in. pipe, ⅝ in.–11 tap	8
132428	* Pipe clamp, 1 in. pipe, ½ in.–13 tap	8
132429	* Pipe clamp, 1 in. pipe, ⅜ in.–16 tap	8
132430	△ Pipe clamp, 1¼ in. vertical and 1¼ in. horizontal pipe	9
132431	△ Pipe clamp, 1¼ in. vertical and 1 in. horizontal pipe	9
132432	△ Pipe clamp, 1¼ in. vertical and ¾ in. horizontal pipe	9
132433	△ Pipe clamp, 1¼ in. vertical and ½ in. horizontal pipe	9
132434	△ Pipe clamp, 1 in. vertical and 1 in. horizontal pipe	9
132435	△ Pipe clamp, 1 in. vertical and ¾ in. horizontal pipe	9
132436	△ Pipe clamp, 1 in. vertical and ½ in. horizontal pipe	9
132437	△ Pipe clamp, ¾ in. vertical and ¾ in. horizontal pipe	9
132438	△ Pipe clamp, ¾ in. vertical and ½ in. horizontal pipe	9
132439	△ Pipe clamp, ½ in. vertical and ½ in. horizontal pipe	9
132440	△ Pipe clamp, 1¼ in. vertical and ¾ in. 17 deg. oblique pipe	19
132441	△ Pipe clamp, 1¼ in. vertical and ½ in. 17 deg. oblique pipe	19
132442	△ Pipe clamp, 1 in. vertical and ¾ in. 17 deg. oblique pipe	19
132443	△ Pipe clamp, 1 in. vertical and ½ in. 17 deg. oblique pipe	19
132444	† Double pipe clamp, ¾ in. vertical and two ¾ in. horizontal pipes	15

* Complete with yoke and nuts.
π Complete with bolts and nuts.
§ Complete with yoke, bolts and nuts.
△ Complete with yokes and nuts.
† Complete with yokes, bolts and nuts.

4967–4 Switchboard Structural Devices

Cat. No.	Description	Fig. No. Plate III
132445	† Double pipe clamp, ¾ in. vertical and two ½ in. horizontal pipes	15
132446	† Double pipe clamp, ½ in. vertical and two ½ in. horizontal pipes	15

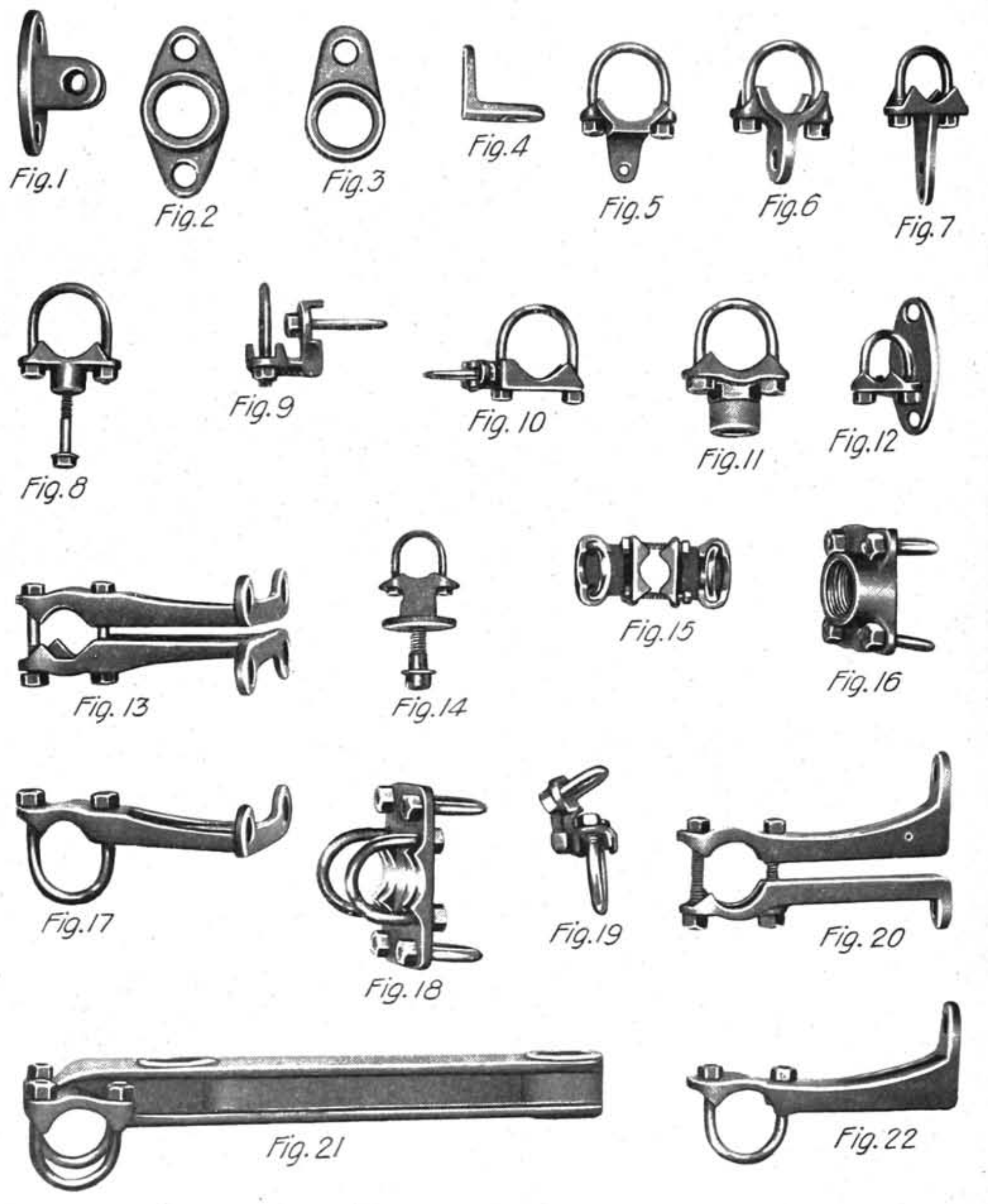


PLATE III

132447	† Double pipe clamp, 1¼ in. vertical and two 1¼ in. horizontal pipes	15
132448	† Double pipe clamp, 1¼ in. vertical and two 1 in. horizontal pipes	15
132449	† Double pipe clamp, 1¼ in. vertical and two ¾ in. horizontal pipes	15

† Complete with yokes, bolts and nuts.

Cat. No.	Description	Fig. No. Plate III
132450	△ Pipe clamp, 1¼ in. vertical and ¾ in. cross pipe	10
132451	△ Pipe clamp, 1 in. vertical and ¾ in. cross pipe	10

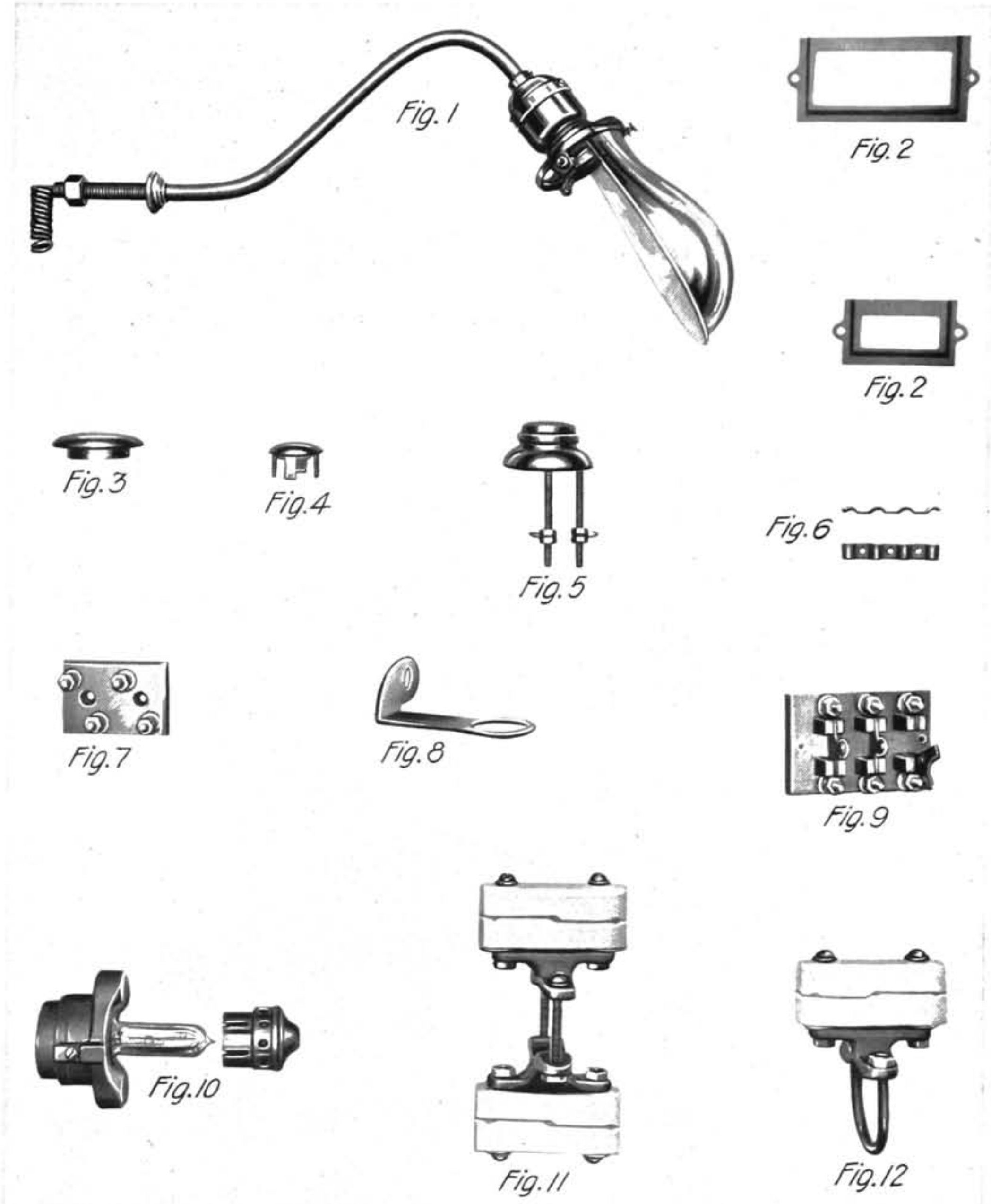


PLATE IV

132452	* Pipe clamp, 1¼ in. vertical and ¾ in. horizontal pipe tap	11
132453	* Pipe clamp, 1¼ in. horizontal pipe to wall	12

* Complete with yoke and nuts.

△ Complete with yokes and nuts.

Cat. No.	Description	Fig. No. Plate III
132454	* Pipe clamp, ¾ in. horizontal pipe to wall	12
132455	* Pipe clamp, ½ in. horizontal pipe to wall	12
132456	* Pipe clamp, 1¼ in. pipe and fuse base	17
132457	π Pipe clamp, 1¼ in. pipe and two fuse bases	13
132458	* Pipe clamp, 1 in. pipe and fuse base	17
132459	π Pipe clamp, 1 in. pipe and two fuse bases	13
132460	* Pipe clamp, 1¼ in. pipe and ½ in. bolt	14
132461	* Pipe clamp, ¾ in. pipe and ½ in. bolt	14
132462	△ Pipe clamp, 1¼ in. vertical and 1¼ in. horizontal pipe, threaded	16
132463	△ Pipe clamp, 1¼ in. vertical and ¾ in. horizontal pipe, threaded	16
132464	△ Pipe clamp, 1¼ in. vertical and 1¼ in. horizontal crossed pipes	18
132465	△ Pipe clamp, 1¼ in. vertical and ¾ in. horizontal crossed pipes	18
132466	π Pipe clamp for panel, 1¼ in. pipe and TA regulator panel, 6 in. from pipe	20
132467	* Pipe clamp for 1¼ in. pipe and TA regulator panel, 6 in. from pipe	22
132468	△ Pipe clamp for 1¼ in. pipe, TA regulator panel and end of switchboard	21
132469	Cap for 1¼ in. pipe	
132470	Cap for 1 in. pipe	
132471	Cap for ¾ in. pipe	
		Plate IV
125551	Card holder, overall length 4¼ in., width 1$\frac{31}{32}$ in., length of opening 3 in., width of opening 1¼ in.	2
125552	Card holder, overall length 3 in., width 1½ in., length of opening 1¾ in., width of opening ¾ in.	2
133657	Goose neck lamp bracket, complete with socket and shade	1

* Complete with yoke and nuts.
π Complete with bolts and nuts.
△ Complete with yokes and nuts.

POLISHED BLACK MOULDED MATERIAL BUTTONS FOR PLUGGING BOLT COUNTER-BORES ON FRONT OF SWITCHBOARD PANELS (PLATE IV)

BUTTONS SET IN PANEL WITH PLASTER OF PARIS

Cat. No.	Diam. of Counter-Bore	Outside Diam. of Button	Fig. No.
132373	¼–$\frac{5}{16}$	$\frac{7}{16}$	3
132374	⅜–$\frac{7}{16}$	$\frac{9}{16}$	3
132375	⅝–¾	$\frac{13}{16}$	3
132376	$\frac{25}{32}$–⅞	1	3
132377	1$\frac{1}{32}$–1⅛	1¼	3
132378	1$\frac{9}{32}$–1½	1⅝	3
132379	1$\frac{7}{32}$–1⅝	1¾	3
132380	1$\frac{11}{16}$–2	2⅛	3
132381	1$\frac{15}{16}$–2¼	2⅜	3
132382	2$\frac{5}{16}$–2½	2¾	3
132383	2$\frac{7}{16}$–2¾	3	3
132384	3$\frac{1}{16}$–3¼	3½	3
132385	2$\frac{13}{16}$–4¼	4½	3
132386	4$\frac{5}{16}$–4¾	5	3
SPRING BUTTON (DOES NOT REQUIRE PLASTER OF PARIS)			
132387	1$\frac{1}{16}$	1¼	4

Cat. No.	Description	Fig. No.
24998	Pilot lamp receptacle	5

TERMINAL BOARDS WITH CUP WASHERS AND NUTS (PLATE IV)

Cat. No.	No. of Studs	Fig. No.	Cat. No.	No. of Studs	Fig. No.
132349	3	7	132355	9	7
132350	4	7	132356	10	7
132351	5	7	132357	11	7
132352	6	7	132358	12	7
132353	7	7	132359	13	7
132354	8	7	132360	14	7

CALIBRATING TERMINAL BOARDS WITH CUP WASHERS AND NUTS FOR INSTRUMENT TRANSFORMERS (PLATE IV)

Cat. No.	Description	Fig. No.
132361	Double-pole, single-throw	9
132362	Triple-pole, single-throw	9

METAL CLEATS (PLATE IV)

NOTE.—Catalogue numbers include screws for fastening in position.

Cat. No.	No. of Wires	No. of Screws Included	Fig. No.	Cat. No.	No. of Wires	No. of Screws Included	Fig. No.
132363	1	1	6	132368	6	3	6
132364	2	1	6	132369	7	4	6
132365	3	2	6	132370	8	4	6
132366	4	2	6	132371	9	5	6
132367	5	3	6	132372	10	5	6

SUPPORTING BRACKET FOR POTENTIAL PLUGS (PLATE IV)

Cat. No.	Description	Fig. No.
129965	Bracket for supporting potential plugs when not in use	8

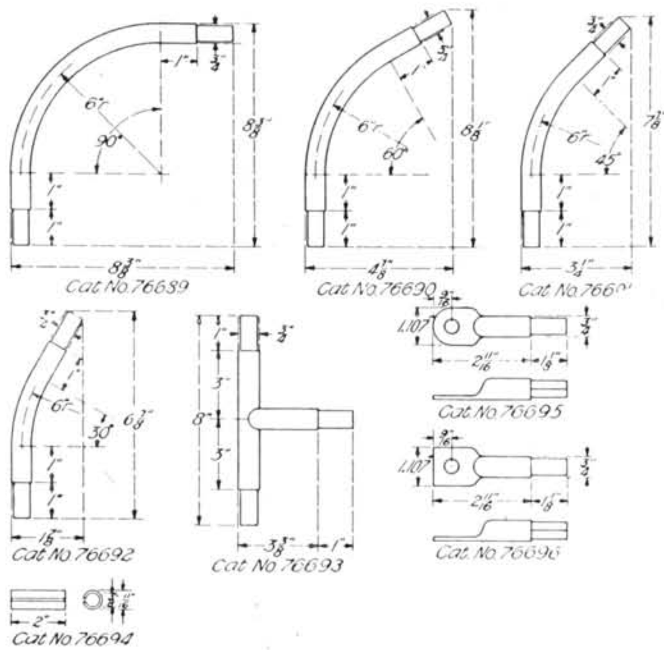
RECEPTACLE INDICATING LAMP AND LENS FOR CONTROLLING SWITCHES (PLATE IV)

Cat. No.	Description	Fig. No.
114215	Porcelain receptacle Cat. No. 40431, complete, with expansion bolts, terminals, glass tube fuse Cat. No. 36099, Type E candelabra lamp and ruby lens with holder	10
114216	Porcelain receptacle Cat. No. 40431, complete, with expansion bolts, terminals, glass tube fuse Cat. No. 36099, Type E candelabra lamp and green lens with holder	10
114217	Porcelain receptacle Cat. No. 40431, complete, with expansion bolts, terminals, glass tube fuse Cat. No. 36099, Type E candelabra lamp and white lens with holder	10
40431	Porcelain receptacle, complete, without fuse	10
114218	Porcelain receptacle Cat. No. 40431, complete, with expansion bolts and terminals	10
36795	Ruby lens and holder, complete	10
36796	Green lens and holder, complete	10
114219	White lens and holder, complete	10

PIPE CLAMPING SUPPORTS FOR POTENTIAL BUS WIRES FOR SWITCHBOARDS (PLATE IV)

Cat. No.	Pipe Diam.	No. of Wires	Fig. No.	Cat. No.	Pipe Diam.	No. of Wires	Fig. No.
133658	½	3	12	133661	½	6	11
133659	¾	3	12	133662	¾	6	11
133660	1¼	3	12	133663	1¼	6	11

COPPER TUBE CONNECTORS FOR SWITCHBOARDS



DIMENSIONS OF COPPER TUBE CONNECTORS

Cat. No.	Descriptive	Outside Diam. in Inches	Inside Diam. in Inches
76689	Bend 90 deg. 6 in. radius	$\frac{3}{4}$	$\frac{11}{16}$
76690	Bend 60 deg. 6 in. radius	$\frac{3}{4}$	$\frac{11}{16}$
76691	Bend 45 deg. 6 in. radius	$\frac{3}{4}$	$\frac{11}{16}$
76692	Bend 30 deg. 6 in. radius	$\frac{3}{4}$	$\frac{11}{16}$
76693	Tee connector	$\frac{3}{4}$	$\frac{11}{16}$
76695	Terminal (round end)	$\frac{3}{4}$	$\frac{11}{16}$
76696	Terminal (square end)	$\frac{3}{4}$	$\frac{11}{16}$
76694	Straight connector 2 in. long	$\frac{11}{16}$	$\frac{5}{8}$

BEND CONNECTORS

Cat. No.	Bend Deg.	Radius Inches	Outside Diam. in Inches	Inside Diam. in Inches
132491	30	6	$\frac{15}{16}$	.776
132492	45	6	$\frac{15}{16}$	.776
132493	60	6	$\frac{15}{16}$	.776
132494	90	6	$\frac{15}{16}$	.776
132495	30	6	$1\frac{5}{16}$	1.084
132496	45	6	$1\frac{5}{16}$	1.084
132497	60	6	$1\frac{5}{16}$	1.084
132498	90	6	$1\frac{5}{16}$	1.084

COPPER TUBE CONNECTORS FOR SWITCHBOARDS—Concluded

"T" CONNECTORS

Cat. No.	Tube Diameter in Inches		Branch Diameter in Inches	
	Outside	Inside	Outside	Inside
132499	$\frac{15}{16}$	.776	$\frac{15}{16}$	.776
132500	$\frac{15}{16}$	.776	$\frac{3}{4}$	$\frac{11}{16}$
132501	$\frac{15}{16}$	.776	Drilled for solid wire	
132502	$1\frac{5}{16}$	1.084	$1\frac{5}{16}$	1.084
132503	$1\frac{5}{16}$	1.084	$\frac{15}{16}$	.776
132504	$1\frac{5}{16}$	1.084	$\frac{3}{4}$	$\frac{11}{16}$
132505	$1\frac{5}{16}$	1.084	Drilled for solid wire	

TERMINAL CONNECTORS

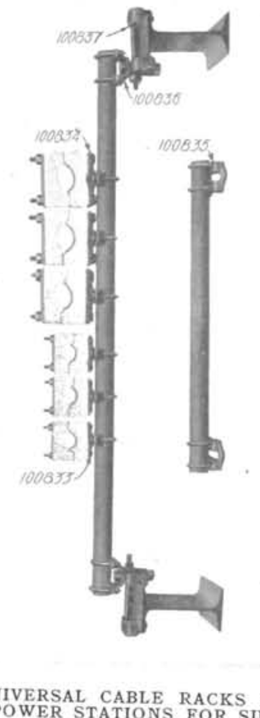
Cat. No.	Description	Outside Diam. in Inches
132509	Square end	$\frac{15}{16}$
132510	Square end	$\frac{3}{4}$
132511	Square end	$1\frac{5}{16}$
132512	Round end	$\frac{15}{16}$
132513	Round end	$\frac{3}{4}$
132514	Round end	$1\frac{5}{16}$

JOINING SLEEVES (TINNED)

Cat. No.	Length in Inches	Outside Diam. in Inches
132506	4	$\frac{15}{16}$
132507	4	$\frac{3}{4}$
132508	4	$1\frac{5}{16}$

PIPE CLAMPS

Cat. No.	Description
100833	Pipe clamp for $1\frac{1}{4}$ in. pipe, complete, with yoke and two ($\frac{5}{16}$ in.–18) nuts. For use with single-wire porcelain cleats Cat. Nos. 43288, 43289 ....
100834	Pipe clamp for $1\frac{1}{4}$ in. pipe, complete, with yoke and two ($\frac{5}{16}$ in.–18) nuts. For use with single-wire porcelain cleat Cat. No. 61574 ....
100835	Pipe clamp for fastening $1\frac{1}{4}$ in. pipe to wall, complete, with two yokes and four ($\frac{5}{16}$ in.–18) nuts ....
100836	Pipe clamp for $1\frac{1}{4}$ in. pipe, complete, with two yokes and four ($\frac{5}{16}$ in.–18) nuts. For use with I beam clamp Cat. No. 100837 ....
100837	Clamp for I beams for supporting pipe clamp Cat. No. 100836



UNIVERSAL CABLE RACKS FOR POWER STATIONS FOR SUPPORTING CABLES FROM I BEAMS OR FLAT SURFACES

4967–10 Switchboard Structural Devices

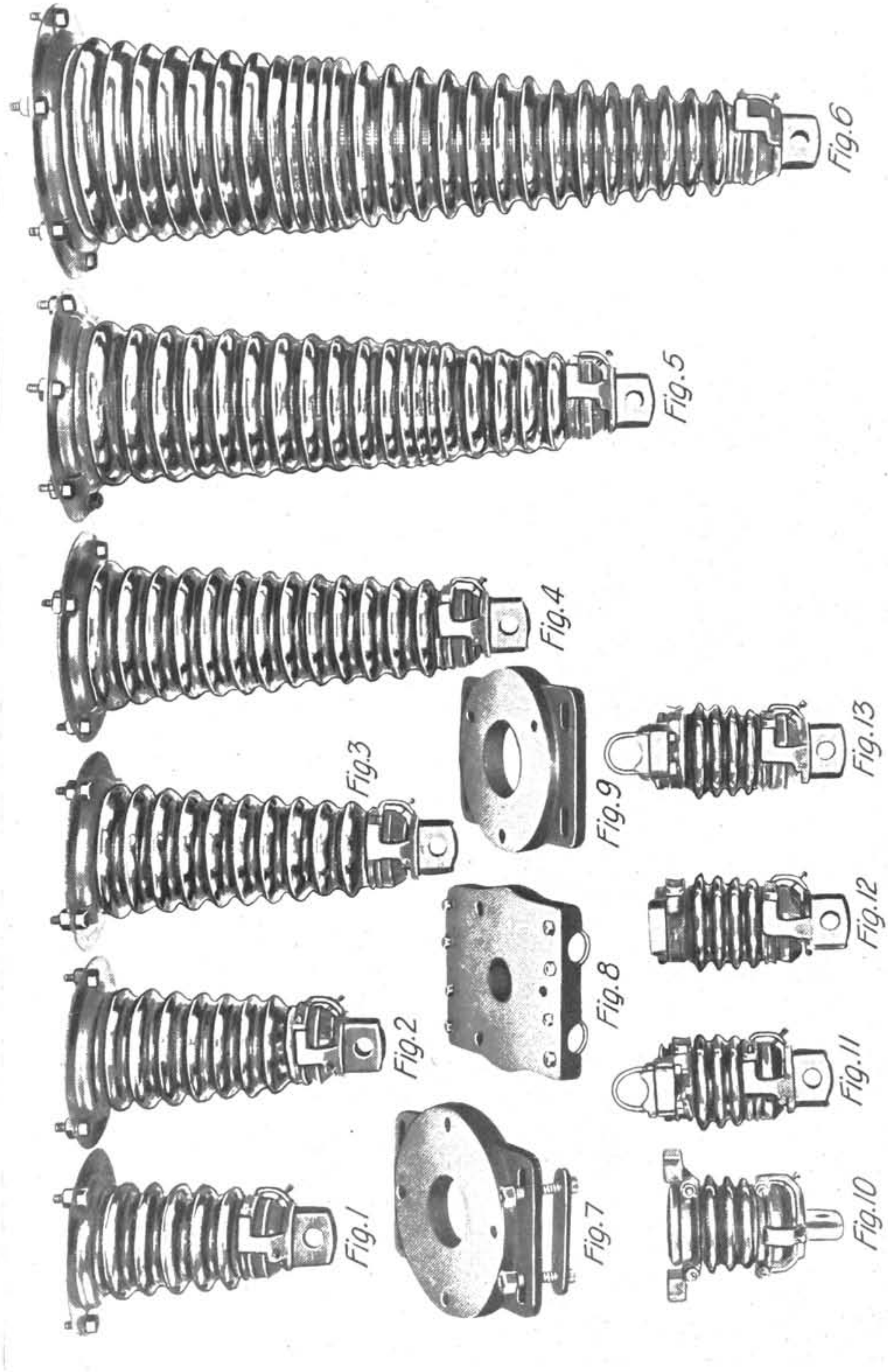


PLATE V

POST TYPE BUS WIRE AND BUS TUBE SUPPORTS FOR STATION USE (PLATE V)

Cat. No.	Voltage	For Mounting on	Fig. No.
127755	110,000	Cast iron base	6
127756	90,000	Cast iron base	5
127757	70,000	Cast iron base	4
127758	45,000	Cast iron base	3
127759	35,000	Cast iron base	2
127760	22,000	Cast iron base	1
127761	15,000	1¼ in. pipe	13
127762	15,000	Flat surface	12
127763	7,000	1¼ in. pipe	11
127764	7,000	Flat surface	10

CAST IRON BASES FOR POST TYPE BUS WIRE AND BUS TUBE SUPPORTS (PLATE V)

FOR MOUNTING ON FLAT SURFACE			FOR MOUNTING ON 1¼ IN. PIPE		
Cat. No.	Voltage	Fig. No.	Cat. No.	Voltage	Fig. No.
127765	110,000	9	127771	110,000	8
127766	90,000	9	127772	90,000	8
127767	70,000 45,000	9	127773	70,000 45,000	8
127769	35,000 22,000	9	127775	35,000 22,000	8

FOR MOUNTING ON 4 IN. CHANNEL IRON			FOR MOUNTING ON 6 IN. CHANNEL IRON		
127777	110,000	7	127783	110,000	7
127778	90,000	7	127784	90,000	7
127779	70,000 45,000	7	127785	70,000 45,000	7
127781	35,000 22,000	7	127787	35,000 22,000	7

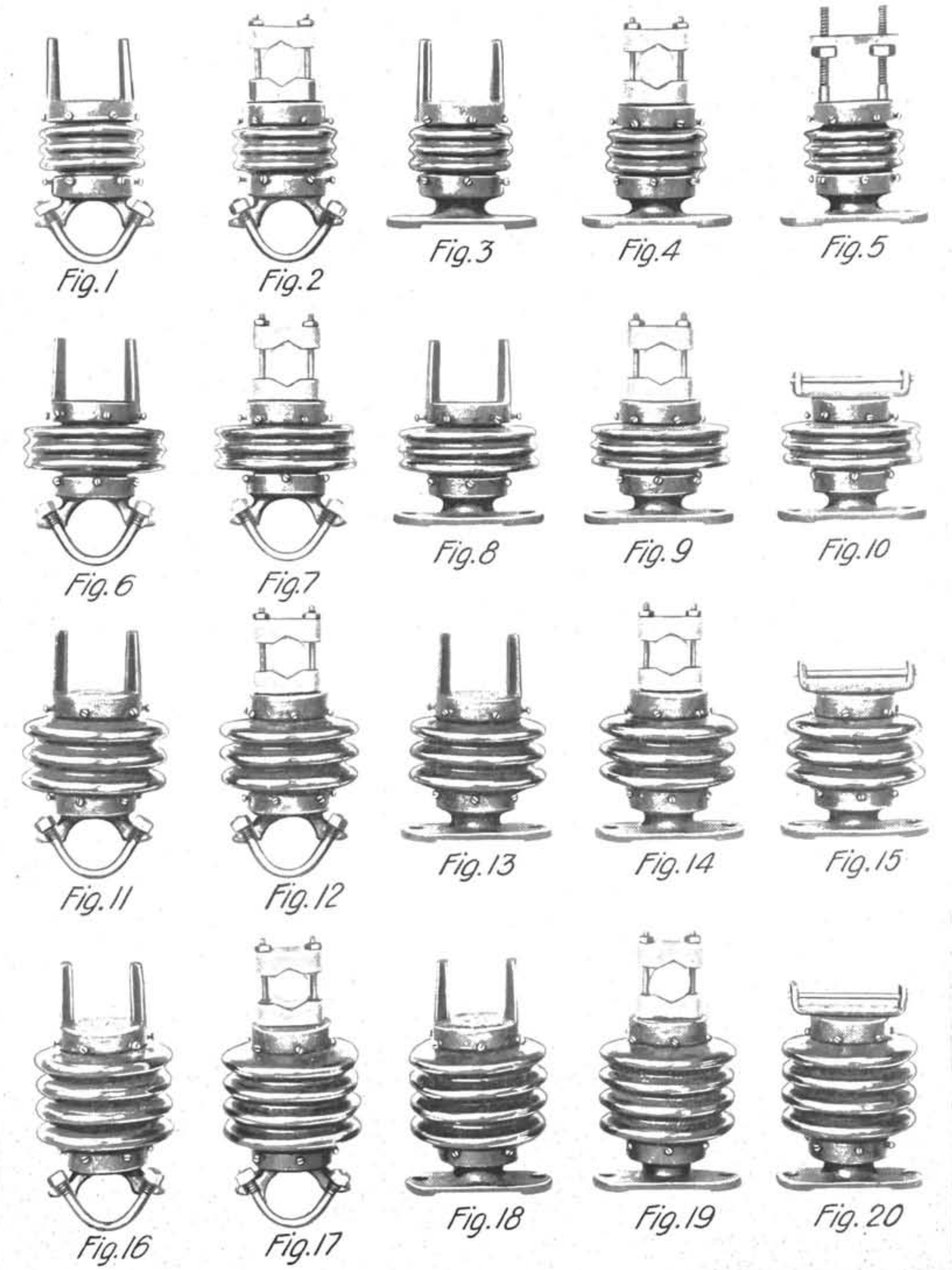

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Fig.17
Fig.18
Fig.19
Fig.20

PLATE VI

POST TYPE BUSBAR AND WIRE SUPPORTS FOR SWITCHBOARDS (PLATE VI)

BUSBAR SUPPORTS FOR MOUNTING ON PIPES, FOR ONE, TWO OR THREE BUSBARS ON EDGE

Cat. No.	Voltage	Dimensions of of Busbar in Inches	Diam. of Pipe in Inches	Fig. No.
127358	1,150	3 by ¼	1¼	1
127359	1,150	3 by ¼	¾	1
127360	1,150	5 by ¼	1¼	1
127361	1,150	5 by ¼	¾	1
127362	2,500	3 by ¼	1¼	6
127363	2,500	3 by ¼	¾	6
127364	2,500	5 by ¼	1¼	6
127365	2,500	5 by ¼	¾	6
127366	6,600	3 by ¼	1¼	11
127367	6,600	3 by ¼	¾	11
127368	6,600	5 by ¼	1¼	11
127369	6,600	5 by ¼	¾	11
127370	16,500	3 by ¼	1¼	16
127371	16,500	3 by ¼	¾	16
127372	16,500	5 by ¼	1¼	16
127373	16,500	5 by ¼	¾	16

BUSBAR SUPPORTS FOR MOUNTING ON FLAT SURFACE, FOR ONE, TWO OR THREE BUSBARS ON EDGE

127374	1,150	3 by ¼	3
127375	1,150	5 by ¼	3
127376	2,500	3 by ¼	8
127377	2,500	5 by ¼	8
127378	6,600	3 by ¼	13
127379	6,600	5 by ¼	13
127380	16,500	3 by ¼	18
127381	16,500	5 by ¼	18

BUSBAR SUPPORTS FOR MOUNTING ON FLAT SURFACE, BUSBARS LAID ON SIDE

Cat. No.	Voltage	Dimensions of Busbar in Inches	Number of Busbars	Fig. No.
127382	2,500	3 by ¼	1	10
127383	2,500	3 by ¼	2	10
127384	2,500	2 by ¼	1	10
127385	2,500	2 by ¼	2	10
127386	2,500	3 by ¼	3	10
127387	6,600	3 by ¼	1	15
127388	6,600	3 by ¼	2	15
127389	6,600	2 by ¼	1	15
127390	6,600	2 by ¼	2	15
127391	16,500	3 by ¼	1	20
127392	16,500	3 by ¼	2	20
127393	16,500	2 by ¼	1	20
127394	16,500	2 by ¼	2	20

POST TYPE BUSBAR AND WIRE SUPPORTS FOR SWITCHBOARDS—Concluded (PLATE VI)

BUS WIRE SUPPORTS FOR MOUNTING ON PIPES, FOR 1¼ INCH MAXIMUM DIAMETER CONDUCTOR

Cat. No.	Voltage	Diameter of Pipe in Inches	Fig. No.
127395	1,150	1¼	2
127396	1,150	¾	2
127397	2,500	1¼	7
127398	2,500	¾	7
127399	6,600	1¼	12
127400	6,600	¾	12
127401	16,500	1¼	17
127402	16,500	¾	17

BUS WIRE SUPPORTS FOR MOUNTING ON FLAT SURFACE, FOR 1¼ INCH MAXIMUM DIAMETER CONDUCTOR

Cat. No.	Voltage	Fig. No.	Cat. No.	Voltage	Fig. No.
127403	1,150	4	127405	6,600	14
127404	2,500	9	127406	16,500	19

STAY INSULATORS FOR BUS SECTIONALIZING SWITCHES IN BUSBAR COMPARTMENTS

Cat. No.	Voltage	Fig. No.	Cat. No.	Voltage	Fig. No.
127407	1,150	5	127409	6,600	5
127408	2,500	5	127410	16,500	5

PORCELAIN PETTICOAT INSULATORS, CAPS AND PINS FOR STATION USE (PLATE VII)

INSULATORS

Cat. No.	Voltage	Fig. No.	Cat. No.	Voltage	Fig. No.
74818	4,400	12	128536	45,000	8
100156	15,000	13	128537	66,000	10
100159	25,000	14	128538	80,000	9
128535	35,000	11			

INSULATOR CAPS, COMPLETE, WITH CLAMPING STRAPS AND NUTS

128539	4,400	7	128543	45,000	3
128540	15,000	6	128544	66,000	2
128541	25,000	5	128545	80,000	1
128542	35,000	4			

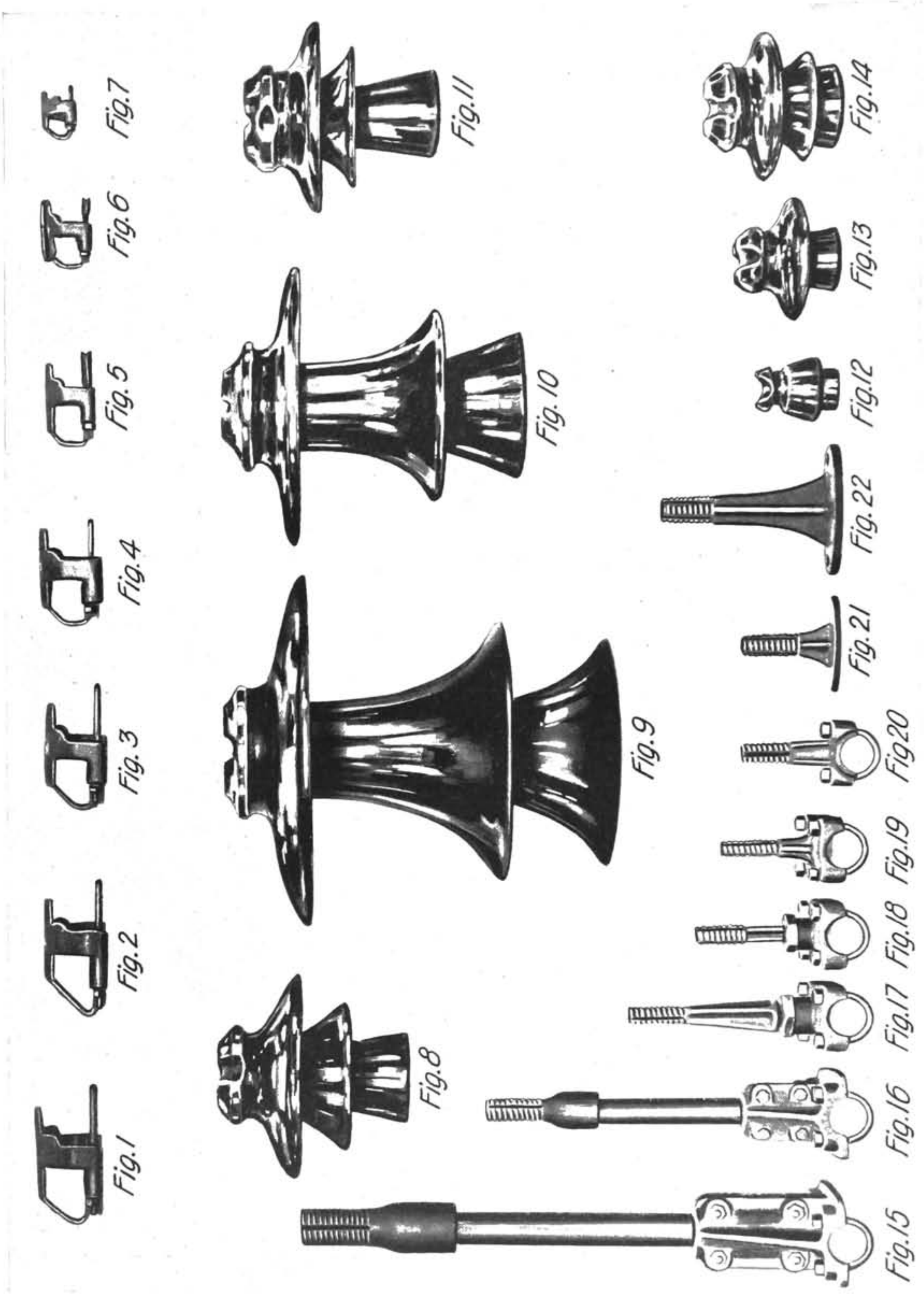
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Fig.19
Fig20
Fig.21
Fig.22

PLATE VII

PORCELAIN PETTICOAT INSULATORS, CAPS AND PINS FOR STATION USE—Concluded (PLATE VII)

INSULATOR PINS, COMPLETE, WITH YOKES AND NUTS, FOR MOUNTING ON PIPE FRAMEWORK

Cat. No.	Voltage	Diam. of Pipe in Inches	Yoke	Fig. No.
66615	4,400–15,000	¾	Single	20
66616	4,400–15,000	1¼	Single	20
128546	4,400–15,000	1¼	Double	19
128547	25,000	1¼	Double	19
128548	35,000	1¼	Double	18
128549	45,000	1¼	Double	17
128550	66,000	1¼	Double	16
128551	80,000	1¼	Double	15

INSULATOR PINS FOR MOUNTING ON FLAT SURFACE

Cat. No.	Voltage	Fig. No.
128552	4,400–15,000	21
128553	25,000	21
128554	35,000	22
128555	45,000	17 (complete, less yoke)
128556	66,000	16 (complete, less yoke)
128557	80,000	15 (complete, less yoke)

BUSBAR CLAMPS FOR CLAMPING BUSBARS TO CONNECTION BARS (PLATE VIII)

NOTE.—Catalogue numbers do not include bolts.
For direct current work two malleable iron clamps are required.
For alternating current work one malleable iron and one composition clamp are required.

Cat. No.	Width in Inches: Busbar	Width in Inches: Connection Bar	Material	Fig. No.
123350	2	1	Malleable iron	1
123351	2	1	Composition	1
123352	2	1½	Malleable iron	1
123353	2	1½	Composition	1
123354	2	2	Malleable iron	1
123355	2	2	Composition	1
123356	2	3	Malleable iron	1
123357	2	3	Composition	1
123358	3	1	Malleable iron	1
123359	3	1	Composition	1
123360	3	1½	Malleable iron	1
123361	3	1½	Composition	1
123362	3	2	Malleable iron	1
123363	3	2	Composition	1
123364	3	3	Malleable iron	1
123365	3	3	Composition	1
123366	3	4	Malleable iron	1

BUSBAR CLAMPS FOR CLAMPING BUSBARS TO CONNECTION BARS—Concluded (PLATE VIII)

NOTE—Catalogue numbers do not include bolts.
For direct current work two malleable iron clamps are required.
For alternating current work one malleable iron and one composition clamp are required.

Cat. No.	Width in Inches		Material	Fig. No.
	Busbar	Connection Bar		
123367	3	4	Composition	1
123368	5	1	Malleable iron	1
123369	5	1	Composition	1
123370	5	2	Malleable iron	1
123371	5	2	Composition	1
123372	5	3	Malleable iron	1
123373	5	3	Composition	1
123374	5	4	Malleable iron	1
123375	5	4	Composition	1
123376	5	5	Malleable iron	1
123377	5	5	Composition	1
123378	10	2	Malleable iron	1
123379	10	2	Composition	1
123380	10	3	Malleable iron	1
123381	10	3	Composition	1
123382	10	4	Malleable iron	1
123383	10	4	Composition	1
123384	10	6	Malleable iron	1
123385	10	6	Composition	1

TERMINALS FOR BUS WIRES AND BUSBARS FOR SWITCHBOARDS (PLATE VIII)

BUS WIRE TERMINALS

Cat. No.	For Bus Wire	For Branch Wires	Fig. No.
131919	No. 0 B.&S.	No. 0, No. 1 or No. 2 B.&S.	3
131920	No. 0 B.&S.	No. 3, No. 4 or No. 5 B.&S.	3
131921	No. 00 B.&S.	No. 0, No. 1 or No. 2 B.&S.	3
131922	No. 00 B.&S.	No. 3, No. 4 or No. 5 B.&S.	3
131923	No. 00 B.&S.	No. 00 B.&S.	3
131924	No. 000 B.&S.	No. 00 B.&S.	3
131925	No. 000 B.&S.	No. 0, No. 1 or No. 2 B.&S.	3
131926	No. 000 B.&S.	No. 3, No. 4 or No. 5 B.&S.	3
131927	No. 0000 B.&S.	No. 000 or No. 00 B.&S.	3
131928	No. 0000 B.&S.	No. 0, No. 1 or No. 2 B.&S.	3
131929	No. 0000 B.&S.	No. 3, No. 4 or No. 5 B.&S.	3
131930	No. 0000 B.&S.	No. 0000 B.&S.	3
131931	500,000 cir. mils	No. 0000 B.&S.	3

CLAMP TERMINALS FOR BUSBARS (PLATE VIII)

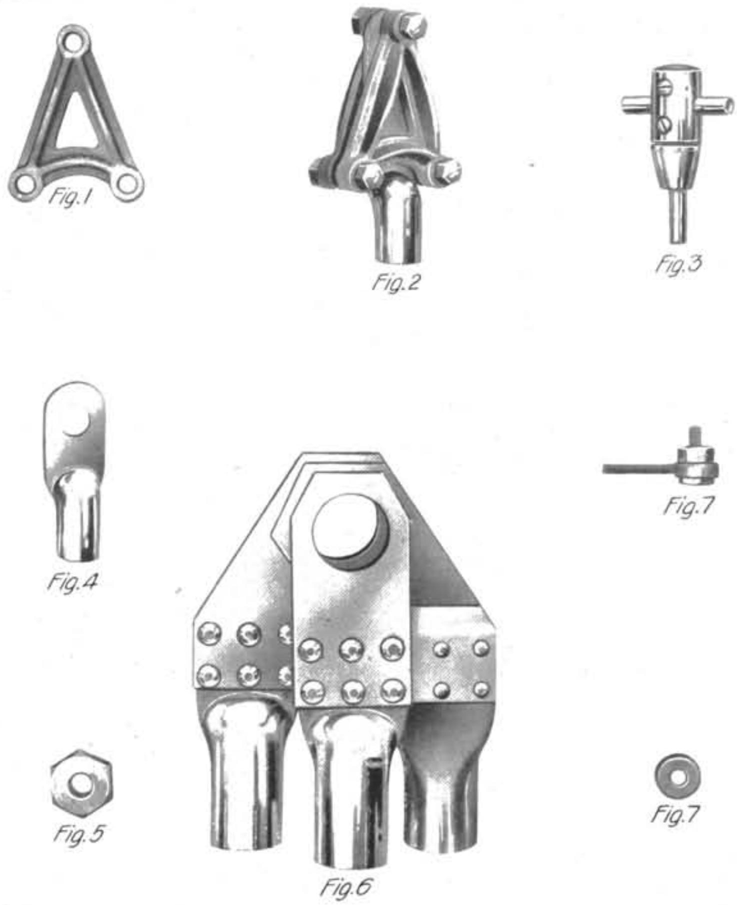

PLATE VIII

DIRECT CURRENT, TWO MALLEABLE IRON CLAMPS

Cat. No.	Width of Busbar One Lamination in Inches	Cable Size	Fig. No.
131932	2	No. 0 B.&S.	2
131933	2	No. 0000 B.&S.	2
131934	3	No. 0 B.&S.	2
131935	3	No. 0000 B.&S.	2
131936	3	1,500,000 cir. mils	2
131937	3	2,000,000 cir. mils	2
131938	5	No. 0000 B.&S.	2
131939	5	500,000 cir. mils	2
131940	5	800,000 cir. mils	2
131941	5	1,000,000 cir. mils	2
131942	5	1,500,000 cir. mils	2
131943	5	2,000,000 cir. mils	2
131944	10	500,000 cir. mils	2
131945	10	800,000 cir. mils	2
131946	10	1,000,000 cir. mils	2
131947	10	1,500,000 cir. mils	2
131948	10	2,000,000 cir. mils	2

CLAMP TERMINALS FOR BUSBARS (PLATE VIII)

ALTERNATING CURRENT, ONE MALLEABLE IRON AND ONE COMPOSITION CLAMP

Cat. No.	Width of Busbar One Lamination in Inches	Cable Size	Fig. No.
131949	2	No. 0 B.&S.	2
131950	2	No. 0000 B.&S.	2
131951	2	300,000 cir. mils	2
131952	3	No. 0 B.&S.	2
131953	3	No. 0000 B.&S.	2
131954	3	300,000 cir. mils	2
131955	3	500,000 cir. mils	2
131956	3	800,000 cir. mils	2
131957	3	1,000,000 cir. mils	2
131958	5	No. 0000 B.&S.	2
131959	5	500,000 cir. mils	2
131960	5	800,000 cir. mils	2
131961	5	1,000,000 cir. mils	2
131962	5	1,500,000 cir. mils	2
131963	5	2,000,000 cir. mils	2
131964	5	2,000,000 cir. mils rope core	2
131965	10	500,000 cir. mils	2
131966	10	800,000 cir. mils	2
131967	10	1,000,000 cir. mils	2
131968	10	1,500,000 cir. mils	2
131969	10	2,000,000 cir. mils	2

CUP WASHERS AND NUTS FOR SMALL SWITCHBOARD WIRING (PLATE VIII)

BRASS CUP WASHERS

Czt. No.	For Stud Size	Fig. No.	Cat. No.	For Stud Size	Fig. No.
131970	8–32	7	131973	$\frac{5}{16}$ in.–18	7
131971	10–32	7	131974	$\frac{3}{8}$ in.–16	7
131972	14–24	7			

HEXAGONAL BRASS NUTS CHAMFERED BOTH SIDES, FOR USE WITH CUP WASHERS (PLATE VIII)

Cat. No.	Tap	Thickness in Inches	Diam. Across Flats in Inches	Fig. No
40728	8–32	$\frac{1}{8}$	$\frac{5}{16}$	5
9962	10–32	$\frac{5}{32}$	$\frac{3}{8}$	5
21953	14–24	$\frac{3}{16}$	$\frac{1}{2}$	5
31734	$\frac{5}{16}$ in.–18	$\frac{1}{4}$	$\frac{19}{32}$	5
31735	$\frac{3}{8}$ in.–16	$\frac{3}{8}$	$\frac{25}{32}$	5

CONTACT NUTS FOR CURRENT CARRYING STUDS (PLATE VIII)

Cat. No.	Ampere Capacity of Stud	Tap	Thickness	Diameter Across Flats	Description	Material	Fig. No.
23646	30	¼ in.–20	¼	½	Hex.	Brass	5
31734	60	$\frac{5}{16}$ in.–18	¼	$\frac{19}{32}$	Hex.	Brass	5
31735	30–60 and 100	⅜ in.–16	⅜	$\frac{25}{32}$	Hex.	Brass	5
31736	200	½ in.–13	½	$1\frac{1}{16}$	Hex.	Brass	5
60170	300	⅝ in.–11	½	$1\frac{7}{16}$	Hex.	Brass	5
104756	400	¾ in.–12	⅝	1⅝	Hex.	Brass	5
104757	500	⅞ in.–12	⅝	$1\frac{13}{16}$	Hex.	Brass	5
104758	600	1 in.–12	⅝	2	Hex.	Brass	5
104759	800	1⅛ in.–12	¾	$2\frac{3}{16}$	Hex.	Brass	5
104760	1,000	1¼ in.–12	⅞	2⅜	Hex.	Brass	5
104761	1,200	1¼ in.–12	1	2⅜	Hex.	Brass	5
26971	1,500	1½ in.–12	1	2¾	Hex.	Composition	5
104762	2,000	1¾ in.–12	1	2¾	Hex.	Composition	5
104763	3,000	2 in.–12	1	3⅛	Hex.	Composition	5
26974	4,000	2½ in.–12	1	3⅞	Hex.	Composition	5
26967'	5,000	2¾ in.–12	1	3⅞	Hex.	Composition	5
104764	6,000	3¼ in.–12	1	4¼	Oct.	Composition	5
26969	8,000	4 in.–12	1	5⅜	Oct.	Composition	5
104765	10,000	4¾ in.–12	1	7⅝	Oct.	Composition	5

NOTE.—The above nuts are chamfered both sides.

TERMINALS FOR BACK CONNECTED SWITCHES AND CIRCUIT BREAKERS (PLATE VIII)

COPPER TUBE CABLE TERMINALS FOR 30 TO 1200 AMPERE BACK CONNECTED SWITCHES AND CIRCUIT BREAKERS

Cat. No.	Ampere Capacity	Diam. of Stud in Inches	Diam. of Stud Hole in Inches	Diam. of Cable Hole in Inches	Fig. No.
41076	30	$\frac{5}{16}$	$\frac{11}{32}$	0.140	4
41077	60	$\frac{5}{16}$	$\frac{11}{32}$	0.265	4
129623	100	⅜	$\frac{13}{32}$	0.140	4
103765	100	⅜	$\frac{13}{32}$	0.265	4
103766	100	⅜	$\frac{13}{32}$	0.357	4
103768	200	½	$\frac{17}{32}$	0.586	4
103769	300	⅝	$\frac{21}{32}$	0.776	4
103770	400	¾	$\frac{25}{32}$	0.881	4
129624	500	⅞	$\frac{29}{32}$	1.084	4
129625	600	1	$1\frac{1}{16}$	1.084	4
103773	800	1⅛	$1\frac{3}{16}$	1.461	4
129626	800	1⅛	$1\frac{3}{16}$	1.699	4
103774	1000	1¼	$1\frac{5}{16}$	1.461	4
103775	1200	1¼	$1\frac{5}{16}$	1.691	4
129627	1200	1¼	$1\frac{5}{16}$	2.012	4

TERMINALS FOR BACK CONNECTED SWITCHES AND CIRCUIT BREAKERS (PLATE VIII)

COPPER TUBE CABLE TERMINALS WITH CONNECTION PLATES, FOR MULTIPLE CABLES, FOR 1500 TO 10,000 AMPERE BACK CONNECTED SWITCHES AND CIRCUIT BREAKERS

Cat. No.	Diam. of Stud in Inches	Size of Cable	Description of Terminal Straight	Fig. No.
104958	1½	1,000,000 cir. mils	Straight	6
104959	1½	1,500,000 cir. mils	Straight	6
104960	1¾	1,500,000 cir. mils	Straight	6
104961	1¾	2,000,000 cir. mils	Straight	6
104962	2	1,000,000 cir. mils	Straight	6
104963	2	1,500,000 cir. mils	Straight	6
104964	2	2,000,000 cir. mils	Straight	6
104965	2½	1,000,000 cir. mils	Straight	6
104966	2½	1,500,000 cir. mils	Straight	6
104967	2½	2,000,000 cir. mils	Straight	6
104968	2¾	1,500,000 cir. mils	Straight	6
104969	2¾	2,000,000 cir. mils	Straight	6
104970	3¼	1,000,000 cir. mils	Straight	6
104971	3¼	1,500,000 cir. mils	Straight	6
104972	3¼	2,000,000 cir. mils	Straight	6
104973	4	1,500,000 cir. mils	Straight	6
104974	4	2,000,000 cir. mils	Straight	6
104975	4¾	1,500,000 cir. mils	Straight	6
104976	4¾	2,000,000 cir. mils	Straight	6
104977	1½	1,000,000 cir. mils	Offset	6
104978	1½	1,500,000 cir. mils	Offset	6
104979	1¾	1,500,000 cir. mils	Offset	6
104980	1¾	2,000,000 cir. mils	Offset	6
104981	2	1,000,000 cir. mils	Offset	6
104982	2	1,500,000 cir. mils	Offset	6
104983	2	2,000,000 cir. mils	Offset	6
104984	2½	1,000,000 cir. mils	Offset	6
104985	2½	1,500,000 cir. mils	Offset	6
104986	2½	2,000,000 cir. mils	Offset	6
104987	2¾	1,500,000 cir. mils	Offset	6
104988	2¾	2,000,000 cir. mils	Offset	6
104989	3¼	1,000,000 cir. mils	Offset	6
104990	3¼	1,500,000 cir. mils	Offset	6
104991	3¼	2,000,000 cir. mils	Offset	6
104992	4	1,500,000 cir. mils	Offset	6
104993	4	2,000,000 cir. mils	Offset	6
104994	4¾	1,500,000 cir. mils	Offset	6
104995	4¾	2,000,000 cir. mils	Offset	6

4967–22 Switchboard Structural Devices

PUNCHED AND DROP FORGED COPPER CABLE TERMINALS, FOR WIRING DEVICES AND PANEL BOARDS (PLATE IX)


Fig. 1


Fig 2


Fig. 3


Fig. 4


Fig. 5


Fig. 6


Fig. 7


Fig. 8


Fig. 9

PLATE IX

TERMINALS WITH ROUNDED ENDS AND ONE STUD HOLE, FOR MOUNTING ON CURRENT CARRYING STUDS

Cat. No.	Ampere Capacity on Rubber Covered Feeder Circuits	Max. Wire	Size B.&S. Cable	Diam. of Stud Hole in Inches	Width of Contact in Inches	Length in Inches	Fig. No.
41074	17	12	12	$\frac{17}{64}$	$\frac{1}{2}$	$\frac{7}{8}$	3
32534	33	8	10	$\frac{5}{32}$	0.263	$\frac{11}{16}$	3
41075	33	8	10	$\frac{17}{64}$	$\frac{1}{2}$	1	3
41082	33	8	10	$\frac{11}{32}$	$\frac{5}{8}$	$1\frac{1}{16}$	3
41076	33	8	10	$\frac{11}{32}$	$\frac{3}{4}$	$1\frac{5}{16}$	3
41078	33	8	10	$\frac{17}{32}$	1	$1\frac{5}{8}$	3
32535	50	5	6	$\frac{3}{16}$	0.356	$\frac{15}{16}$	3
41081	50	5	6	$\frac{11}{32}$	$\frac{5}{8}$	$1\frac{1}{4}$	3
41080	50	5	6	$\frac{11}{32}$	$\frac{3}{4}$	$1\frac{5}{16}$	3
32536	75	3	4	$\frac{7}{32}$	0.464	$1\frac{1}{8}$	3
48332	75	3	4	$\frac{7}{32}$	0.464	$\frac{5}{8}$	9
51878	75	3	4	$\frac{11}{32}$	0.464	$1\frac{1}{16}$	9
41077	90	2	3	$\frac{11}{32}$	$\frac{3}{4}$	$1\frac{1}{2}$	3
41079	90	2	3	$\frac{17}{32}$	1	$1\frac{13}{16}$	3
32537	125	0	1	$\frac{9}{32}$	0.639	$1\frac{15}{16}$	3
32538	175	000	0	$\frac{11}{32}$	0.744	$2\frac{1}{16}$	3
36031	175	000	00	$\frac{13}{32}$	0.818	$2\frac{1}{8}$	3
32539	210	0000	0000	$\frac{13}{32}$	1.026	$2\frac{5}{8}$	3
51879	210	0000	0000	$\frac{17}{32}$	1.026	2	8
32540	225		250,000 cir. mils	$\frac{17}{32}$	1.107	$2\frac{11}{16}$	3
32541	250		300,000 cir. mils	$\frac{17}{32}$	1.199	$3\frac{3}{16}$	3
51880	325		400,000 cir. mils	$\frac{21}{32}$	1.379	$2\frac{1}{2}$	8
32542	325		400,000 cir. mils	$\frac{17}{32}$	1.379	$3\frac{5}{8}$	3
32543	375		500,000 cir. mils	$\frac{21}{32}$	1.573	$4\frac{5}{32}$	3
32544	450		600,000 cir. mils	$\frac{21}{32}$	1.670	$4\frac{15}{32}$	3
32545	550		800,000 cir. mils	$\frac{25}{32}$	1.960	$5\frac{1}{16}$	3
47319	550		800,000 cir. mils	$\frac{25}{32}$	2	$3\frac{1}{2}$	8
32546	650		1,000,000 cir. mils	$\frac{29}{32}$	2.190	$5\frac{3}{8}$	3
32547	850		1,500,000 cir. mils	$1\frac{1}{32}$	2.660	$6\frac{19}{32}$	3
32548	1050		2,000,000 cir. mils	$1\frac{1}{32}$	3.03	$7\frac{5}{8}$	3

PRICE SUPPLEMENT

TO ACCOMPANY BULLETIN No. 4967

Switchboard Structural Devices

July, 1912

NOTE—Prices subject to change without notice.

CAT. NO. PAGE	LIST PRICE	CAT. NO. PAGE	LIST PRICE	CAT. NO. PAGE	LIST PRICE	CAT. NO. PAGE	LIST PRICE
9962-19 per 100	$0.50	36051—23 per 100	$81.00	104756—20 per 100	$32.00	123363—16 each	$0.60
21953—19 per 100	1.20	36052—24 per 100	81.00	104757—20 per 100	42.00	123364—16 each	.25
23646—20 per 100	2.50	36053—24 per 100	82.50	104758—20 per 100	54.00	123365—16 each	.95
24998—6 each	.30	36054—23 per 100	112.00	104759—20 per 100	72.00	123366—16 each	.30
26967—20 each	3.25	36055—24 per 100	110.00	104760—20 per 100	94.00	123367—17 each	1.00
26969—20 per 100	585.00	36056—24 per 100	137.00	104761—20 per 100	118.00	123368—17 each	.20
26971—20 per 100	165.00	36057—23 per 100	175.00	104762—20 per 100	170.00	123369—17 each	.50
26974—20 per 100	265.00	36058—24 per 100	176.00	104763—20 per 100	175.00	123370—17 each	.30
31734—19,20 per 100	3.00	36059—24 per 100	230.00	104764—20 per 100	415.00	123371—17 each	.95
31735—19,20 per 100	5.50	36060—23 per 100	285.00	104765—20 per 100	825.00	123372—17 each	.45
31736—20 each	.20	36061—24 per 100	285.00	104958—21 each	2.60	123373—17 each	1.75
32534—22 per 100	4.00	36795—7 each	1.45	104959—21 each	3.00	123374—17 each	.50
32535—22 per 100	4.50	36796—7 each	1.10	104960—21 each	3.00	123375—17 each	1.95
32536—22 per 100	6.00	40431—7 each	.30	104961—21 each	3.80	123376—17 each	.50
32537—22 per 100	7.50	40728—19 per 100	.35	104962—21 each	2.90	123377—17 each	2.15
32538—22 per 100	8.50	41071—23 per 100	4.00	104963—21 each	3.40	123378—17 each	.50
32539—22 per 100	16 00	41072—23 per 100	5.00	104964—21 each	3.90	123379—17 each	1.90
32540—22 per 100	22.50	41073—23 per 100	7.00	104965—21 each	3.20	123380—17 each	.70
32541—22 per 100	25.00	41074—22 per 100	4.00	104966—21 each	3.70	123381—17 each	2.70
32542—22 per 100	35.00	41075—22 per 100	4.25	104967—21 each	4.40	123382—17 each	1.05
32543—22 per 100	48.50	41076—20,22 per 100	4.50	104968—21 each	4.60	123383—17 each	4.15
32544—22 per 100	55.00	41077—20,22 per 100	6.50	104969—21 each	5.50	123384—17 each	1.15
32545—22 per 100	66.50	41078—22 per 100	6.25	104970—21 each	3.60	123385—17 each	4.55
32546—22 per 100	82.50	41079—22 per 100	7.25	104971—21 each	4.00	125551—6 each	.20
32547—22 per 100	135.00	41080—22 per 100	6.00	104972—21 each	4.70	125552—6 each	.15
32548—22 per 100	230.00	41081—22 per 100	4.50	104973—21 each	4.70	127358—13 each	1.20
32549—23 per 100	6.00	41082—22 per 100	4.25	104974—21 each	5.50	127359—13 each	1.15
32550—23 each	.08	47319—22 per 100	66.50	104975—21 each	6.60	127360—13 each	1.25
32551—23 each	.15	48332—22 per 100	6.00	104976—21 each	7.30	127361—13 each	1.20
32552—23 per 100	12.00	51878—22 per 100	6.00	104977—21 each	3.00	127362—13 each	1.35
32553—24 per 100	35.00	51879—22 per 100	20.00	104978—21 each	3.70	127363—13 each	1.30
32554—24 each	.80	51880—22 per 100	41.00	104979—21 each	3.70	127364—13 each	1.45
32555—24 per 100	135.00	51881—24 per 100	7.50	104980—21 each	4.60	127365—13 each	1.40
32556—23 per 100	15 00	51882—24 per 100	8.30	104981—21 each	3.30	127366—13 each	2.50
36019—23 per 100	4.00	51883—23 per 100	15.00	104982—21 each	3.80	127367—13 each	2.45
36020—23 per 100	5.00	51884—23 each	.35	104983—21 each	4.80	127368—13 each	2.60
36021—24 per 100	5.00	51885—23 per 100	34.50	104984—21 each	3.70	127369—13 each	2.55
36022—23 per 100	5 00	60170—20 per 100	18.00	104985—21 each	4.10	127370—13 each	2.55
36023—23 per 100	7.00	64456—23 per 100	8.00	104986—21 each	5.00	127371—13 each	2.50
36024—24 per 100	7 00	64457—24 per 100	8.00	104987—21 each	7.00	127372—13 each	2.65
36025—23 per 100	8.00	66615—16 each	.36	104988—21 each	8.00	127373—13 each	2.60
36026—24 per 100	8.00	66616—16 each	.40	104989—21 each	3.90	127374—13 each	1.20
36027—23 per 100	9.25	74818—14 per 100 net	4.66	104990—21 each	4.40	127375—13 each	1.25
36028—24 per 100	9.50	76689—8 each net	.30	104991—21 each	5.20	127376—13 each	1.35
36029—23 per 100	10.00	76690—8 each net	.30	104992—21 each	4.90	127377—13 each	1.40
36030—24 per 100	10.00	76691—8 each net	.30	104993—21 each	5.90	127378—13 each	2.50
36031—22 per 100	12.00	76692—8 each net	.25	104994—21 each	6.40	127379—13 each	2.60
36032—23 per 100	12.00	76693—8 each net	.35	104995—21 each	7.00	127380—13 each	2.55
36033—23 per 100	16.00	76694—8 each net	.05	114215—7 each	2.75	127381—13 each	2.65
36034—24 per 100	15.50	76695—8 each net	.20	114216—7 each	2.50	127382—13 each	2.20
36035—23 per 100	20.00	76696—8 each net	.20	114217—7 each	2.50	127383—13 each	2.20
36036—24 per 100	20.00	100156—14 per 100 net	16.81	114218—7 each	.65	127384—13 each	2.15
36037—23 per 100	26.50	100159—14 per 100 net	29.97	114219—7 each	1.10	127385—13 each	2.15
36038—24 per 100	26.50	100833—9 each	.18	123350—16 each	.10	127386—13 each	2.25
36039—23 per 100	25.00	100834—9 each	.25	123351—16 each	.30	127387—13 each	3.30
36040—23 per 100	28.50	100835—9 each	.35	123352—16 each	.12	127388—13 each	3.30
36041—24 per 100	28.50	100836—9 each	.30	123353—16 each	.35	127389—13 each	3.25
36042—23 per 100	45.00	100837—9 each	.18	123354—16 each	.15	127390—13 each	3.25
36043—24 per 100	45.00	103765—20 per 100	6.50	123355—16 each	.40	127391—13 each	3.40
36044—24 per 100	48 50	103766—20 per 100	7.50	123356—16 each	.20	127392—13 each	3.40
36045—23 per 100	65.00	103768—20 per 100	15.00	123357—16 each	.45	127393—13 each	3.35
36046—24 per 100	65.00	103769—20 per 100	33.50	123358—16 each	.12	127394—13 each	3.35
36047—24 per 100	54.50	103770—20 per 100	48.00	123359—16 each	.35	127395—14 each	1.65
36048—23 per 100	66.50	103773—20 per 100	148.00	123360—16 each	.15	127396—14 each	1.55
36049—24 per 100	66.50	103774—20 per 100	148.00	123361—16 each	.55	127397—14 each	1.75
36050—24 each	1.20	103775—20 per 100	250.00	123362—16 each	.20	127398—14 each	1.65

PRICE SUPPLEMENT TO ACCOMPANY BULLETIN NO. 4967

CAT. NO. PAGE	LIST PRICE
127399 14........each	$2.80
127400 14........each	2.70
127401 14........each	2.95
127402—14........each	2.85
127403—14........each	1.60
127404—14........each	1.75
127405—14........each	2.90
127406—14........each	3.00
127407 14........each	1.75
127408 14........each	1.90
127409 14........each	3.00
127410 14........each	3.10
127755 11........each	47.00
127756—11........each	31.00
127757—11........each	25.50
127758—11........each	17.50
127759—11........each	14.00
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127761—11........each	9.50
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127763—11........each	7.00
127764—11........each	6.50
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127766—11........each	3.60
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127769—11........each	3.00
127771—11........each	5.50
127772—11........each	4.75
127773—11........each	4.00
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127777—11........each	6.50
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127779—11........each	6.00
127781—11........each	5.75
127783—11........each	6.75
127784—11........each	6.50
127785—11........each	6.25
127787—11........each	6.00
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128536—14...per 100 net	64.80
128537—14...per 100 net	149.85
128538—14...per 100 net	346.50
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128543—14........each	1.50
128544—14........each	1.55
128545—14........each	1.60
128546—16........each	.65
128547—16........each	1.50
128548—16........each	2.00
128549—16........each	2.65
128550—16........each	3.10
128551—16........each	4.00
128552—16........each	.40
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128554—16........each	.95
128555—16........each	2.50
128556—16........each	2.90
128557—16........each	3.75
129623—20......per 100	4.50
129624—20......per 100	72.00
129625 20......per 100	72.00
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131924—17........each	.80
131925—17........each	.80
131926—17........each	.80
131927 17........each	.80
131928—17........each	.80
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131934—18........each	.55
131935 18........each	.65
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131937—18........each	3.30
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131939 18........each	1.55
131940—18........each	1.90
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131942—18........each	3.25
131943 18........each	4.45
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131946—18........each	3.70
131947—18........each	7.80
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131955—19........each	1.50
131956—19........each	1.80
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131958—19........each	1.15
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131962—19........each	4.55
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131964—19........each	6.75
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131967—19........each	5.70
131968—19........each	6.80
131969—19........each	8.55
131970—19......per 100	3.50
131971—19......per 100	10.00
131972—19......per 100	10.25
131973—19......per 100	15.50
131974—19......per 100	24.00
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132354 7........each	1.70
132355—7........each	1.90
132356—7........each	2.10
132357 7........each	2.30
132358—7........each	2.50
132359 7........each	2.70
132360—7........each	2.90
132361—7........each	1.30
132362—7........each	2.00
132363—7......per 100	.95
132364 7......per 100	1.15
132365 7......per 100	1.35
132366—7......per 100	$1.55
132367—7......per 100	1.75
132368—7......per 100	1.95
132369—7......per 100	2.15
132370—7......per 100	2.35
132371—7......per 100	2.55
132372—7......per 100	2.75
132373—6......per 100	1.70
132374—6......per 100	1.70
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132408—3........each	.90
132409—3........each	.85
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132411—3........each	.45
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132414—3........each	.30
132415—3........each	.20
132416—3........each	.25
132417—3........each	.10
132418—3........each	.35
132419—3........each	.25
132420—3........each	.25
132421—3........each	.20
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132433—3........each	.30
132434—3........each	.30
132435—3........each	.30
132436—3........each	$0.30
132437—3........each	.25
132438—3........each	.25
132439—3........each	.25
132440—3........each	.30
132441—3........each	.30
132442—3........each	.30
132443—3........each	.30
132444—3........each	.45
132445—4........each	.45
132446—4........each	.45
132447—4........each	.55
132448—4........each	.55
132449—4........each	.55
132450—5........each	.25
132451—5........each	.25
132452—5........each	.40
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132454—6........each	.40
132455—6........each	.40
132456—6........each	.55
132457—6........each	1.15
132458—6........each	.55
132459—6........each	1.15
132460—6........each	.40
132461—6........each	.25
132462—6........each	.70
132463—6........each	.60
132464—6........each	.75
132465—6........each	.70
132466—6........each	.80
132467—6........each	.45
132468—6........each	4.40
132469—6......per 100	2.00
132470—6......per 100	1.50
132471—6......per 100	1.00
132491—8........each	1.85
132492—8........each	2.00
132493—8........each	2.05
132494—8........each	2.25
132495—8........each	2.35
132496—8........each	2.50
132497—8........each	2.70
132498—8........each	3.00
132499—9........each	2.40
132500—9........each	2.50
132501—9........each	2.65
132502—9........each	3.30
132503—9........each	3.05
132504—9........each	2.95
132505—9........each	3.10
132506—9........each	.25
132507—9........each	.25
132508—9........each	.35
132509—9........each	.65
132510—9........each	.55
132511—9........each	1.15
132512—9........each	.65
132513—9........each	.55
132514—9........each	1.15
133657—6........each	1.75
133658—7........each	.40
133659—7........each	.45
133660—7........each	.50
133661—7........each	.75
133662—7........each	.85
133663—7........each	.95

PUNCHED AND DROP FORGED COPPER CABLE TERMINALS, FOR WIRING DEVICES AND PANEL BOARDS (PLATE IX)—Continued

TERMINALS WITH ROUNDED ENDS AND TWO STUD HOLES, FOR MOUNTING ON CURRENT CARRYING STUDS

Cat. No.	Amperes Capacity on Rubber Covered Feeder Circuits	Max. Wire	Size B.&S. Cable	Diam. of Stud Hole in Inches	Width of Contact in Inches	Length in Inches	Fig. No
36020	33	8	10	5/32	0.263	1 1/16	1
36023	50	5	6	3/16	0.356	1 3/8	1
36025	75	3	4	7/32	0.464	1 5/8	1
64456	75	3	4	1/4	0.546	2	1
36027	125	0	1	9/32	0.639	2 5/16	1
36029	175	000	0	11/32	0.744	2 3/4	1
36033	175	000	00	13/32	0.818	3 1/8	1
36035	210	0000	0000	13/32	1.026	3 1/2	1
36037	225		250,000 cir. mils	17/32	1.107	3 15/16	1
36040	250		300,000 cir. mils	17/32	1.199	4 1/8	1
36042	325		400,000 cir. mils	17/32	1.379	4 11/16	1
36045	375		500,000 cir. mils	21/32	1.573	5 5/16	1
36048	450		600,000 cir. mils	21/32	1.670	5 5/8	1
36051	550		800,000 cir. mils	25/32	1.96	6 1/2	1
36054	650		1,000,000 cir. mils	29/32	2.19	7 1/4	1
36057	850		1,500,000 cir. mils	1 1/32	2.66	8 5/8	1
36060	1050		2,000,000 cir. mils	1 1/32	3.03	9 1/2	1

TERMINALS WITH SQUARED ENDS AND ONE STUD HOLE, FOR BOLTING TO FLAT SURFACES

36019	33	8	10	5/32	0.263	11/16	4
41071	33	8	10	0.1695	1/2	7/8	4
36022	50	5	6	3/16	0.356	15/16	4
41072	50	5	6	0.196	5/8	1 1/4	4
32549	75	3	4	7/32	0.464	1 1/8	4
41073	90	2	3	17/64	3/4	1 9/16	4
32550	125	0	1	9/32	0.639	1 15/16	4
32551	175	000	0	11/32	0.744	2 1/16	4
36032	175	000	00	13/32	0.818	2 1/8	4
32552	200	0000	0000	11/32	7/8	2 3/8	4
51883	210	0000	0000	13/32	1.026	2 5/8	4
32556	210		250,000 cir. mils	13/32	1	2 9/16	4
51884	225		250,000 cir. mils	17/32	1.107	2 11/16	4
36039	250		300,000 cir. mils	17/32	1.199	3 3/16	4
51885	325		400,000 cir. mils	17/32	1.379	3 5/8	4

PUNCHED AND DROP FORGED COPPER CABLE TERMINALS, FOR WIRING DEVICES AND PANELS (PLATE IX)—Concluded

TERMINALS WITH SQUARED ENDS AND ONE STUD HOLE, FOR BOLTING TO FLAT SURFACES

Cat. No.	Amperes Capacity on Rubber Covered Feeder Circuits	Max. Wire	Size B.&S. Cable	Diam. of Stud Hole in Inches	Width of Contact in Inches	Length in Inches	Fig. No.
32553	325	...	400,000 cir. mils	$\frac{13}{32}$	1	3	5
36044	375	...	500,000 cir. mils	$\frac{21}{32}$	1.573	$4\frac{5}{32}$	4
36047	450	...	600,000 cir. mils	$\frac{21}{32}$	1.67	$4\frac{15}{32}$	4
32554	450	...	600,000 cir. mils	$\frac{13}{32}$	$1\frac{3}{8}$	$3\frac{7}{8}$	5
36050	550	...	800,000 cir. mils	$\frac{25}{32}$	1.96	$5\frac{1}{16}$	4
36053	650	...	1,000,000 cir. mils	$\frac{29}{32}$	2.19	$5\frac{3}{8}$	4
36056	850	...	1,500,000 cir. mils	$1\frac{1}{32}$	2.66	$6\frac{19}{32}$	4
32555	850	...	1,500,000 cir. mils	$\frac{17}{32}$	2	$5\frac{5}{8}$	5
36059	1050	...	2,000,000 cir. mils	$1\frac{1}{32}$	3.03	$7\frac{5}{8}$	4

TERMINALS WITH SQUARED ENDS AND TWO STUD HOLES, FOR BOLTING TO FLAT SURFACES

36021	33	8	10	$\frac{5}{32}$	0.263	$1\frac{1}{16}$	2
36024	50	5	6	$\frac{3}{16}$	0.356	$1\frac{3}{8}$	2
36026	75	3	4	$\frac{7}{32}$	0.464	$1\frac{5}{8}$	2
64457	75	3	4	$\frac{1}{4}$	0.546	2	2
51881	75	3	4	$\frac{7}{32}$	$\frac{7}{16}$	$2\frac{1}{8}$	*7
36028	125	0	1	$\frac{9}{32}$	0.639	$2\frac{5}{16}$	2
51882	125	0	1	0.136	0.639	$1\frac{15}{16}$	6
36030	175	000	0	$\frac{11}{32}$	0.744	$2\frac{3}{4}$	2
36034	175	000	00	$\frac{13}{32}$	0.818	$3\frac{1}{8}$	2
36036	210	0000	0000	$\frac{13}{32}$	1.026	$3\frac{1}{2}$	2
36038	225		250,000 cir. mils	$\frac{13}{32}$	1.107	$3\frac{15}{16}$	2
36041	250		300,000 cir. mils	$\frac{17}{32}$	1.199	$4\frac{1}{8}$	2
36043	325		400,000 cir. mils	$\frac{17}{32}$	1.379	$4\frac{11}{16}$	2
36046	375		500,000 cir. mils	$\frac{21}{32}$	1.573	$5\frac{5}{16}$	2
36049	450		600,000 cir. mils	$\frac{21}{32}$	1.67	$5\frac{5}{8}$	2
36052	550		800,000 cir. mils	$\frac{25}{32}$	1.96	$6\frac{1}{2}$	2
36055	650		1,000,000 cir. mils	$\frac{29}{32}$	2.19	$7\frac{1}{4}$	2
36058	850		1,500,000 cir. mils	$1\frac{1}{32}$	2.66	$8\frac{5}{8}$	2
36061	1050		2,000,000 cir. mils	$1\frac{1}{32}$	3.03	$9\frac{1}{2}$	2

*Except has two stud holes.

General Electric Company
Schenectady, N.Y.

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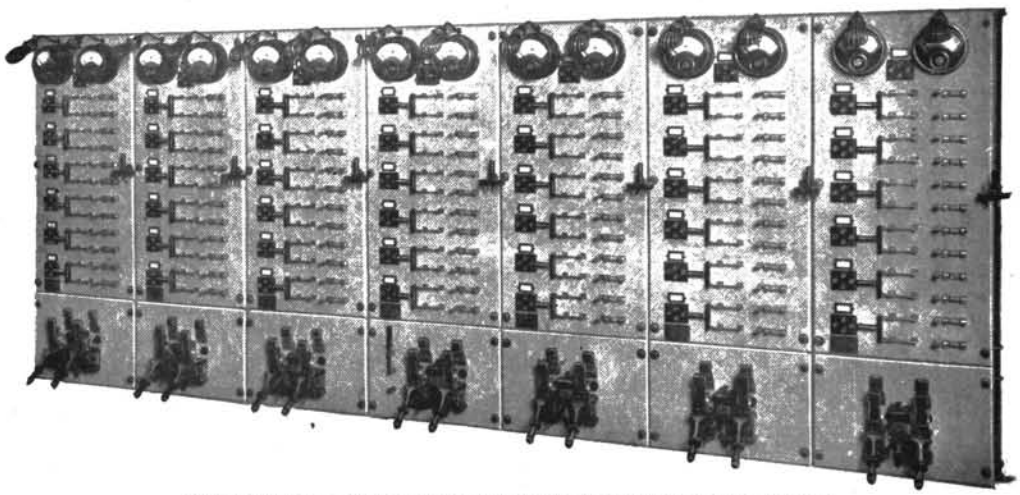
ELECTRIC AUTOMOBILE APPLIANCES

The devices described in this bulletin which are for use on or in connection with electric automobiles, are of the highest quality, and are admirably suited to the conditions for which they were designed.

Intending purchasers, if requiring further information, are requested to furnish data as nearly complete as possible, in order that the devices best suited to the conditions may be recommended. The General Electric Company is prepared to quote on special apparatus if, for any reason, the devices here listed will not meet certain conditions.



FRONT VIEW 42 CIRCUIT VEHICLE BATTERY-CHARGING BOARD

METHODS OF CHARGING

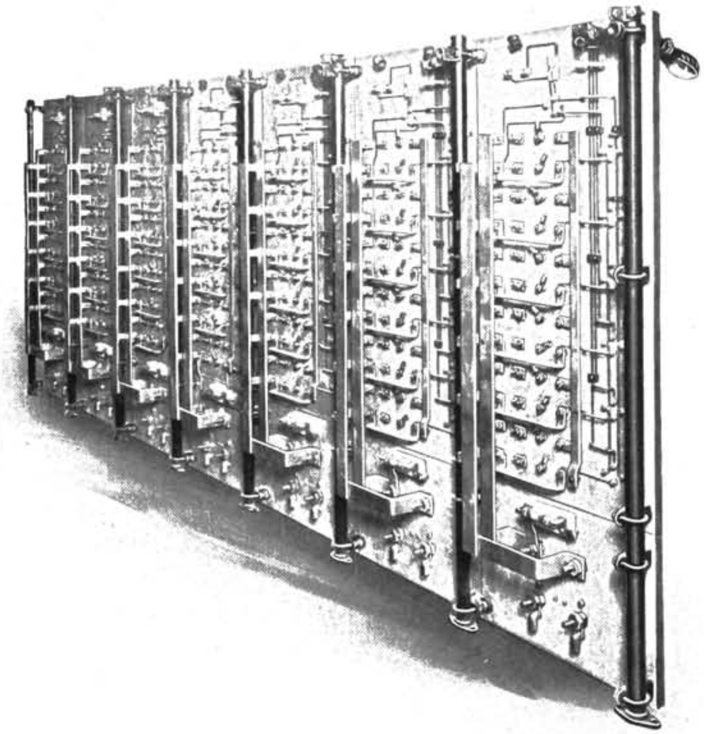
Where direct current is available from the central station at approximately 110 volts two-wire, or 110/220 volts three-wire, batteries may be charged directly through charging rheostats. Where the voltage is 220 direct or over, a motor-generator set should be used to deliver the lower voltage required for the battery as the use of charging rheostats alone would result in too great a waste of power. Ordinarily, however, the current supplied by the central station is alternating and in such cases converting apparatus is necessary, which may consist either of a motor-generator-set with alternating current motor and direct current generator, or of a mercury arc rectifier outfit. In all cases, switchboard apparatus is required in addition to the charging rheostats and such converting appliances as may be necessary. The General Electric Company has, therefore, standardized a complete line of panels which will be found to be extremely well adapted to ordinary conditions.

No panels are catalogued for the control of motor-generator sets as the range of require-

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

* *Supersedes Bulletin No. 4772.*

ments for these is very wide, but the company is prepared to submit complete special estimates on equipments to suit particular cases.



BACK VIEW 42 CIRCUIT VEHICLE BATTERY-CHARGING BOARD

BATTERY-CHARGING PANELS GENERAL

Equipment

The apparatus equipment of the panels listed in this bulletin are of the highest grade manufactured. The various types of appliances used on the different panels are referred to under the panel descriptions, but details and illustrations are given in a separate section of this bulletin, or in other bulletins which may be obtained on application to any of the offices of the General Electric Company.

Material—Supports and Finish

All of the panels herein listed are of marine finished slate 1½ in. thick with ⅜ in. bevel, and, unless otherwise ordered, are mounted on a self supporting pipe framework of ¾ in. or 1¼ in. pipe. The instruments furnished with the panels have a dull black finish, all live parts on the front of the panels are polished and lacquered, and the pipe supports are black japanned. Blue Vermont marble or natural black slate may be substituted at moderate increase in price.

Connections

Panels are shipped complete with all inter-connections between apparatus mounted on the panel. No connecting leads to lines or apparatus located away from the panels are included in the catalogue numbers, but panels are furnished with all necessary terminal lugs for attaching such leads.

CHARGING PANELS FOR DIRECT CURRENT SERVICE

These panels are designed for use where there is a source of direct current available at approximately 110 volts two-wire or 110/220 volts three-wire, or where motor-generators have been installed which deliver direct current at these voltages. Two types of panels have been developed for this service, the private garage and the public garage type.

Private Garage Charging Panels

These panels are intended for use in private garages where there are not more than two cars to be charged at the same time. They require very little space as they are for mounting on the wall of the garage by means of supports (which hold the panels about 10 inches from the wall). The charging rheostat may be located on the floor conveniently beneath the panel or fastened directly to the wall at the side. The standard panels are arranged for one and two charging circuits.

Diagrams of these are shown on this page and the equipment designated corresponds with the wiring diagrams also shown. Detailed descriptions of the apparatus as specified will be found on pages 24 and 25.

In the single circuit panels (Figs. 1 and 3) the ammeter is continuously in circuit. The voltage of the source of supply and also the voltage applied to the batteries outside the charging rheostat is read by connecting the voltmeter by means of the two point receptacles and plug provided. The lever switches, when opened, completely isolate the battery and connections from the source of supply. In the double-circuit panels (Figs. 2 and 4), the ammeter is not in circuit excepting when one double-throw switch blade is thrown to the lower clip depending on which circuit it is desired to read. The current in only one circuit can be indicated at a time and an ammeter fuse is provided to protect the instrument in case both switches are closed on the lower throw together. The line and battery voltages are indicated by a plugging arrangement similar to that used in the single circuit panel.

In both panels the switches are fused against possible trouble anywhere in the battery circuits; the capacity of the fuses provided depends upon the expected charging current in any particular case. While the panels covered by the catalogue numbers listed below are designed for service from two-wire mains or from one side of a three-wire system, the two-circuit panels listed can be adapted by small changes so that the circuits can be balanced across a three-wire main. The catalogue numbers include the iron supports for mounting the panels but do not include the charging rheostats or cable. Complete information regarding these will be found on pages 11 and 34.

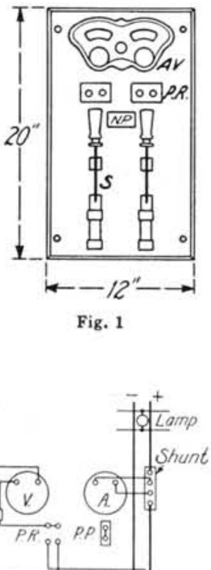


Fig. 1

CHARGING PANELS FOR PRIVATE GARAGES

EQUIPMENT

AV = One Type DK-5 combined ammeter and voltmeter with illuminated dials, with...... ampere and...... volt scales.
PR = Two point potential receptacles.
NP = Name plate.
S = S.P.S.T. 250 volt 100 amp. Type D-12 lever switches with ...... amp. fuse blocks and one set of enclosed fuses †
S₁ = S.P.D.T. 250 volt 100 ampere Type D-12 lever switches.
F = ... ampere fuse blocks with one set of enclosed fuses. †
P.P. = One two-point potential plug and holder (not shown).

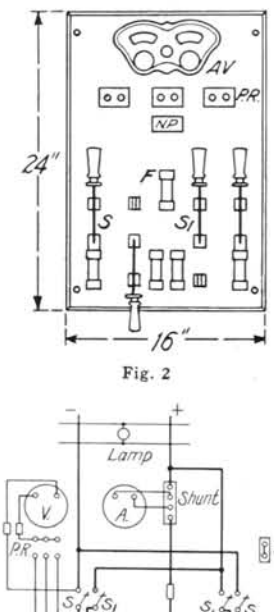


Fig. 2

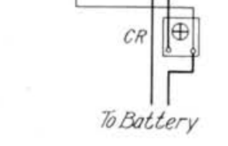


Fig. 3

No. Circuits	Fig.	Volt-meter Scale	Am-meter Scale	AMP. CAP.		Cat. No.
				Fuse Block for S	F	
1	1	120	40	30	....	125282
1	1	120	80	60	....	125283
2	2	120	40	30	30	125284
2	2	120	80	60	60	125285

† Purchasers are requested to state the capacity of fuses which will best suit individual needs, information for selecting these is given on page 26. If these data are not given with orders, the company will use its discretion in furnishing fuses.

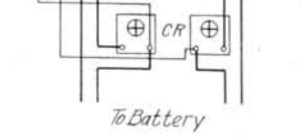


Fig. 4

Public Garage Charging Panels

The requirements of the public garage demand convenient switching apparatus for charging a number of electric automobile batteries at the same time from the same source of supply. The panels described in this bulletin have been developed after a thorough inquiry into the actual needs of garage owners, and electric vehicle manufacturers and they will be found to be of most practical design and admirably adapted to the purpose for which they are intended.

These panels are standardized for service from two-wire and three-wire mains, for two, four and six charging circuits, and with and without subbases or bases in the rear with fuses for the incoming line.

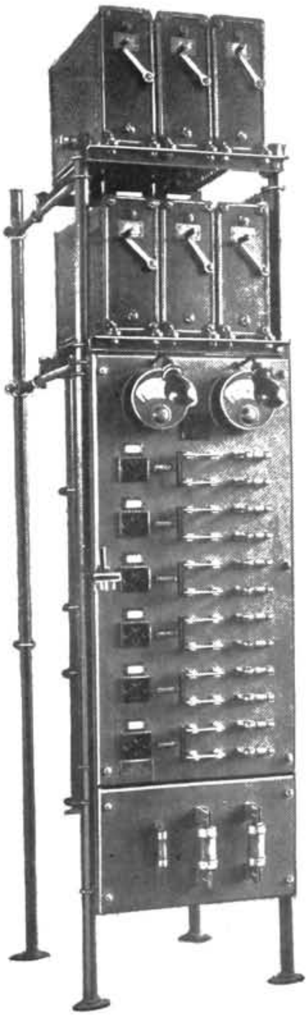


Fig. 5

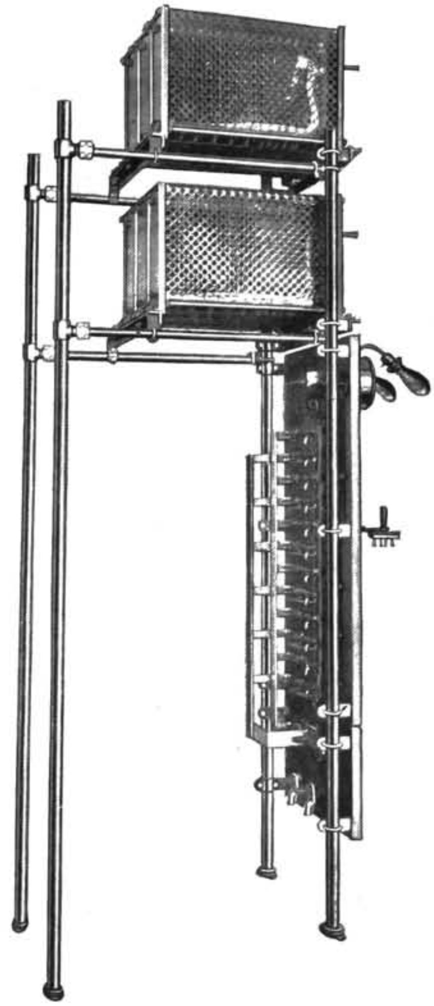


Fig. 6

MODERATE CAPACITY PUBLIC GARAGE PANELS

It is possible to add charging sections without instruments to two- and four-circuit panels already installed, when more circuits than may have been contemplated at the time of the initial installation are to be controlled, but these are not standardized as it is necessary to make a special provisio for the connection bars. The same applies to fused bases except where these are ordered with the panel. Information applying to any special case can be obtained on application to any sales office of the Company.

Two classes of panels of the same general type are catalogued. The moderate capacity panels can be used where the charging current on any individual circuit does not exceed sixty amperes while those described under the heading "Heavy Duty Panels" have been designed more particularly with reference to the large overload current at which certain classes of automobile batteries can be charged.

MODERATE CAPACITY PANELS

Figs. 5 and 6 show the front and back view respectively of a six-circuit panel complete with fused subbase. Any number of these panels may be assembled together to form a continuous switchboard where large numbers of batteries are to be charged simultaneously. Catalogue numbers do not include any provision for interconnecting panels, therefore it is necessary for the purchaser to install a common bus preferably beneath the floor with cables connecting this to the panels.

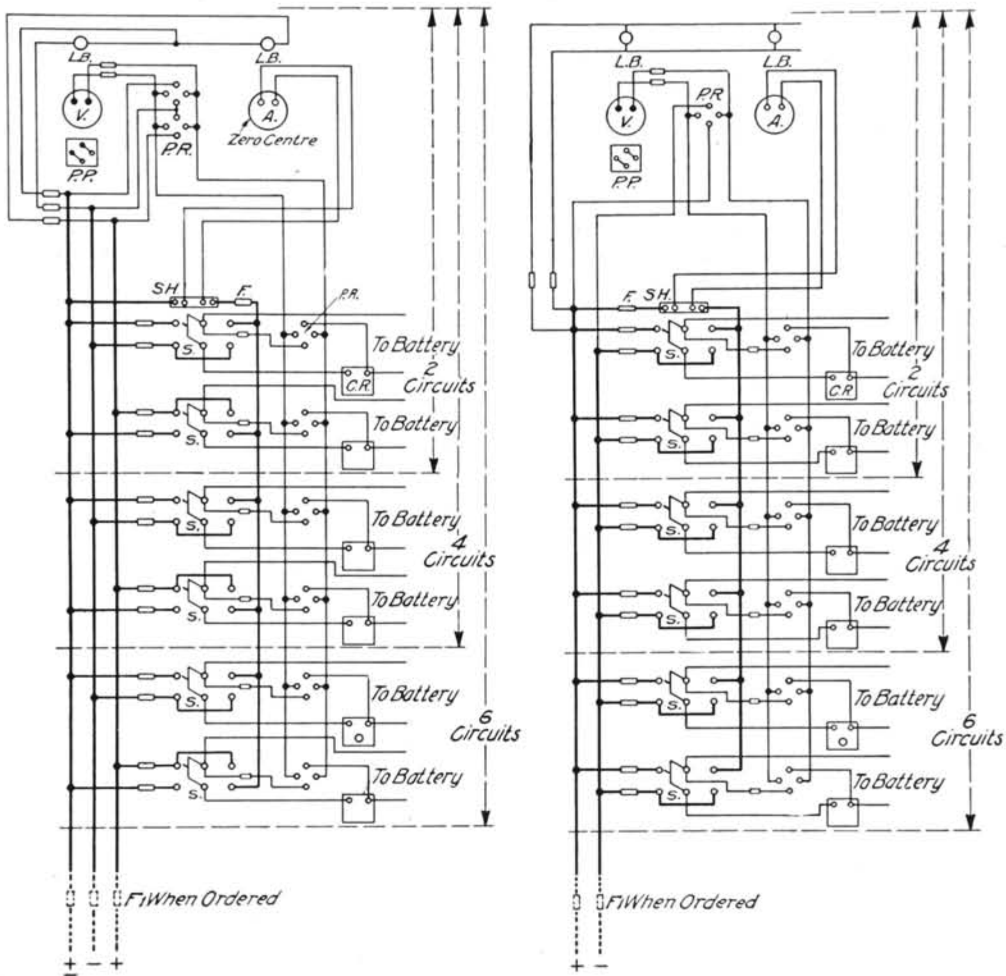
An example of this type of installation is illustrated on pages 1 and 2. Here are seven similar charging panels controlling a total of 42 circuits. The subbases were furnished with reverse current breakers instead of fuses.

The charging rheostats are mounted compactly above the panels as shown in Figs. 5 and 6, and the rheostats are operated conveniently by means of a special operating hook. This method of mounting will recommend itself to garage owners, particularly where the floor space is limited and also because the complete control of any circuit is immediately under the hand of the operative. Furthermore, this method of mounting permits of the most convenient running of the leads from the circuit switch to the rheostats, and thence along the wall to the various vehicle charging plugs. The dimensions of the panels and subbases are shown on page 7.

Each of the battery-charging circuits is controlled by a double-pole, double-throw, lever switch which, when opened, cuts off completely both sides of the circuit from the source of supply. The right-hand side of the switches is the regular charging side, and is furnished with enclosed fuses for the protection of the circuit in case of trouble in the batteries, rheostats, or connecting leads. The left-hand side is connected to the ammeter bus, so that the charging current on any circuit may be read on the ammeter when the switch is thrown in that position. However, the current can be indicated through only one battery circuit at a time. The ammeter is provided with an individual fuse (mounted on the back of the panel) for the protection of the instrument in case two or more switches should be thrown to the left-hand (ammeter) position simultaneously and also to provide protection against possible trouble in the individual circuits during the time that the circuit is being read. Potential receptacles and the necessary plug (with holder) are furnished so that the voltage of the source of supply can be read on the voltmeter and also the voltage applied to any of the batteries outside the charging rheostats. As only one plug is furnished with each panel equipment, there is no possibility of the operator making a short circuit on the potential bus.

While the panels are primarily designed for service from direct current city mains, they are perfectly adapted for use in connection with panels controlling motor-generators or generators driven by prime movers; a generator panel in such cases is usually provided with overload and reverse current breakers so that the fused subbase is ordinarily not required with the charging outfit proper. Circuit breakers with overload, underload or reverse current attachments may be substituted for the fuses on the subbase where desired at a moderate increase in price.

The panels as listed on the following page are complete with all necessary inter-connections between apparatus mounted thereon and with terminal lugs for making connections to rheostats and supply line. The catalogue numbers include also a complete supporting framework for panels and rheostats as shown. Fuse bases are included only when the table indicates that the incoming line fuse blocks F_1, are also included.



CONNECTIONS OF PUBLIC GARAGE CHARGING PANELS

MODERATE CAPACITY CHARGING PANELS FOR PUBLIC GARAGES

TWO-WIRE AND THREE-WIRE

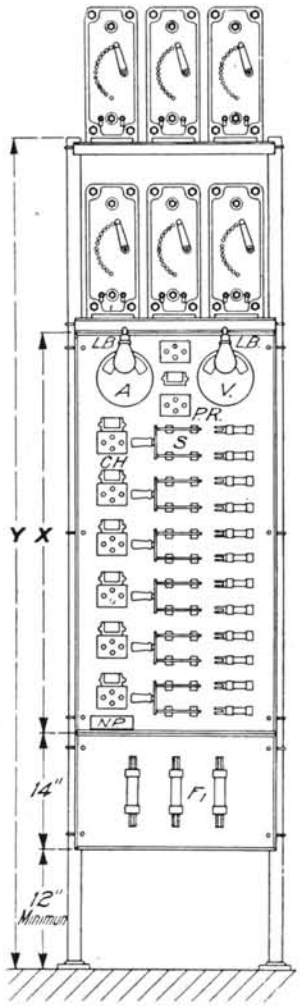


Fig. 7

EQUIPMENT

A—One Type D-8 ammeter with shunt with 80 amp. scale for two-wire panels and 80–0–80 amp. scale for three-wire panels.
V—One Type D-8 voltmeter with 150 volt scale.
L.B.—Two lamp brackets with lamp sockets and glass half shades.
S—D.P.D.T. 250 volt 100 amp. Type D-12 lever switches (one for each circuit) with 60 amp. fuse blocks and one set of enclosed fuses. †
P.R.—Four point potential receptacles (one for each switch with one additional for two-wire panels and two additional for three-wire panels).
P.P.—One four point potential plug and holder (not shown).
C.H.—Card holders (one for each switch and one additional per panel).
N.P.—One name plate.
F—One 100 amp. fuse block mounted on back of panel with one enclosed fuse. †
F_1—..........amp. fuse blocks (2 for two-wire panels and 3 for three-wire panels) with one set of enclosed fuses. †
CR—Charging rheostats (one for each circuit) not included in Cat. Nos.*

For system of connections see page 6.

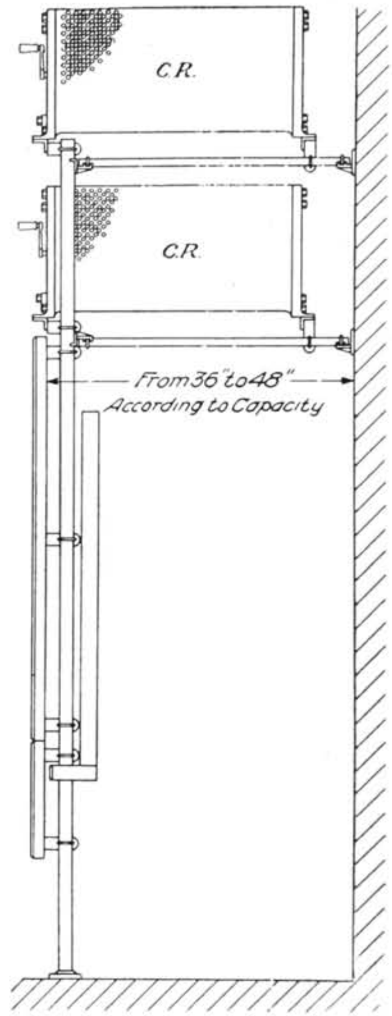


Fig. 8

TWO-WIRE PANELS					THREE ~~TWO~~-WIRE PANELS				
Catalogue Numbers	No. Circuits	Dimensions X	Dimensions Y	Ampere Capacity F_1	Catalogue Numbers	No. Circuits	Dimensions X	Dimensions Y	Ampere Capacity F_1
126504	6	48 in.	8 ft. 2 in.	400	126510	6	48 in.	8 ft. 2 in.	200
126505	6	48 in.	8 ft. 2 in.	...	126511	6	48 in.	8 ft. 2 in.	...
126506	4	36 in.	8 ft. 2 in.	400	126512	4	36 in.	8 ft. 2 in.	200
126507	4	36 in.	8 ft. 2 in.	...	126513	4	36 in.	8 ft. 2 in.	...
126508	2	24 in.	6 ft. 7 in.	200	126514	2	24 in.	6 ft. 7 in.	100
126509	2	24 in.	6 ft. 7 in.	...	126515	2	24 in.	6 ft. 7 in.	...

Width of all panels 24 inches.
* Complete data on rheostats including dimensions is given on page 11.
† Purchasers are requested to advise the capacity of fuses which will best suit their individual needs, information for selecting these being given on page 26. If this data is not given with orders, the Company will use its own discretion in furnishing fuses.

HEAVY DUTY PANELS

These panels are in general similar to the moderate capacity panels described on pages 4 to 7, the main point of difference being in the method of supporting the charging rheostats where the size and weight of these make mounting them above the panels impracticable. The panels are, however, listed as shown on pages 9 and 10 with both styles of support, the type to be ordered in any particular case obviously depending on the type of rheostat selected. Figs 9 and 10 show the front and back respectively of these panels; the rheostat framing is not indicated. It will be observed that the panel is sectionalized and also that the line fuses, when ordered, are of the open link type mounted on a base in the rear of the panel instead of the fusing arrangement used in the moderate capacity panels. The open link type of fuse has been used as enclosed fuses are not manufactured in capacities sufficiently large to take care of the extreme condition of service for which the panels and rheostats are designed. The general method of operating the board is the same as that for the moderate capacity panels and the same remarks with reference to the equipment furnished under the catalogue numbers also apply.

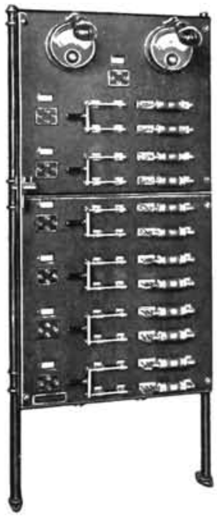


Fig. 9

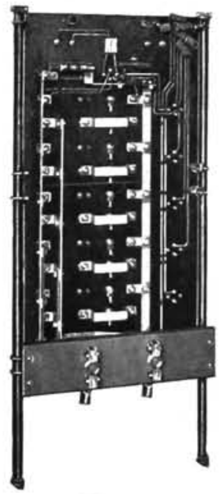


Fig. 10

HEAVY DUTY PUBLIC GARAGE PANELS

HEAVY DUTY CHARGING PANELS FOR PUBLIC GARAGES

TWO-WIRE AND THREE-WIRE

(With Supports for CR-211 Rheostats, Fig. 15)

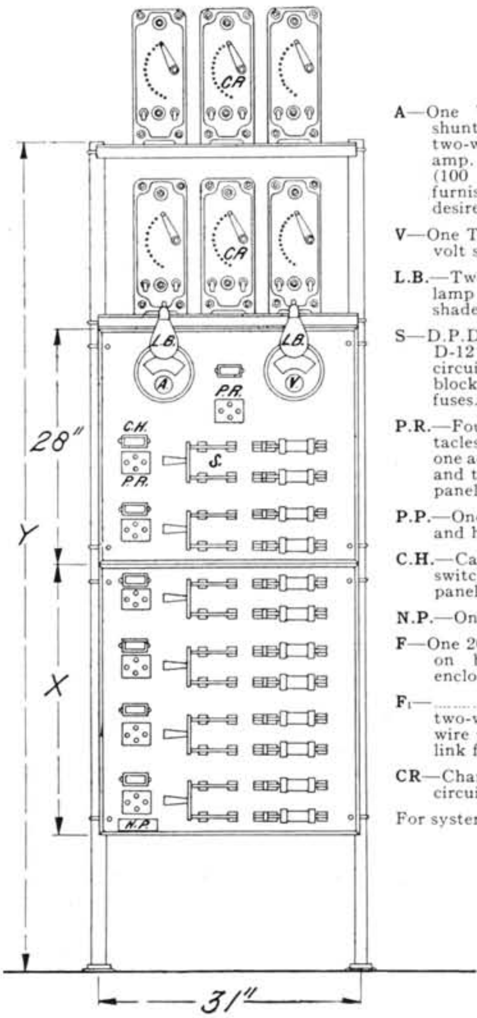


Fig. 11

EQUIPMENT

A—One Type D-8 ammeter with shunt with 150 amp. scale for two-wire panels and 150-0-150 amp. scale for three-wire panels. (100 or 200 amp. scales can be furnished instead of 150 amp. if desired, without change in price.)

V—One Type D-8 voltmeter with 150 volt scale.

L.B.—Two lamp brackets with key lamp sockets and glass half shades.

S—D.P.D.T. 250 volt 200 amp. Type D-12 lever switches (one for each circuit) with 200 amp. fuse blocks and one set of enclosed fuses.†

P.R.—Four point potential receptacles (one for each switch with one additional for two-wire panels and two additional for three-wire panels.)

P.P.—One four point potential plug and holder (not shown).

C.H.—Card holders (one for each switch and one additional for panel).

N.P.—One name plate.

F—One 200 amp. fuse block mounted on back of panel with one enclosed fuse.†

F_1—.........amp. fuse blocks (2 for two-wire panels and 3 for three-wire panels) with one set of open link fuses.†

CR—Charging rheostats (one for each circuit) not included in Cat. Nos.*

For system of connections, see page 6.

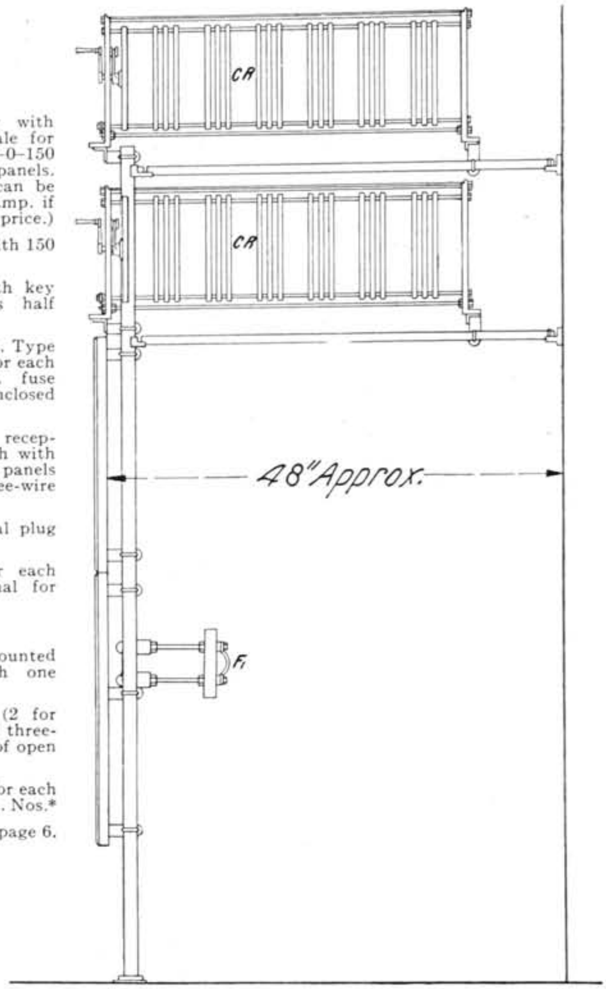


Fig. 12

TWO-WIRE PANELS					THREE-WIRE PANELS				
Catalogue Numbers	Dimensions X	Dimensions Y	Ampere Capacity F_1	No. Circuits	Catalogue Numbers	Dimensions X	Dimensions Y	Ampere Capacity F_1	No. Circuits
134502	32 in.	8 ft. 2 in.	1000	6	134508	32 in.	8 ft. 2 in.	600	6
134503	32 in.	8 ft. 2 in.	. . .	6	134509	32 in.	8 ft. 2 in.	. . .	6
134504	16 in.	8 ft. 2 in.	800	4	134510	16 in.	8 ft. 2 in.	400	4
134505	16 in.	8 ft. 2 in.	. . .	4	134511	16 in.	8 ft. 2 in.	. . .	4
134506	. . . .	6 ft. 7 in.	400	2	134512	. . . .	6 ft. 7 in.	200	2
134507	. . . .	6 ft. 7 in.	. . .	2	134513	. . . .	6 ft. 7 in.	. . .	2

* Complete data on rheostats including dimensions is given on page 11.

† Purchasers are requested to advise the capacity of fuses which will best suit their individual needs, information for selecting these being given on page 26. If this data is not given with orders, the Company will use its own discretion in furnishing fuses.

HEAVY DUTY CHARGING PANELS FOR PUBLIC GARAGES

TWO-WIRE AND THREE-WIRE

(With Supports for CR-211 Rheostats, Fig. 16)

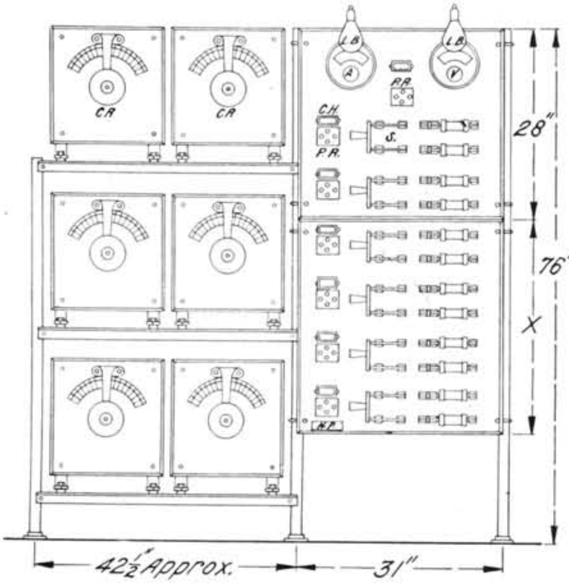


Fig. 13

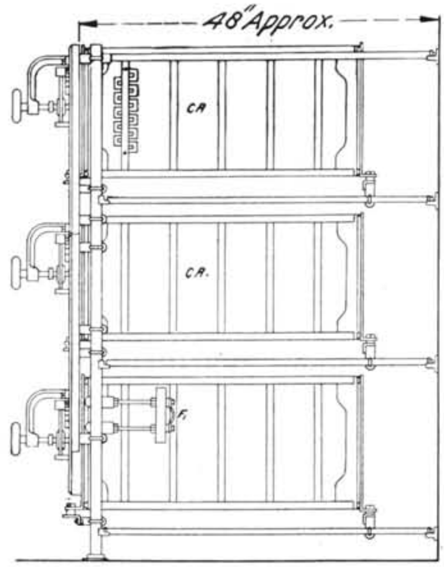


Fig. 14

EQUIPMENT

A—One Type D-8 ammeter with shunt with 200 amp. scale for two-wire panels and 200-0-200 amp. scale for three-wire panels (100 or 150 amp. scales can be furnished instead of 200 amp. if desired, without change in price).
V—One Type D-8 voltmeter with 150 volt scale.
L.B.—Two lamp brackets with key lamp sockets and glass half shades.
S—D.P.D.T. 250 volt 200 amp. Type D-12 lever switches (one for each circuit) with 200 amp. fuse blocks and one set of enclosed fuses.†
P.R.—Four point potential receptacles (one for each switch with one additional for two-wire panels and two additional for three-wire panels).
P.P.—One four point potential plug and holder (not shown).
C.H.—Card holders (one for each switch and one additional per panel).
N.P.—One name plate.
F—One 200 amp. fuse block mounted on back of panel with one enclosed fuse.†
F_1—..............amp. fuse blocks (2 for two-wire panels and 3 for three-wire panels) with one set of open link fuses.†
CR—Charging rheostats (one for each circuit) not included in Cat. Nos.*
For system of connections, see page 6.

TWO-WIRE PANELS				THREE-WIRE PANELS			
Catalogue Numbers	Dimension X	Ampere Capacity F_1	No. Circuits	Catalogue Numbers	Dimension X	Ampere Capacity F_1	No. Circuits
134514	32 in.	1000	6	134520	32 in.	600	6
134515	32 in.	...	6	134521	32 in.	...	6
134516	16 in.	800	4	134522	16 in.	400	4
134517	16 in.	...	4	134523	16 in.	...	4
134518	....	400	2	134524	...	200	2
134519	....	...	2	134525	....	...	2

* Complete data on rheostats including dimensions is given on page 12.
† Purchasers are requested to advise the capacity of fuses which will best suit their individual needs, information for selecting these being given on page 26. If this data is not given with orders, the Company will use its own discretion in furnishing fuses.

BATTERY-CHARGING RHEOSTATS

The Type CR-211 rheostat contains every essential of the modern battery-charging rheostat. With the proper rheostat for a given battery, it is possible to start the charge at the correct rate and to reduce the current as the charging progresses to the final amount required by the battery. These rheostats have sufficient current-carrying capacity and resistance for long charging at a low rate also. They are strongly constructed and amply ventilated. The resistances are the General Electric Company's standard grids and Form R units and are supported by the tie rods which are insulated with mica sleeves. The enclosing cover can be removed very easily, making the leads, which run to the back of the switch base, and all other inner parts readily accessible.

The switch proper is mounted on a slate base immediately back of the front end casting, and a metal sleeve provides a bearing for the switch shaft where it passes through

**CR-211 BATTERY-CHARGING RHEOSTATS
FOR CIRCUITS UP TO 115 VOLTS MAXIMUM**

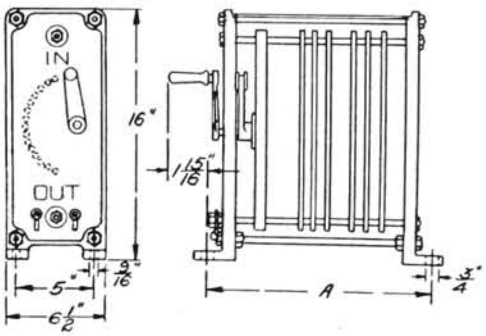


Fig. 15

Cat. No.	No. of Steps	Total Ohms	Dimension A	Fig.	Type of Cell	No. of Cells	Charging Amperes	
							Start	Finish
125953	15	17	22	15	Lead	12–18	15	5
125954	15	17	22	15	Lead	12–18	20	6
125955	15	13	22	15	Lead	20–28	20	5
125956	15	9	28	15	Lead	20–28	25	8
125957	15	4	28	15	Lead	30–36	30	10
125958	15	4	28	15	Lead	30–36	40	10
125959	15	2.6	22	15	Lead	37–40	30	10
125960	15	2.6	28	15	Lead	37–40	40	10
125961	15	1.5	22	15	Lead	41–44	30	10
125962	15	1.5	22	15	Lead	41–44	40	10
125963	15	1.28	28	15	Lead	41–44	50	12
125964	14	1.0	28	15	Lead	41–44	60	15
125965	15	2.8	28	15	Edison A-4	20–40	30	30
125966	15	1.7	28	15	Edison A-4	44–60	30	30
125967	15	2.0	28	15	Edison A-6	20–40	45	45
125968	15	1.2	22	15	Edison A-6	44–60	45	45
125969	14	1.4	36	15	Edison A-8	20–32	60	60
125970	14	1.0	28	15	Edison A-8	36–44	60	60
125971	14	0.72	28	15	Edison A-8	48–60	60	60
127052	10	1.17	39	15	Edison A-10	20–32	75	75
127053	10	0.81	36	15	Edison A-10	36–44	75	75
127054	10	0.60	28	15	Edison A-10	48–60	75	75
127055	10	0.96	44	15	Edison A-12	20–32	90	90
127056	10	0.68	36	15	Edison A-12	36–44	90	90
127057	10	0.48	28	15	Edison A-12	48–60	90	90

the slate. The switch arm is a solid casting which forms a rigid construction and greatly improves the contact between the arm and the contact segments. The battery terminals are placed near the bottom of the front of the rheostat where there is ample room for the leads, and are insulated by mica sleeves.

The rheostat may be installed on the wall, floor, or above the switchboard panels.

There are four sizes, Cat. Nos. 134608, 134609, 134610 and 134612, which require so many grids that the length of the rheostat would be prohibitive, if the above construction were used. The resistance is therefore mounted in two or more tiers in an angle iron frame. The slate base carrying the dial switch is mounted on the end of the frame. The dial switch is especially designed to carry heavy currents and is operated by means of a handwheel. The shaft carrying the switch arm is supported by a bracket. This rigid construction insures a good contact between the switch arm and the segments of the dial, a very important consideration where heavy charging currents are used.

Three rheostats have been designed for use in public garages which require a rheostat capable of charging more than one type of Edison battery. These rheostats will charge any one of the batteries for which they are designed, at either normal or double normal charging rate.

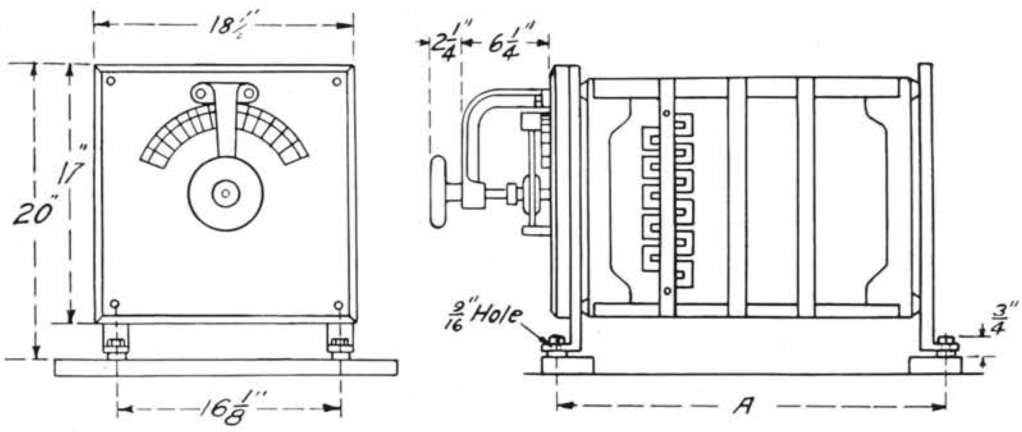


Fig. 16

FOR CHARGING EDISON CELLS AT EITHER NORMAL OR DOUBLE NORMAL RATE

PRIVATE GARAGE

Cat. No.	No. of Steps	Total Ohms	Dimension A	Fig.	Type of Cell	No. of Cells	CHARGING AMPERES Double Rate	Normal Rate
134605	14	0.56	22	15	Edison A-4	60	60	30
134606	14	0.34	22	15	Edison A-6	60	90	45
134607	10	0.26	28	15	Edison A-8	60	120	60
134608	14	0.235	24	16	Edison A-10	60	150	75
134609	14	0.23	24	16	Edison A-12	60	180	90

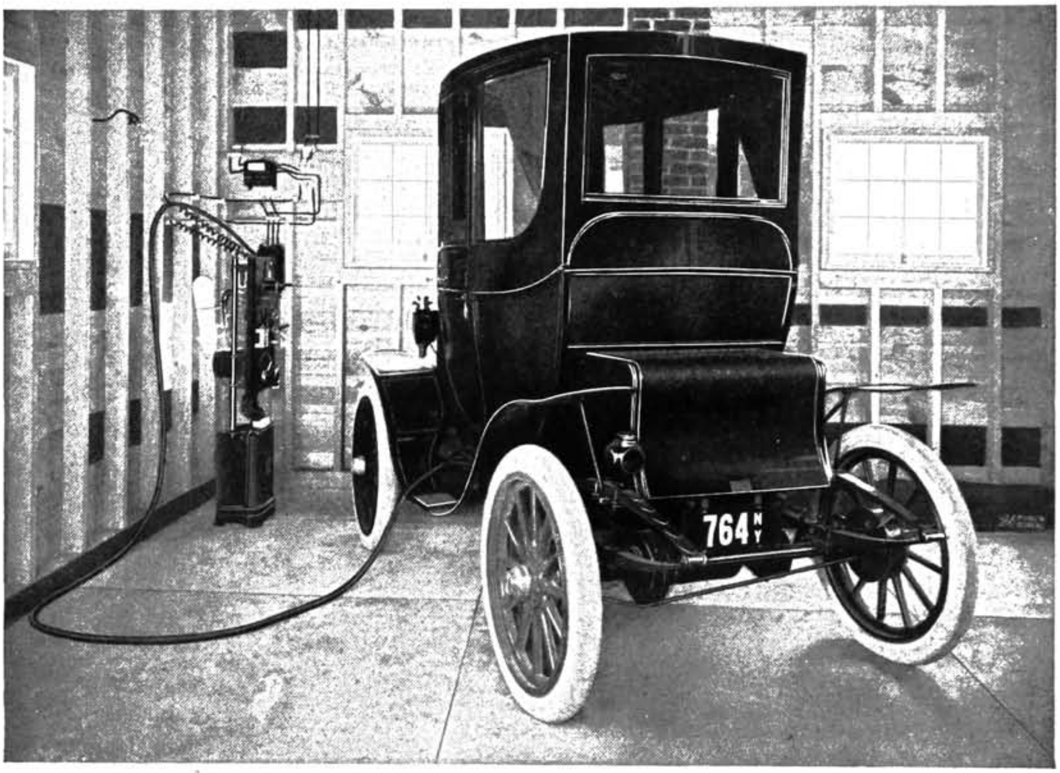
PUBLIC GARAGE

Cat. No.	No. of Steps	Total Ohms	Dimension A	Fig.	Type of Cell	No. of Cells	Double Rate	Normal Rate
134610	14	0.565	30	16	Ed.-A-4-6-8-10-12	60	180	30
134611	10	0.63	36	15	Edison-A-4-6-8	60	120	30
134612	14	0.23	24	16	Edison-A-10-12	60	180	90

CHARGING APPARATUS FOR ALTERNATING CURRENT SERVICE

MERCURY ARC RECTIFIERS

The General Electric Company's mercury arc rectifier, as a highly efficient device for changing alternating to direct current, needs no introduction. Thousands of them are in daily use charging storage batteries in electric automobiles, and almost innumerable other purposes. Since the introduction of what was known as the "standard battery-charging type" mercury arc rectifier, many improvements in that design have been made and other types and designs have also been made to suit new conditions arising from time to time. This bulletin is designed to cover the entire line of battery-charging rectifiers in a general way. On many of the types, however, individual publications have been issued and can be furnished on request.



BATTERY-CHARGING RECTIFIER IN USE

THEORY

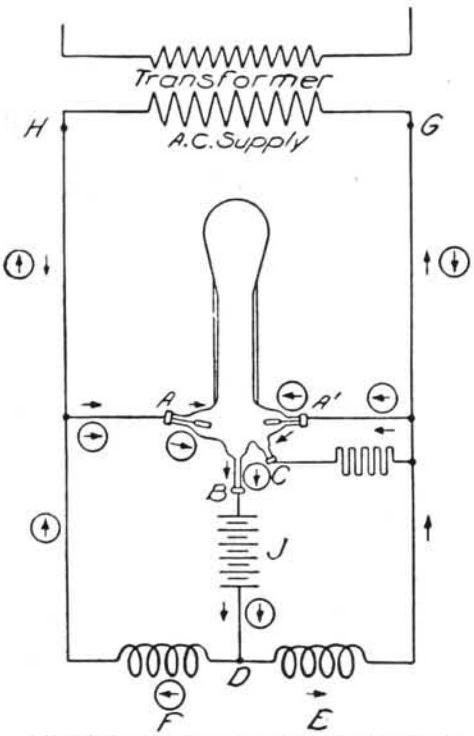
Before describing the various types of rectifiers, a few words in reference to the theory may be of interest, and will be of assistance in describing the various types of rectifier sets mentioned later.

All types of mercury arc rectifier have three essential parts—the rectifier tube, the main reactance and the panel.

The rectifier tube is an exhausted glass vessel in which are two graphite electrodes (anodes AA′) and one mercury cathode (B). Each anode is connected to a separate side of the alternating current supply, and also through one-half of the main reactance to the negative side of the load. The cathode is connected to the positive side. There is also a small starting electrode (C) connected to one side of the alternating current circuit through resistance, and used for starting the arc. When the rectifier tube is rocked, so as to form and break a mercury bridge between the cathode "B" and the starting anode "C," a slight arc is formed. This starts what is known as the "excitation" of the tube, and the cathode begins supplying ionized mercury vapor. This condition of excitation can be kept up only as long as there is current flowing towards the cathode. If the direction of supply voltage is reversed, so that the formerly negative electrode, or cathode, becomes positive with the reversal of the alternating current circuit, the current ceases to flow, since, in order to flow in the opposite direction, it would require the formation of a new cathode, which can be accomplished only by special means. Therefore, in the rectifier tube, the current must always flow toward the cathode which is kept in a state of excitation by the current itself.

Such a tube would cease to operate on alternating current voltage after one-half the cycle, if some means were not provided to maintain the flow of current continuously toward the cathode.

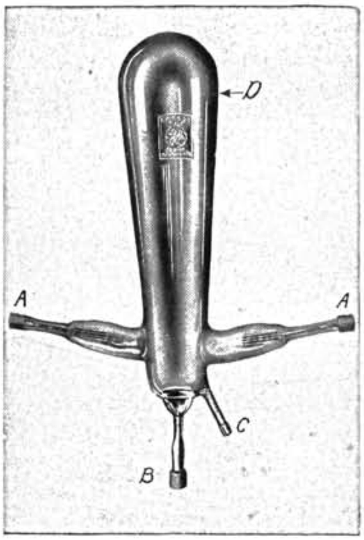
The maintenance of the current flow is accomplished by the main reactance. As the current alternates, first one anode and then the other becomes positive, the current flowing from the positive anode through the mercury vapor, toward the cathode, thence through the battery, or other load, and back through one-half of the main reactance to the opposite side of the alternating current supply circuit. As the current flows through the main reactance, it charges it, and while the value of the alternating wave is decreasing, reversing and increasing, the reactance discharges, thus maintaining the arc until the voltage reaches the value required to maintain the current against the counter e.m.f. of the load, and reducing the fluctuations in the direct current. In this way, a true continuous current is produced with very little loss in transformation.

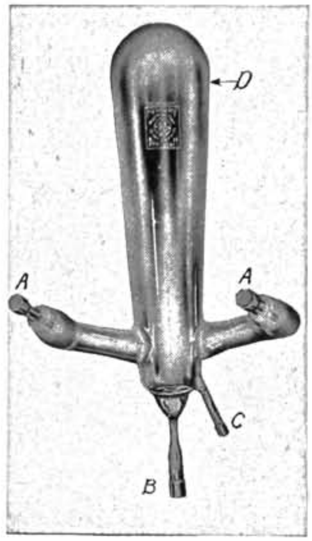


ELEMENTARY DIAGRAM OF CONNECTIONS

That there may be no misapprehension, particular attention is called to the fact that the rectifier is so designed that the entire alternating current wave is used. This, of course, means that the rectifier has approximately twice the efficiency that would be obtained if only one-half of the alternating wave were used.

To get an idea of the operation of the mercury arc rectifier, assume the instant that the terminal "H" of the supply transformer is positive, the anode "A" is then positive, and the arc is free to flow between "A" and "B." Following the direction of the arrow still further, the current passes through the battery "J," through one-half of the main reactance coil "E," and back to the negative terminal "G" of the transformer. When the impressed e.m.f. falls below a value sufficient to maintain the arc against the counter e.m.f. of the arc and load, the reactance "E" which heretofore has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc in the rectifier tube until the e.m.f. of the supply has passed through zero, reversed and built up to such a value as to cause the anode "A′" to have a sufficient positive value to start the arc between it and the cathode "B." The discharge circuit of the reactance coil "E" is now through the arc "A′B" instead of through its former circuit. Consequently the arc "A′B" is now supplied with current, partly from the transformer, and partly from the reactance coil "E." The new circuit from the transformer is indicated by the arrows enclosed in circles.



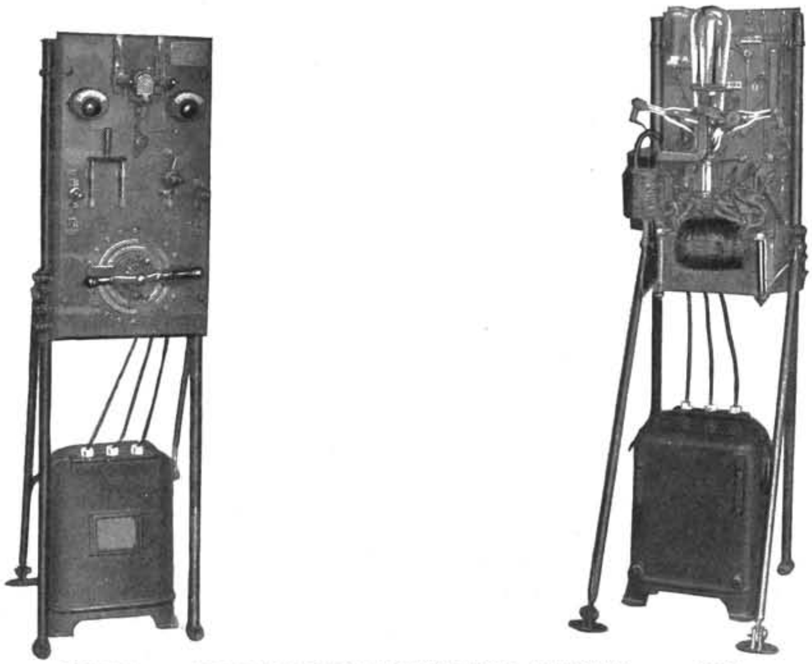


100 AND 200 VOLT MERCURY ARC RECTIFIER TUBES

STANDARD BATTERY-CHARGING SET, 60-140 CYCLES

The commercial battery-charging rectifier set largely sold for charging the batteries in electric automobiles is shown in the accompanying illustrations. This rectifier set is made in five standard sizes, of 10, 20, 30, 40 and 50 amperes capacity, and in direct current voltages ranging from 10 to 100 when operated from 110 volts alternating current, and from 20 to 175 when operated from 220 volts. This rectifier is suitable for operation on circuits of 60 cycles or more. Special rectifier sets of this type are also furnished for delivering higher direct current voltages than the foregoing from 220 volts alternating current supply, and rectifiers up to a maximum of 350 volts direct current have been furnished in capacities up to and including 50 amperes.

Particular attention is called to the completeness of this charging set. It is supplied with ammeter and voltmeter for indicating the direct current output, and with a double regulating dial switch having seventeen contact buttons, six of which are connected to rough regulation and eleven to fine regulation taps, on what is termed a "regulating compensator." This compensator is designed to give a very wide range of alternating current voltage across the anodes of the rectifier tube, and consequently a wide range of voltage from the direct current side of the rectifier.



FRONT STANDARD BATTERY-CHARGING RECTIFIER REAR

In operation this rectifier is simple. After the set is adjusted for the proper direct current voltage output, the alternating current line switch is closed; the circuit breaker closed, the spring starting switch on the right-hand side of the panel moved up and held while the tube is rocked to form the necessary starting arc. As soon as the arc is formed, the starting switch is released, and it automatically springs into the load position, when the rectifier begins charging the storage battery.

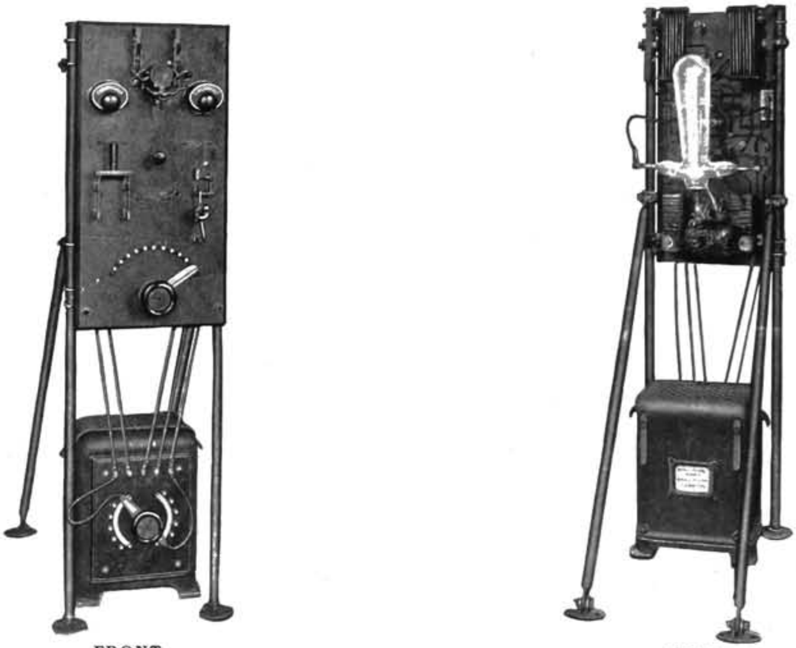
The reason for the starting switch and the starting load resistance to which the upper clip is connected is that the rectifier will not readily start against the counter electromotive force of the battery, making it desirable to have the auxiliary starting load resistance, which is a non-inductive resistance, mounted on the back of the panel, as a starting load.

Efficiency

The efficiency of this type of rectifier, or, in fact, any other type of mercury arc rectifier, will vary with the direct current voltage output, since there is a definite voltage drop in the mercury arc in the tube, irrespective of the current or voltage. Therefore, on the low voltages, the efficiency is lower than on the higher voltages. The efficiency of the rectifier is practically the same from one-third current up to the maximum current output, though slightly greater at the low current than at the higher. At 60 volts direct current, the efficiency would be about 70 per cent.; at 70 volts, 75 per cent.; at 100 volts, 78 per cent.; at 175 volts and higher, 80 to 82 per cent.

BATTERY-CHARGING SET 25-60 CYCLES

Special rectifiers are illustrated below for operation on 25, 30, 40 or 60 cycles. These rectifiers do not have such a wide range of direct current voltage from a given alternating current supply, but will be found well adapted to vehicle and other battery charging. For complete ratings see page 22. The efficiencies of these sets will be about the same as those of the standard sets.



FRONT REAR

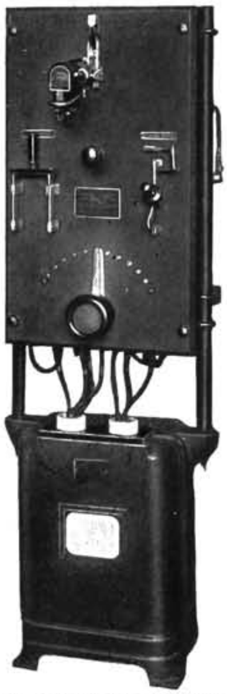
BATTERY-CHARGING SET, 25-60 CYCLES

RUNABOUT TYPE RECTIFIER

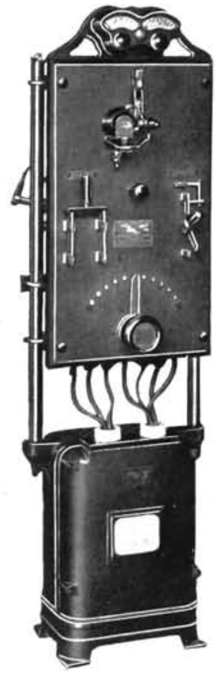
There are many women owning electric runabouts, stanhopes and broughams, who do their charging at home with mercury arc rectifiers, and to encourage this class of charging of electric pleasure vehicles, a rectifier has been designed which in simplicity of operation compares very favorably with the operation of a battery-charging rheostat, and yet has all the range of voltage necessary for the batteries for which it is designed.

This new type of rectifier, on account of the work for which it is designed, has been designated as the "Runabout Type." It is built with a minimum number of parts, and is as near absolute simplicity as seems possible in a device which not only changes alternating current to direct current, but must be equipped with means for regulating the charging current. In the runabout type rectifier, there is a main reactance, the winding of which is equipped with four taps which make possible the connecting of the rectifier for various direct current voltages covering a range sufficient to charge all the ordinary lighter electrics. The main reactance, designated the "compensating reactance", stands on the floor. The top contains two receptacles for receiving the two panel pipe supports on which is mounted the rectifier panel. On the back of the panel is a suitable holder for the rectifier tube. For use in rocking the tube, a small handle is mounted on the front of the panel. The panel is equipped with a main line switch, a single-pole circuit breaker for protection against overload, and a starting switch for connecting the rectifier temporarily to the starting resistance load.

To obtain a regulation of the charging current, a reactance coil is connected in series with the alternating current supply. This coil has eleven taps connected to as many buttons of a semi-dial switch similar in many respects to the ordinary rheostat switch. This makes it possible to efficiently vary the charging current and voltage over the entire range required by any battery which the rectifier is designed to charge. In order to minimize the cost, this type of rectifier is not regularly equipped with ammeter or voltmeter, although it can be so equipped.



WITHOUT INSTRUMENTS



WITH INSTRUMENTS

RUNABOUT TYPE RECTIFIER

Capacity

The runabout type of rectifier is designed for operation on 60 to 140 cycle, 110 or 220 volt alternating current supply. See page 22 for the number of cells of battery that can be charged from this rectifier on 110 and 220 volts. It can be furnished in 30, 40 and 50 amperes capacity. With slight changes it can be used on 25 to 40 cycle circuits.

MULTIPLE OPERATION

When it is desired to charge at a higher rate than the maximum capacity of a single rectifier tube (50 amperes), two or more rectifiers can be very satisfactorily operated in multiple. The standard panels before described can, with a few slight changes, be readily adapted for multiple operation.

AUTOMATIC STARTING DEVICE

An electro-magnetic starting device may be placed on the mercury arc rectifier panels if desired, and is particularly useful where large fluctuations or momentary interruptions, sufficient to stop the arc, are liable to occur in either supply or load. This device rocks the tube and starts the arc automatically.

Automatic starting devices may be placed on any of the panels listed on page 22 and full information regarding the additional price and other details will be furnished on application to the nearest sales office. They may be shipped with new panels or installed on those already in service.

AUTOMATIC CHARGING

Since the introduction of the rectifier, there has been from time to time considerable discussion relative to the automatic cutting-out of the rectifier when the battery is approximately charged. This cutting-out is due to the fact that the rise in battery voltage causes a fall in charging current to such a point that the reactance is ineffective and the arc in the rectifier tube ceases to flow. While many users of rectifiers depend on this with quite satisfactory results, the General Electric Company does not recommend it. There are so many variable factors entering into a question of this kind, such as increase in line voltage, decrease in battery voltage due to high temperature, and low voltage, caused by the short-circuiting of plates, that it is not good policy to state that the rectifier will cut out automatically at any time. The possibilities of serious overcharge and consequent damage to the battery are too great to risk. It is always recommended that operators give some attention to their battery and rectifier during charge, in order to insure proper and satisfactory charging, good mileage, and longer life of battery.

Automatic time switches are used with very satisfactory results for the purpose of cutting out a battery when it is approximately fully charged, and the General Electric Company makes such a device for use in connection with rectifier panels.

GARAGE CHARGING OF PLEASURE AND COMMERCIAL VEHICLES

The great advantage of rectifiers in a public garage is that they can be installed in units and the number of units increased to keep pace with the growth of the garage and the requirements for charging.

One panel can be operated as efficiently as a dozen; therefore, the investment in a rectifier charging set will always be proportional to the business done, and a garage owner is not compelled to install a large charging set to take care of prospective business.

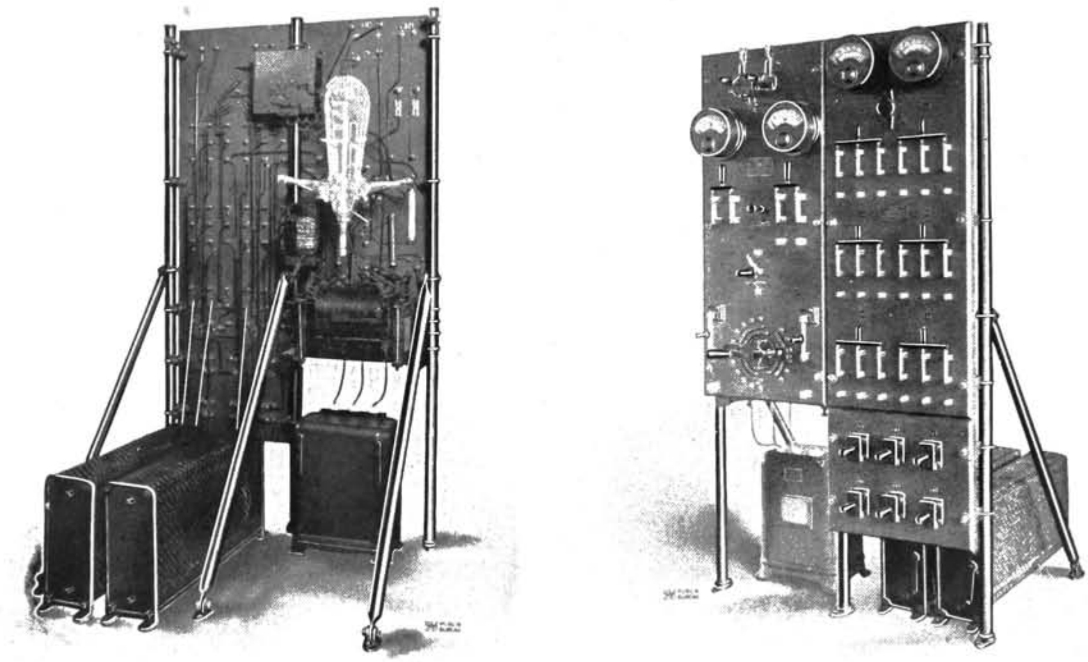
REAR OF RUNABOUT TYPE RECTIFIER

Many garages are equipped with the so-called "Public Garage Type Rectifier" which embodies a method of series-multiple charging which is giving very satisfactory results with high efficiency. In the average public garage, the batteries may vary from a 12-cell to a 44-cell, rendering extremely inefficient on the average charging by means of multiple circuits with a rheostat in each circuit. With the garage type of rectifier, where the charging is done in series-multiple, it is possible to equalize the number of batteries in series-multiple groups in such a way that there will be little loss in rheostats.

The public garage type of rectifier consists of two panels, a feeder or distributing panel to which the charging circuits are connected, and a rectifier panel similar to the 40 ampere standard battery charging rectifier set, except that it has a range of voltage from 45 to 230 volts direct current when operated from a 220 volt, 60 cycle, alternating current supply. This means that the garage type of rectifier will charge as many as 90 cells in series, or when connected in series-multiple, 180 cells. The feeder panel is so arranged that the series and series-multiple connections are all made on the panel. The external connections to the various vehicles are made as with the multiple charging system, except that the operator should use some care in dividing up his batteries, in order to get the proper equalization of charging voltage on the series groups. The garage type rectifier system of charging, when properly handled, is probably the most efficient method of charging batteries in a garage.

GARAGE CHARGING OF DELIVERY SERVICE VEHICLES

The so-called "Commercial Vehicle Type Rectifier" is designed for charging at a 30 or 50 ampere rate a 40–44 cell lead plate battery, or a 60 cell Edison battery. This rectifier is designed particularly for use in the garages of department stores, express companies, and other concerns maintaining electric delivery service, where all of the batteries are of approximately the same number of cells and ampere-charging rate.



PUBLIC GARAGE TYPE RECTIFIER

This type of rectifier has been designed for operation on 220 volts, 25 to 60 cycles alternating current. The panel is made both with and without ammeter and voltmeter. Each rectifier is a complete unit and a charging outfit may be begun by installing a single rectifier panel with instruments, and as additional capacity is required adding panels without instruments.

The instrument panel is equipped with high grade direct current ammeter and voltmeter. On each panel there is a double-pole potential receptacle, one side of which is connected to the voltmeter on one instrument panel, and the other side to the direct current terminals of the rectifier panel on which the receptacle is mounted. Thus, if the voltmeter plug is inserted, in any receptacle, the voltmeter will indicate the voltage on that rectifier and battery under charge. There is also an arrangement by means of a spring switch for connecting the ammeter on the instrument panel to any of the rectifiers connected to it, so that, even though each panel is not equipped with indicating instruments, the charging current and voltage can be readily determined. Only one voltmeter plug is furnished with each group of panels, therefore there is no likelihood of connecting two rectifiers simultaneously to one voltmeter.

THREE COMMERCIAL VEHICLE TYPE RECTIFIER SETS

The efficiency of one of these sets will be between 75 and 80 per cent., and the power-factor, which will depend upon the amount of regulating reactance in circuit, will vary between 70 and 90 per cent.

DATA ON MERCURY ARC RECTIFIERS

STANDARD OUTFITS WITH INSTRUMENTS

Cat. No.	D.C. Amp.	Range D.C. Volts	A.C. Volts	Cat. No. Rectifier Tube	Voltmeter Scale	Ammeter Scale	Cells Lead Battery	Cells Edison Battery	Approx. Ship. Wt.
119588	10	10– 75 20– 75	110 220	40949	75	15	5–30 10–30	7–40 14–40	530
119589	20	10– 75 20– 75	110 220	40952	75	30	5–30 10–30	7–40 14–40	540
119590	30	10– 75 20– 75	110 220	40955	75	40	5–30 10–30	7–40 14–40	590
119591	40	10– 75 20– 75	110 220	40958	75	60	5–30 10–30	7–40 14–40	635
119592	50	10– 75 20– 75	110 220	47409	75	60	5–30 10–30	7–40 14–40	660
119593	10	10–100 20–120	110 220	40949	120	15	5–38 10–46	7–54 14–65	530
119594	20	10–100 20–120	110 220	40952	120	30	5–38 10–46	7–54 14–65	540
119595	30	10–100 20–120	110 220	40955	120	40	5–38 10–46	7–54 14–65	590
119596	40	10–100 20–120	110 220	40958	120	60	5–38 10–46	7–54 14–65	635
119597	50	10–100 20–120	110 220	47409	120	60	5–38 10–46	7–54 14–65	660
119598	10	75–175	220	40950	175	15	32–68	54–95	530
119599	20	75–175	220	40953	175	30	32–68	54–95	540
119600	30	75–175	220	40956	175	40	32–68	54–95	590
119601	40	75–175	220	40959	175	60	32–68	54–95	635

SETS WITHOUT INSTRUMENTS

119602	10	10–100 20–150	110 220	40949	...	...	5–38 10–46	7–54 14–80	530
119603	20	10–100 20–150	110 220	40952	...	...	5–38 10–46	7–54 14–80	540
119604	30	10–100 20–150	110 220	40955	...	...	5–38 10–46	7–54 14–80	590
119605	40	10–100 20–150	110 220	40958	...	...	5–38 10 46	7–54 14–80	635
119606	50	10–100 20–150	110 220	47409	...	...	5 38 10–46	7–54 14–80	660
119607	10	75–175	220	40950	...	..	32–68	54–95	530
119608	20	75–175	220	40953	...	...	32–68	54–95	540
119609	30	75–175	220	40956	...	...	32–68	54–95	590
119610	40	75–175	220	40959	...	...	32–68	54–95	635

Cat. Nos. include only one tube.
Above rectifiers are for 60–140 cycle circuits.

COMMERCIAL VEHICLE TYPE

104997	30	80–120	220	40955	40 150	44	60	575
104998	30	80–120	220	40955	No Inst.	44	60	565
119055	50	80–120	220	47409	60 150	44	60	640
119056	50	80–120	220	47409	No Inst.	44	60	630

One extra tube included in above Cat. Nos.

PUBLIC GARAGE TYPE

This rectifier is for charging 180 cells of lead plate battery, connected in series-multiple at 20 amperes per battery. Capacity of rectifier 40 amperes 45-230 volts direct current alternating current voltage 220. Can be equipped with 6 charging circuit subbase.

Cat. No. 104996 rectifier without extra tube or subbase.

Cat. No. 73303 subbase.

Cat. No. 40959 tube used on this rectifier.

RUNABOUT TYPE
NORMAL FREQUENCY 60 CYCLES
PANELS WITH DK-5 INSTRUMENTS

Cat. No.	D.C. Amp.	Range D.C. Volts	A.C. Volts	Cat. No. Rectifier Tube	Ammeter Scale	Voltmeter Scale	Cells Lead Battery	Cells Edison Battery	Approx. Ship. Wt.
124672	30	30– 82 30–118	110 220	40955	40	120	20–32 20–46	25–44 25–60	570
124673	40	30– 82 30–118	110 220	40958	60	120	20–32 20–46	25–44 25–60	610
124674	50	30– 82 30–118	110 220	47409	60	120	20–32 20–46	25–44 25–60	670

PANELS WITHOUT INSTRUMENTS

124675	30	30– 82 30–118	110 220	40955	...	...	20–32 20–46	25–44 25–60	550
124676	40	30– 82 30–118	110 220	40958	...	...	20–32 20–46	25–44 25–60	600
124677	50	30– 82 30–118	110 220	47409	...	...	20–32 20–46	25–44 25–60	650

Above rectifiers include only one tube.

SPECIAL RECTIFIERS—BATTERY CHARGING TYPE
NORMAL FREQUENCY 25 CYCLES—FREQUENCY LIMITS 25-60 CYCLES

115682	15–30	15– 45 45– 75	110 220	40955	40	75	8–17 22–28	9–25 38–40	590
115683	8–30	15– 45 45– 75	110 220	40955	40	75	8–17 22–28	9–25 38–40	640
115684	15–30	15– 45 45–120	110 220	40955	40	120	8–17 22–46	9–25 38–64	590
115685	8–30	15– 45 45–120	110 220	40955	40	120	8–17 22–46	9–25 38–64	640
115686	20–40	15– 45 45– 75	110 220	40958	60	75	8–17 22–28	9–25 38–40	635
115687	10–40	15– 45 45– 75	110 220	40958	60	75	8–17 22–28	9–25 38–40	690
115688	20–40	15– 45 45–120	110 220	40958	60	120	8–17 22–46	9–25 38–64	635
115689	10–40	15– 45 45–120	110 220	40958	60	120	8–17 22–46	9–25 38–64	690
115690	25–50	15– 45 45– 75	110 220	47409	60	75	8–17 22–28	9–25 38–40	660
115691	15–50	15– 45 45– 75	110 220	47409	60	75	8–17 22–28	9–25 38–40	720
115692	25–50	15– 45 45–120	110 220	47409	60	120	8–17 22–46	9–25 38–64	660
115693	15–50	15– 45 45–120	110 220	47409	60	120	8–17 22–46	9–25 38–64	720

Cat. Nos. on the above special rectifiers include only one tube.

When operated on 125 cycles the d.c. voltages given on this page will be about 15 per cent. lower.

MERCURY ARC RECTIFIER TUBES

Cat. No.	D.C. Amperes	D.C. Volts	D.C. Voltage Range
40949	10	100	1–150
40950	10	200	75–250
40952	20	100	1–150
40953	20	200	75–250
40955	30	100	1–150
40956	30	200	75–250
40958	40	100	1–150
40959	40	200	75–250
47409	50	100	1–150

Rectifier tubes will not be sold except with complete rectifier sets or for renewal purposes on G.E. rectifier sets already installed.

DIMENSIONS OF VARIOUS TYPES MERCURY ARC RECTIFIERS

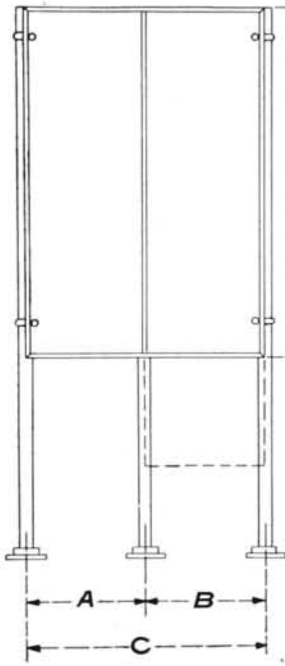


Fig. 17

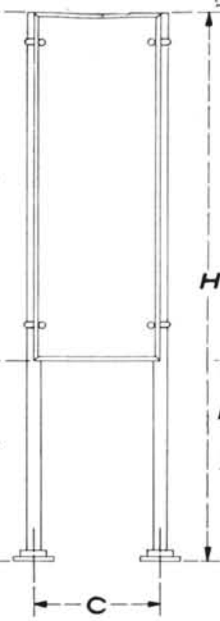


Fig. 18

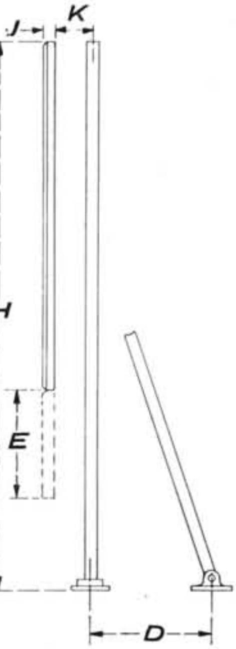


Fig. 19

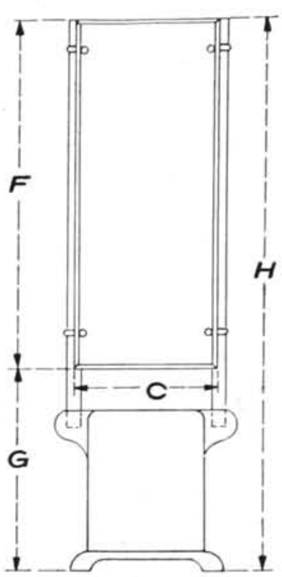


Fig. 20

Type	Fig.	A	B	C	D	E	F	G	H	J	K	Bevel
Standard 60/140 cycles	18 and 19	—	—	16	19	—	31	33	64	1½	2½	⅜
Standard 25/60 cycles	18 and 19	—	—	16	19	—	31	33	64	1½	2½	⅜
Runabout with meters	19 and 20	—	—	16	—	—	28	26	60	1½	2½	⅜
Runabout without meters	19 and 20	—	—	16	—	—	28	26	54	1½	2½	⅜
Garage	17 and 19	20	20	40	24	—	48	28	76	1½	2½	⅜
Garage subbase	17 and 19	—	20	—	—	16	—	—	—	1½	2½	⅜
Commercial	18 and 19	—	—	24	24	—	48	28	76	1½	2½	⅜

MOTOR-GENERATOR SETS

The General Electric motor-generator sets for battery charging are of two standard types.

MCC MOTOR-GENERATOR SET

The MCC sets consist of a direct current generator driven by a direct current motor, and the MIC sets consist of a direct current generator driven by an alternating current motor.

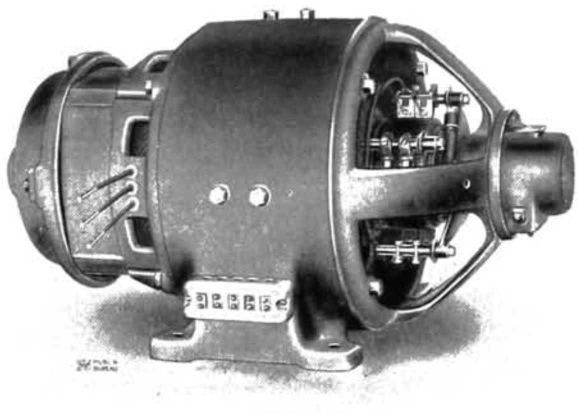
The MCC sets are equipped with 125 volt, shunt wound generators and 230 or 550 volt motors and range in capacity from 0.125 kw. to 13 kw., the speed varying from 2250 r.p.m. in the 0.125 kw. set to 1250 r.p.m. in the 12.5 kw. set. Both motor and generator have the same type and size of frame; these are bolted together and form a compact and symmetrical outfit.

4968-24 Electric Automobile Appliances

The MIC sets range in capacity from 0.2 kw. to 10 kw. and are equipped with 125 volt shunt wound generators and 110 or 220 volt single-phase motors or 110, 220, 440 or 550 volt two- or three-phase motors.

The speed of this type is 1800 r.p.m.

In designing these sets every effort has been made to avoid the use of complicated parts and this has resulted in simple, strong and compact machines, which will permanently maintain their high efficiency under rigid service conditions.



MIC MOTOR-GENERATOR SET

DETAILS OF EQUIPMENTS

TYPE D-8 AMMETER

D-8 Instruments

The Type D-8 ammeters and voltmeters which are used on the Public Garage panels and with the Commercial Vehicle and Public Garage rectifier outfits are standard round pattern, switchboard instruments of the highest grade mechanically and electrically. They are built on the D'Arsonval principle in accordance with the most modern practice and are dead beat, that is, the pointer comes quickly to rest after each change in the value of the current passing through the exciting coil. Combining a very small air gap between the magnet pole faces and the iron core with unusually high torque and light moving elements, these instruments possess exceptional and long continued accuracy. The scales are uniform throughout their entire length and are very legible, a point which is of great importance in all battery-charging work. The voltmeters are self-contained, and the ammeters are self-contained in capacities up to and including 60 amperes; above this, external shunts are used. The cases are of cast iron 7½ in. in diameter and the instruments are protected from stray fields and are dustproof. The standard finish is dull black with raised portions of polished copper.

For further information see Bulletin 4760.

Pocket Type Instruments

The Type OS or pocket instruments which are used on the Standard type of rectifier

POCKET TYPE AMMETER

outfit have been developed to meet the demand for an accurate, high grade and compact instrument. It is admirably adapted for use in connection with the rectifier panels as it combines with its small size an exceptional length of scale in proportion to the range of the instrument. It is built on the Thomson inclined coil principle and is substantially constructed. The case is of iron and affords protection against stray fields. The finish is dull black with bright copper parts.

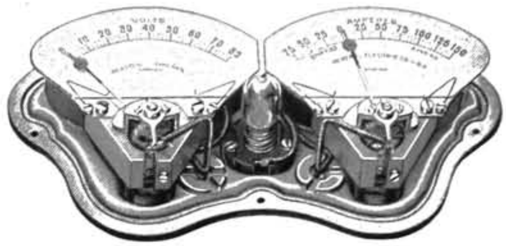
Further information regarding these instruments is given in Bulletin 4469.

Type DK-3 Instruments

The combination of ammeter and voltmeter which is known as the Type DK-3 automobile instrument (DK-5 when adapted for switchboard service) was designed primarily for use on electric automobiles but the design with slight modification lends itself so well to some classes of switchboard work that it has been adopted for use on the direct current private garage type of panels. The instrument contains two D'Arsonval elements

DK-3 COMBINED AMMETER AND VOLTMETER

so that, electrically, it is identical with the Type D-8 switchboard instruments. This insures accuracy and reliability under the most trying conditions of service. The design and construction are such that the instrument when used for this class of service will withstand without injury the constant vibration and exposure to which it is subjected. The magnets used in the Type DK-3 instruments are made from the best quality of magnet steel obtainable, this being put through a special hardening and aging process which insures almost absolute permanency. Type DK-3 instruments are dead beat and the scales are very open and have evenly spaced divisions throughout their range. These instruments are only 8⅜ in. by 4¼ in. over all and consequently require very little room. The terminals are in the base and



DK-3 COMBINED AMMETER AND VOLTMETER WITH COVER REMOVED

are so arranged that the wiring can be installed in the car and the instrument placed in position after the upholstering is finished. Each instrument is equipped with a small two candle-power lamp which is placed within the case so that no objectionable reflectors or shades are necessary. Lamps of different voltages can be furnished. When the instrument is used for automobile service a zero center scale is furnished for the ammeter as the current must be indicated both on charge and discharge, but when furnished for switchboard use, this is not usually necessary. For convenience in ordering as an automobile instrument, the following tabulation is given. Other scale values can be furnished on order.

For further information, see Bulletin 4848.

Cat. No. *	Capacities	
	Volts	Amperes
116050	80	75–0–150
116051	100	75–0–150
116052	120	75–0–150

* Cat. Nos. include leads, external shunt for ammeter and lamp.

Switches

The knife blade switches used on all of the General Electric Company's charging and rectifier panels are of the Company's Type L Form D12, which are strong and durable. The blade and shoulder at the handle end are forged in one piece from the best hard drawn copper and the clip block and stud also consist of a single forging. The contact clips are made of hard drawn spring copper securely pinned and soldered into the clip blocks. The hinge clips are provided with large and substantial spring washers which serve to maintain good contact; these spring washers are held under tension by positively locked nuts thus preventing the contacts from working loose. The cross bars are made of selected insulation firmly secured to the blade and the handles are of hard wood, stained black and polished and fastened to the cross bars by heavy studs and nuts. The copper parts are polished and lacquered to give the "draw file" finish. The lever switches are furnished both with and without clip blocks for holding fuses. All of the special switches of the knife blade type which are used on the rectifier panels follow fundamentally in details of construction the D12 switches and are of the same high grade.

TYPE L FORM D12 LEVER SWITCH WITH ENCLOSED FUSES

Data regarding these switches is given in Bulletin 4772.

Fuses

All fuses (except instrument fuses and the incoming line fuses listed with the panels catalogued on pages 9 and 10) included with the panels described in this bulletin are of the General Electric Company's enclosed type. They have ferrule contacts up to and including 60 amperes; above this they have knife blade contacts. One complete set of fuses is included in the panel catalogue numbers of capacities as listed.

The following table will be of assistance in determining the capacity of fuses best suited to the requirements of specific cases.

ENCLOSED TYPE

Fuse Block Ampere Rating	Ampere Capacity Standard Fuses
30	3–5–8–10–12–15–20–25–30
60	35–40–45–50–55–60
100	65–70–75–80–90–100
200	110–120–130–140–150–160–170–180–190–200
400	225–250–275–300–325–350–375–400

OPEN LINK TYPE

200	100–125–150–175–200
400	300–325–350–375–400
600	400–425–450–475–500–550–600
800	600–650–700–750–800
1000	800–850–900–950–1000

NOTE.—In selecting enclosed fuses, it should be observed that all are designed to carry 10 per cent. overload continuously, and to blow at 50 per cent. overload in from 1 to 12 minutes, depending on the capacity. Open link fuses are not rated as closely as the enclosed type but will carry approximately 10 per cent. overload indefinitely and blow at about 25 per cent. overload.

Circuit Breakers

While the standard equipments of the direct current charging panels include fuses connected in the supply mains, some other form of automatic protective device is sometimes required and while ordinarily fuses give entire satisfaction for this class of work, the circuit breaker has the advantage of being adjustable to trip instantaneously at any predetermined current over a wide range of calibration, and of requiring no renewals after opening.

Type C Form P Circuit Breakers

The General Electric Type C Form P circuit breaker represents the highest develop-ment in circuit breaker construction and is absolutely reliable, even when used on systems of extremely high generator capacity. This is a point which should be given careful consideration in selecting breakers for battery work, since a circuit breaker of low rupturing capacity may become a menace under short-circuit conditions rather than a protection. In addition to adequate rupturing capacity the Type C Form P breakers have among other characteristics, the following:

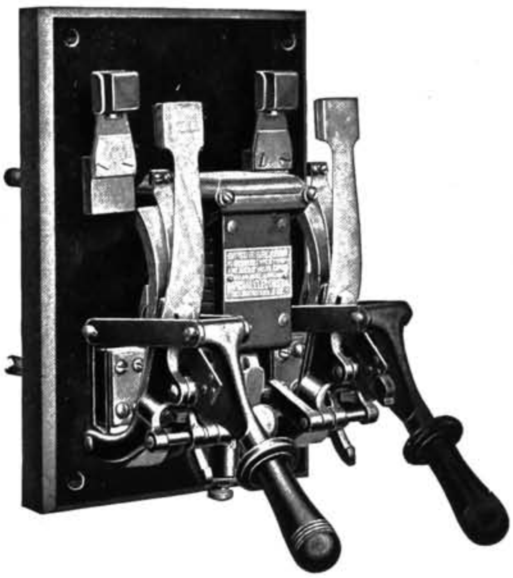
1. Ease of closing is secured by a toggle mechanism that also prevents the breaker from opening as a result of jar.

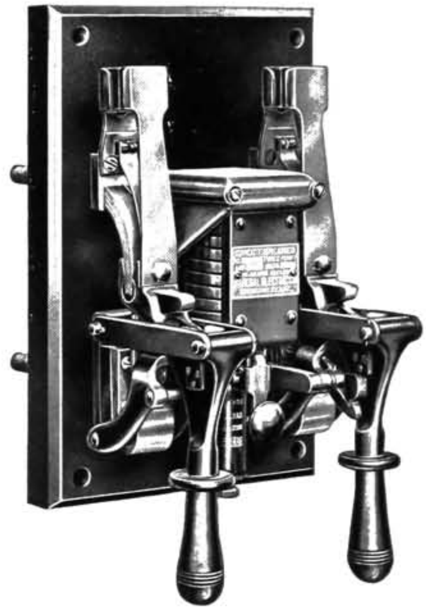
2. A special form of laminated brush is used that insures an end contact on each lamination and equally distributes the pressure over the contact surface.

3. The main contacts are protected from burning by auxiliary copper and carbon contacts, the arc being finally ruptured on these contacts. While this feature is not peculiar to General Electric breakers, the method of holding the carbons and the facility with which burned contacts may be replaced is not duplicated in devices of other manufacture.

4. The opening of the breaker is positively and quickly accomplished when tripped, by the spring of the laminated brush and the action of gravity, no auxiliary springs being employed.

The finish is attractive, all copper current carrying parts being polished and lacquered, links, pins, etc., being copper plated and given a coat of black oxide to prevent corrosion.





DOUBLE-POLE TYPE C FORM P CIRCUIT BREAKER, OPEN AND CLOSED

These breakers are made single-, double-, and triple-pole, for 250 volt circuits and in current capacities ranging from 15 to 1200 amperes. To meet the demand for a circuit breaker which will open under conditions other than abnormal current, the General Electric Company is prepared to furnish breakers equipped as follows:

With Underload Trip.—With this device the breaker opens when the current falls below a certain predetermined value.

With Reverse Current Trip.—With this device the breaker opens when there is a reversal of the direction of the current flowing in the circuit.

With Low Voltage Release.—With this device the breaker opens when the voltage of the circuit falls below a certain predetermined value.

With Shunt Trip.—With this device the breaker is opened from an auxiliary tripping circuit which may have no connection with the circuit in which the breaker is connected.

Any of these devices may be used alone or in combination with any other, proper auxiliary switches being in some cases necessary. Time-limit relays can also be furnished which introduce a delay when

SHUNT TRIP ATTACHMENT FOR TYPE C FORM P CIRCUIT BREAKERS

required between the time of the occurrence of the abnormal condition in the circuit and the actual opening of the breaker.

Further information regarding these breakers is contained in Bulletin 4839.

Type C Form G Circuit Breakers

The overload circuit breakers used on the Mercury Arc Rectifier Panels are the company's Type C Form G which were developed to meet the demand for an inexpensive

DOUBLE-POLE TYPE C FORM G CIRCUIT BREAKER
250 VOLT OVERLOAD

automatic protective device for systems of small capacity. While this circuit breaker is of considerably lighter mechanical construction and does not have the same rupturing capacity as the Type C Form P, it is nevertheless an efficient and reliable device, when used for the service for which it is designed. It has the same special features which have been mentioned in connection with the Type C Form P breakers with the exception that in the underload type (not used with the rectifier panels), the opening is accomplished by means of springs. While for general switchboard work the Type C Form P breaker is recommended in preference to the Type C Form G, the latter has many applications. The CG breaker can be obtained either single-, double- or triple-pole and in current capacities ranging from 3 to 300 amperes. The standard finish is similar to that given all other types of General Electric breakers.

Further details are given in Bulletin 4840.

AUTOMOBILE MOTORS

The ultimate success of any type of electrical vehicle depends very largely upon the efficiency of the propelling motor.

The motor to attain the maximum possibilities for this service should embody in its design those features which assure the necessary structural strength combined with high torque per ampere values, well chosen speed characteristics, high efficiency at all loads and ample overload capacity.

While unnecessary weight is to be avoided, the use of iron and copper can not be unduly stinted without materially reducing the high electrical qualities so essential where the source of power is limited, as when derived from storage batteries.

The torque per ampere is relatively high and increases in direct proportion as the current increases, and this without causing a material decrease in efficiency when the motor is exerting extra power or operating on overload.

G-E AUTOMOBILE MOTOR

The frames are made from cast steel, cylindrical in form, and are accurately machined, thus being readily applicable to the various special forms of suspension employed.

Ball bearings are used throughout, affording a reduction in dimensions, friction losses and weight.

While the General Electric standard line of automobile motors includes only nine sizes of frames, this number is successfully meeting the pleasure and commercial demands of all classes of service, from the light runabout, coupe, or speedy roadster to baggage trucks or those built for five-ton loads.

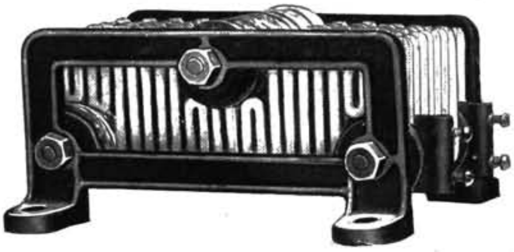
STANDARD G-E AUTOMOBILE MOTORS

The General Electric Company's universal type of automobile motor has embodied to the fullest extent the theoretical possibilities in its torque, speed and efficiency characteristics combined in a strongly constructed yet light weight motor.

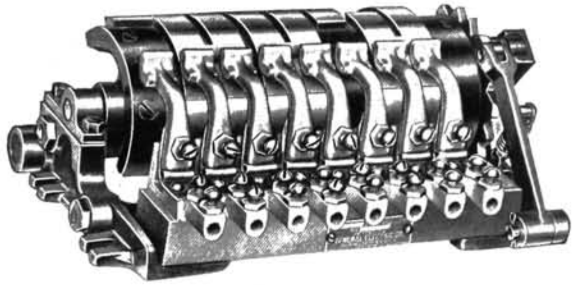
AUTOMOBILE MOTOR CONTROLLER

For each type of motor and class of service a controller embodying the continuous torque control features is provided.

Continuous torque control assures the starting and acceleration of the vehicle



RESISTANCE FOR ELECTRIC VEHICLES



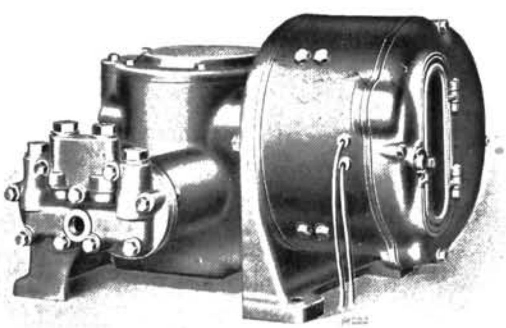
AUTOMOBILE MOTOR CONTROLLER

by gradual, easy steps and eliminates entirely the series of jerky movements so objectionable to the operator or passengers and detrimental to the transmission. In combination with this type of control and windings employed, a marked improvement in efficiencies is secured, thus affording increased mileage per battery charge.

All resistances are of the widely-known grid type which has proved more satisfactory than any other type in the past few years. The grid type units give the greatest thermal capacity with a minimum weight and ensure freedom from burn-outs, as mica insulation is used throughout.

AUTOMATIC AIR COMPRESSOR OUTFITS

The use of compressed air under automatically regulated pressure is a necessity in the modern garage. In addition to furnishing an ideally efficient method of inflating



CP-27 AIR COMPRESSOR

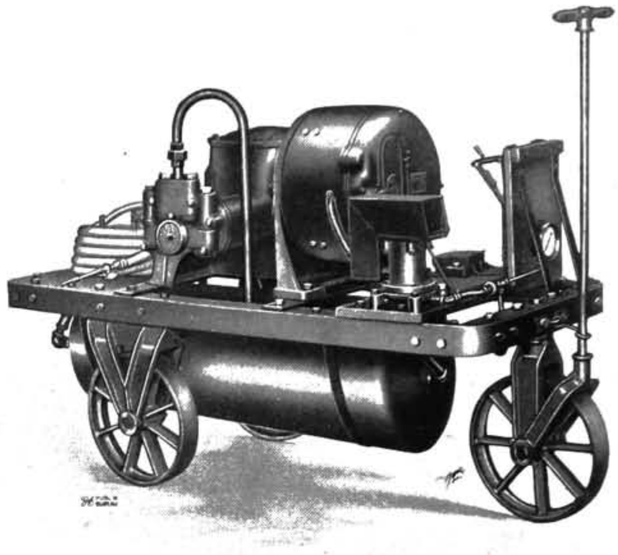
AIR COMPRESSOR GOVERNOR, TYPE MC

tires, it may be used for cleaning the upholstery and machinery of cars.

The General Electric compressor outfit is similar in construction to that used in the company's air brake system for electric cars. It consists of a motor-driven air compressor, an automatic governor and a combined switch and fuse, together with storage tanks, cocks, etc. The motor is series wound and can be furnished for operating on 550, 250 or 125 volts direct current circuits or on two-phase or three-phase 25, 40 or 60 cycle, 110, 220 or 440 alternating current circuits. The motor drives the compressor through a herring-bone gear.

The cylinder heads are formed by a single casting secured to the cylinders by tap bolts.

There is one intake and one discharge valve in each cylinder head. The intake air passages have liberal areas and are arranged closing the main switch the governor will maintain the air in the tanks at a predetermined pressure without further attention.



PORTABLE AIR COMPRESSOR SET

so that the incoming air must pass through an air strainer. For further details see Bulletins No. 4699A and 4810.

The use of clean filtered air eliminates the trouble caused by dirt-clogged tire valves.

One of the most practical features of this outfit is the fact that it is automatic. After For further details of the governor see Bulletin No. 4427A.

The capacity of the compressors may be either 15 or 25 cubic feet piston displacement per minute at pressures up to and including 90 pounds per square inch.

CHARGING PLUG AND RECEPTACLE FOR COMMERCIAL VEHICLE

A commercial vehicle to be a business proposition must give continuous service over a long period of time. All parts must be

PLUG FOR CHARGING RECEPTACLE

so constructed as to withstand rough handling, shocks and mis-use. These requirements apply to the mechanical features of a vehicle but particularly to the electrical equipment.

A charging plug and receptacle as part of the electrical equipment must necessarily be

CHARGING RECEPTACLE FOR BATTERIES

of the same strong construction. To meet the demand for apparatus of this type, the General Electric Company has developed a plug and receptacle which embody in their construction all the features which are desirable from a mechanical standpoint and combine to give the maximum of efficiency during the charging operation.

For the purpose of keeping out water and dirt and for the protection of the internal parts, the receptacle is provided with a hinged cover which, actuated by a stout spring, automatically swings into position when the charging plug is removed. This action is very positive and the cover cannot be jarred out of position by the movements of the vehicle. The interior walls of the receptacle are protected from rust by a coat of enamel. If necessary the moulded interior can be removed and replaced by the removal of the screw and cover plate holding it in place.

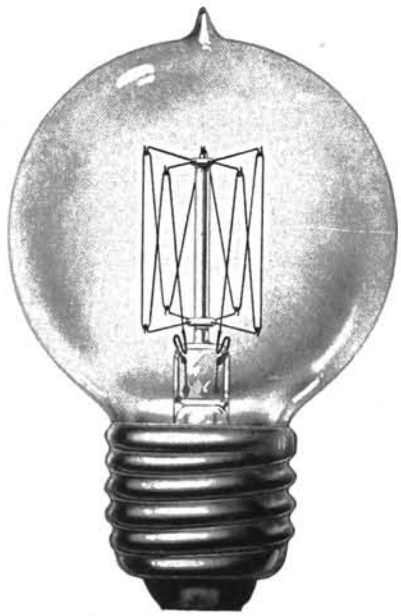
The charging plug which is liable to rough usage through careless handling is built to withstand very severe treatment. Each of the contacts is protected by a ring of insulating compound. The outside brass shell acts only as a carrier for the outer insulating ring. This arrangement prevents the plug from being short circuited when dropped on a metal floor or in contact with any metallic substance. The insulating compound is fireproof, allowing the charging leads to be permanently sweated in without softening of the material. One end of the wooden handle is counter-bored to provide for tying a knot in the leads before soldering. This takes the strain off the joint in case the plug is accidentally pulled out by means of the cable.

The plug is designed to be self-centering and cannot be inserted in the receptacle in any but the proper manner. When in place a rigid electrical connection is made between contacts of a generous area which insures the transmission of the charging current at the maximum of efficiency. The normal capacity is 100 amperes with an ability to withstand 50 per cent. overload for an indefinite time.

G-E EDISON MAZDA ELECTRIC VEHICLE LAMPS

The General Electric Company has developed a line of Mazda Incandescent lamps with drawn wire filaments specially designed for use on electric vehicles. These lamps are suitable for head-lights, side-lights or tail-lights and can be furnished in any voltage from 21 to 90, thus making them adaptable to both commercial and pleasure vehicles.

The high efficiency of the Mazda lamp (which operates at 1.23 watts per candle, and therefore consumes only about one-third the current of the old carbon lamp) results in a great saving in power consumption, which is an important factor in storage battery operation. The G-E Edison Mazda lamp gives a brilliant white light—a valuable feature especially when used as a head-light—and the lamp, because of the high specific resistance of the filament, undergoes smaller change in candle-power, efficiency, and life than a carbon lamp, with a given variation in line voltage. This is advantageous especially in storage battery operation where variations in voltage are likely to occur.



G-16½ BULB—15 WATTS

The drawn wire filament is much stronger than the old pressed filament at any time during life; therefore it is much better able to with-

G-18½ BULB—25 WATTS

stand the jars and strains incident to vehicle operation. It is continuous and is clamped to the leading in wires which makes a more flexible joint. This type of mount, shorter than that of the old pressed filament, together with the fact that the drawn wire is stiffer at operating temperatures than the pressed filament, adds to the strength of the lamp and eliminates the danger of sagging and crossing of the filament.

The accompanying illustrations show the two sizes of bulb in which electric vehicle lamps are made.

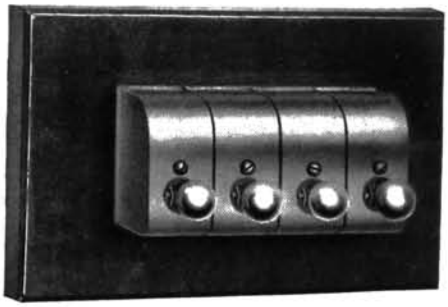
For further data regarding lamps, reflectors and the various wiring supplies for use in electric automobiles, see Bulletin 4795.

TUMBLER AND SNAP SWITCHES

TWO-GANG COMBINATION TUMBLER SWITCH

SINGLE-POLE TUMBLER SWITCH

These switches are made in two styles, flush and surface. All parts are especially strong and adapted to automobile service. The movement of the switch is controlled by means of the projecting lever, and does not depend upon the action of springs. All switches listed, when made up in combinations of two or more are furnished with busbar terminals, allowing all connections to be made at the switch, thereby eliminating all joints and splices.



FOUR-GANG SURFACE TUMBLER SWITCH

A form of the standard push button switch in miniature; made up in very compact form and suitable for use where space is limited. The buttons are of metal. The terminal plate is held in place by two long screws which prevent it from jarring loose. The switch is supplied with either the ordinary push button control or with lock control and key and furnished in any combination of gangs.

SINGLE-POLE FLUSH PUSH BUTTON SWITCH

The three-circuit snap switch is designed to be mounted on the back of the dashboard The escutcheon plate and switch handle are the only parts visible then from the front. The switch handle may be removed to prevent tampering with the lights. The switch may be wired to give the following combinations: 1st position, side and tail lights; 2nd position, head and tail lights; 3rd position, all lights on; 4th position, all lights off.

THREE-CIRCUIT SNAP SWITCH WITH MOULDED HANDLE

THREE-CIRCUIT SNAP SWITCH WITH LOCK ATTACHMENT AND KEY

TWIN CHARGING CABLES

These cables should be ordered by specification number, giving the ampere capacity and number of feet required.

25 Ampere Twin Cable

Spec. No. 1942 "A" 25 ampere cable, each conductor consisting of 49 No. 25 B.&S. gauge (equal to No. 8 B.&S. gauge) insulated with $\frac{3}{64}$ in. red core rubber weatherproof braid. Two such conductors are laid flat and finished with a weatherproof double braid.

50 Ampere Twin Cable

Spec. No. 1942 "B" 50 ampere cable, each conductor consisting of 49 0.024 in.

copper wires (equal to No. 6 B.&S. gauge) insulated with $\frac{1}{16}$ in. red core rubber weatherproof braid. Two such cables are laid flat and finished with a weatherproof double braid.

100 Ampere Twin Cable

Spec. No. 1942 "C" 100 ampere cable, each conductor consisting of 49 0.041 in. tinned copper wires (equal to No. 1 B.&.S gauge) insulated with $\frac{5}{64}$ in. red core rubber weatherproof braid. Two such conductors are laid flat and finished with a weatherproof double braid.

125 Ampere Twin Cable

Spec. No. 1942 "D" 125 ampere cable, each conductor consisting of 61 0.041 in. copper wires (equal to No. 0 B.&S. gauge) insulated with $\frac{5}{64}$ in. red core rubber weatherproof braid. Two such conductors are laid flat and finished with a weatherproof double braid.

Information Blank for Public Garage Charging Equipment

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.

For the...Garage

....Manager

City..State......................

(A) NATURE OF SUPPLY

1. Alternating or Direct Current..

2. Frequency (if alternating)......................Cycles No. Phases..................................

3. If both a-c. and d-c. available, give rate on each { alternating...................cents per kilowatt-hour; direct...................." " " "

4. Voltages available { alternating...volts; direct...volts

5. Approximate percentage fluctuation in voltage { alternating.................................%; direct.................................%

6. Remarks..

....

(B) CHARGING INFORMATION

7. Will charging operators be on duty day and night?...

8. Number of cells and charging rates of batteries:

Number Batteries	Number Cells	Type	Number Charges per Week	Average Hours Charging Required per Charge	Normal Charging Rate			Overcharge and How Long Required		Maximum Number Cars to Charge at One Time	Minimum Number Cars to Charge at One Time
					Amp. Start	Amp. Finish	Time Hours	Amp.	Hrs.		
	24										
	28										
	30										
	32										
	36										
	40										
	42										
	44										
	24										
	40										
	60										

9. Charging apparatus installed at present time...

....

10. Remarks...

....

Date..191...... Signed...

....

If complete recommendations on a charging equipment are desired, fill out this blank completely and mail to the nearest sales office with request.

Information Blank for Multiple Mercury Arc Rectifier

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.

IMPORTANT NOTICE

The rectifier tubes and auxiliary devices for use therewith are licensed for use respectively only with auxiliary devices and tubes sold by or under license from the General Electric Company.

1st. NATURE OF LOAD

IF BATTERIES STATE:

1. Maker's name...
2. Number of cells...
3. Number of cells in series...
4. Rate of charging recommended by maker...
5. Ampere-hour capacity as operated...
6. Charging amperes required (a) maximum..................(b) minimum..................(c) average..................
7. Volts per cell (a) fully charged..................(b) discharged..................
8. Are batteries to float on rectifier or to be charged and discharged?..................

....

IF NOT BATTERIES STATE:

9. Intended use...
10. Amperes required (a) maximum..................(b) minimum..................(c) average..................
11. Voltage required direct current...
12. Range of regulation required direct current voltage...

2d: NATURE OF SYSTEM

13. Frequency...
14. Alternating current voltage available...
15. Approximate percentage fluctuation in alternating current voltage..................
16. Further information...

....

Date..................................191...... Signature...

....

Address...

Note.: The information called for on this blank should be FULLY and CAREFULLY given.

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E. C., England, 83 Cannon St.

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

General Electric Company
Schenectady, N.Y.

SUPPLY DEPARTMENT

August, 1912 *Bulletin No. 4973*

RESISTANCE UNITS

The success of motor starting and controlling apparatus depends, to a great extent, upon the resistance units which are used in the construction of the rheostats.

The service required of the controlling apparatus is almost as varied as that of the motors which they control. The rheostat must, consequently, be designed to meet the same exacting conditions.

The service varies from a few seconds starting duty to continuous use under all conditions of vibration and moisture, meeting such extremes as are found in steel mills, mining, marine service and powder mills.

The General Electric Company has developed a complete line of resistance units for all kinds of service (Fig. 1). The object of this bulletin is to describe the various types and the uses for which they are designed and especially adapted.

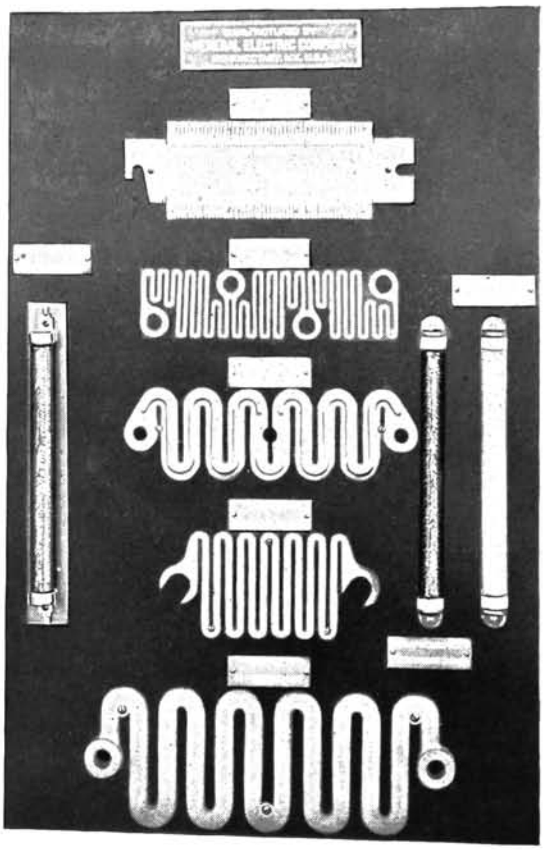


Fig. 1
RESISTANCE UNITS

FORM P UNITS

In the construction of Form P resistance units (Fig. 2) a low temperature co-efficient resistance wire is wound on an asbestos tube making them non-fragile. After being wound the tube is treated with a special compound forming a coating inside and out, re-inforcing the tube and imparting strength and solidity. A porcelain bushing is inserted in each end of the tube, the coating compound cementing it in place. The unit is then thoroughly baked and when completed will withstand very rough usage. The coating being a good conductor of heat, produces uniform radiation.

When this type of unit is subjected to very excessive current and raised to such a degree of heat as to melt the wire, the circuit will open without appreciable arcing and as the wire is embedded in a cementing compound the coil cannot unwind.

Ratings

The Form P units are made in six standard sizes: A, B, C, D, E and F. Their continuous ratings being 35, 50, 80, 175, 350 and 115 watts respectively when assembled in frames which afford good ventilation.

As resistance units are used for so many different purposes, it is hard to give them a definite watt rating. Those mentioned above are only used when assembled in a frame affording free ventilation.

Customers contemplating purchasing this form of unit in quantity should correspond with the nearest district or local office for more definite information in regard to the watt rating, specifying the conditions under which the units must operate.

Form P units are extensively used in small motor starting and controlling apparatus and for armature and field resistance. They are also used as permanent resistances to protect contactor and circuit breaker coils, and as series resistances in signal work, etc. The units are mounted in punched end frames by means of porcelain bushings which insure good insulation from the frames.

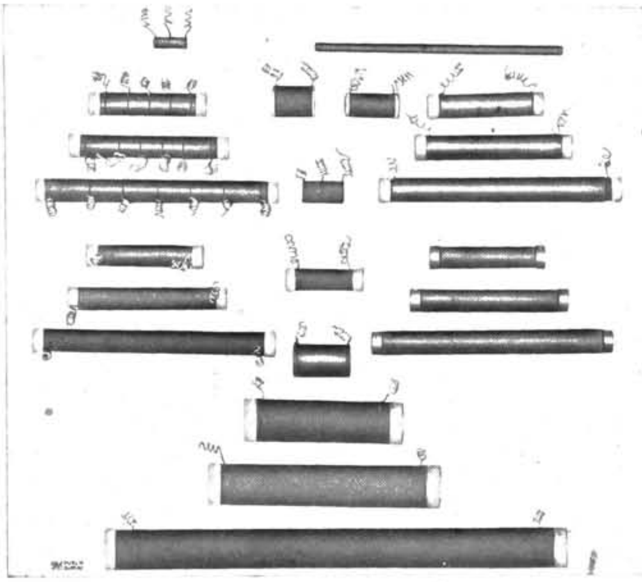


Fig. 2
FORM P RESISTANCE UNITS

FORM PM UNITS

Form PM units (Fig. 3) are similar to the Form P, except that metal bushings are used in place of the porcelain. They can thus be mounted by inserting them in fuse clips which greatly facilitates quick repairs and replacements.

Fig. 3
FORM PM RESISTANCE UNITS

Form PM units can be furnished in the same ratings as the Form P.

FORM PE UNITS

The Form PE unit is a special type of the Form P and is used extensively in connection with switchboard instruments (Fig. 4). A special porcelain bushing is used in this type and the leads are attached on the inside of the tube. They are enclosed in perforated metal casings, to adapt them for switchboard mounting, which produce a neat appearance, and at the same time provide good ventilation and protection.

The cases are designed to enclose from one to four units of the same size and rating as the Form PB size units.

EDGEWISE WOUND UNITS

The edgewise wound unit is made of a strip of steel or german silver or other special alloy and is wound on edge (Fig. 5). After the resistance is formed it is stretched apart and dipped in a fireproof cement. It is then put on the iron tube, insulated by mica, the taps attached, and pressed together forcing the cement from between the convolutions except for a very thin layer. This layer of cement insulates the adjacent turns from each other. The unit is then thoroughly baked, producing a solid compact unit capable of withstanding the severest use.

Fig. 4
FORM PE RESISTANCE UNITS

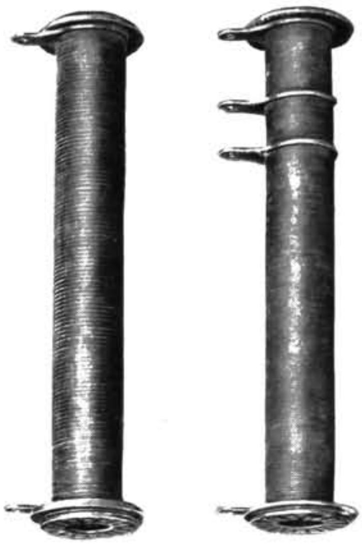


Fig. 5
EDGEWISE WOUND RESISTANCE COIL

They are extensively used for work in which the jarring is excessive, such as crane and turret service on battle ships and gun boats. They are also used in enclosed starters.

PLATE TYPE RESISTANCE

The plate type resistance consists of small coils of wire of a very low temperature coefficient. The coils are assembled in a retaining plate formed of a special pressed compound. When the units are assembled, a slight tension is used to separate the convolutions, the coils are then covered with a fireproof cement completely filling all the space inside and surrounding the coils. The plate is then dried and baked and a bottom cover attached. The units being entirely embedded in the cement, no visible arcing is produced in case the rheostat is burned out by overheating. The danger from fire is consequently eliminated (Fig. 6).

The units are only adapted to small current carrying capacities, when embedded in cement, being rated from 5 to 10 amperes for continuous service. When assembled in plates they are rated according to their watt dissipation.

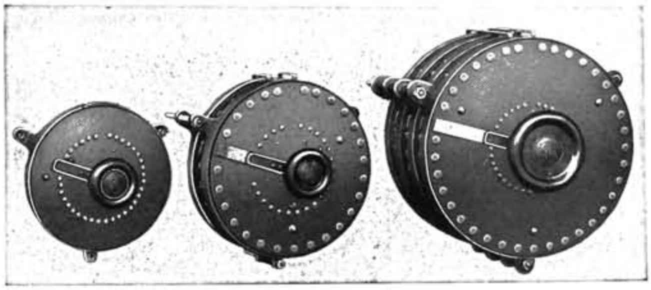


Fig. 6
PLATE TYPE RESISTANCES

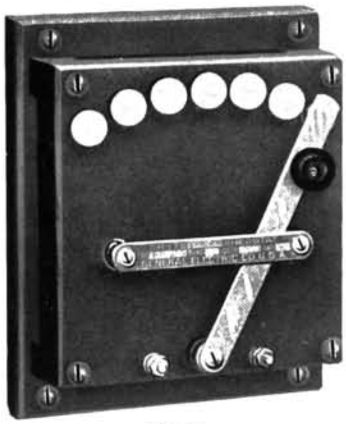


Fig. 7
REGULATING RHEOSTATS FOR HOUSEHOLD MOTORS AND HEATING DEVICES

For higher current capacities and watt dissipation the plates are connected in multiple.

The plate type is used extensively in the construction of field rheostats, theater dimmers and speed regulation for small motors. Small regulating rheostats for use with glue pots, shoe irons, etc., are made of the plate type units (Fig. 7).

Complete ratings of plate type rheostats are given in Bulletin No. 4814, copy of which will be forwarded from the nearest district office upon request.

FORM R UNITS—MOISTURE PROOF

In the manufacture of Form R (Fig. 8) units, a bare non-corrosive wire of low temperature coefficient is wound on grooved porcelain insulating supports. The porcelain supports are mounted on rust proof special sheet metal punchings arranged for assembling in frames.

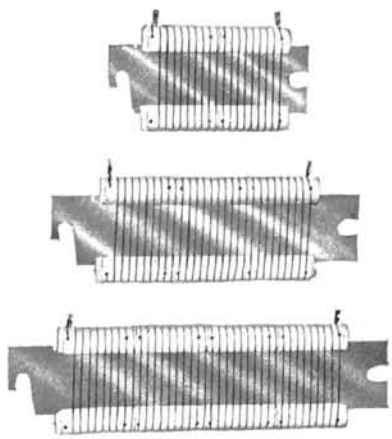


Fig. 8
FORM R RESISTANCE UNITS SHOWING WY AND Z SIZES

This construction produces a moisture proof unit particularly adapted for use in damp places such as mine and marine service (Fig. 9).

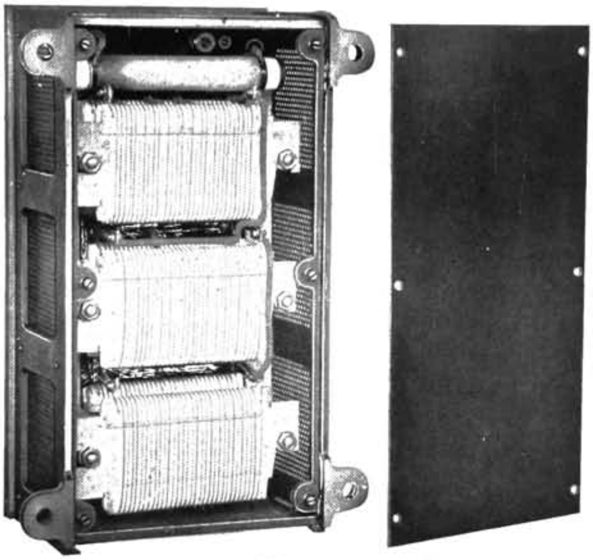


Fig. 9
ASSEMBLY OF FORM R RESISTANCE UNITS IN AN ENCLOSING CASE FOR MARINE SERVICE

Rheostats built of these units are used extensively on shipboard to meet naval specifications, where they are subjected to the salt air. They are also used very extensively in the Canal Zone, Panama, where the damp moist air during the rainy season soon destroys the insulation of the ordinary commercial resistance units.

They can very easily be removed from the frames and replaced, thus facilitating quick repairs. Taps are made by means of screw clamps.

Form R units are made in three sizes.

Fig. 10
FORM V RESISTANCE UNITS

FORM V GRIDS

Form V grids are stamped from sheets of german silver or calorite (Fig. 10). The one set of dies cuts the outline and presses the grid into form giving it a V cross section. This produces a non-oxidizing non-fragile unit capable of standing the most severe vibration.

Although adapted to all kinds of service, these units were originally designed for use in gunboat turrets where the serious concussion of gun discharge would shatter the PM grid resistance.

The V unit is not affected by moisture or salt water and therefore is especially adapted for marine service in that respect.

These grids are assembled in punched end frames and are insulated from them and from each other by mica tubes and washers.

The dimensions and ratings furnished on application.

TYPE IG UNITS

Type IG, or iron grid units, are designed particularly for heavy starting and speed controlling service (Fig. 11). The larger units are provided with two supporting lugs and the smaller sizes with three or four lugs.

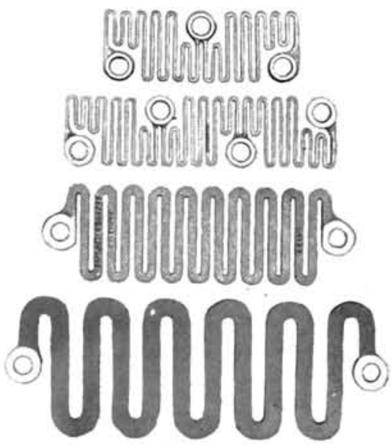


Fig. 11
TYPE IG RESISTANCE UNITS

The grids are mounted on tie rods between cast iron or punched end frames being insulated from the rods and frame by mica tubes and washers (Fig. 13). The grids are made in four sizes and when arranged in series have a continuous capacity of 20 to 200 amperes.

The IG grid lends itself readily to ventilation and dissipates heat rapidly. It can be heated to a bright red color without injury.

This type of resistance is used in the construction of large motor starting and controlling rheostats, and large field rheostats. (Fig. 12.)

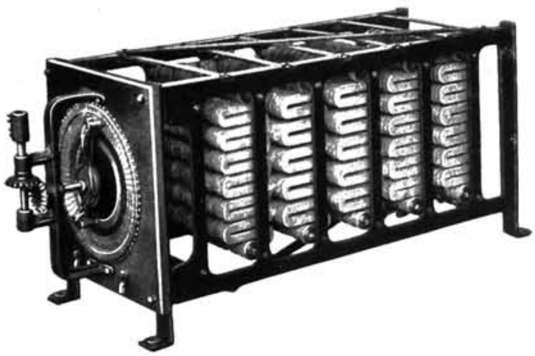


Fig. 12
ASSEMBLY OF IG RESISTANCE UNITS IN LARGE RHEOSTATS

RG UNITS

While the RG grid (Fig. 14) has been developed principally for railway service, its solid construction, flexibility and liberal rating render it highly useful for industrial purposes. The grids are made

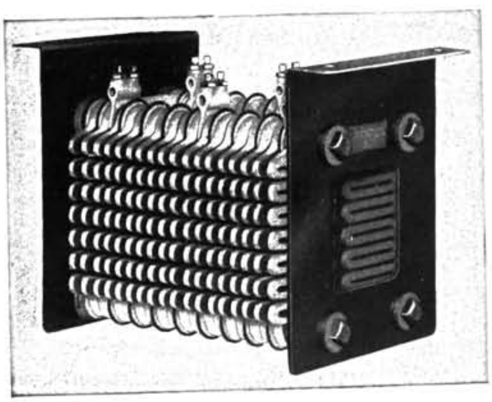


Fig. 13
ASSEMBLY OF RG GRIDS

of a highly uniform grade of cast iron, giving maximum strength and elasticity. The large cross section and short convolutions eliminate the liability of breakage or short circuits due to vibration. When subjected to heavy overloads and suddenly cooled they are not apt to break, a feature which renders them very reliable.

The assembly of these grids in rheostats for industrial purposes is the same as for

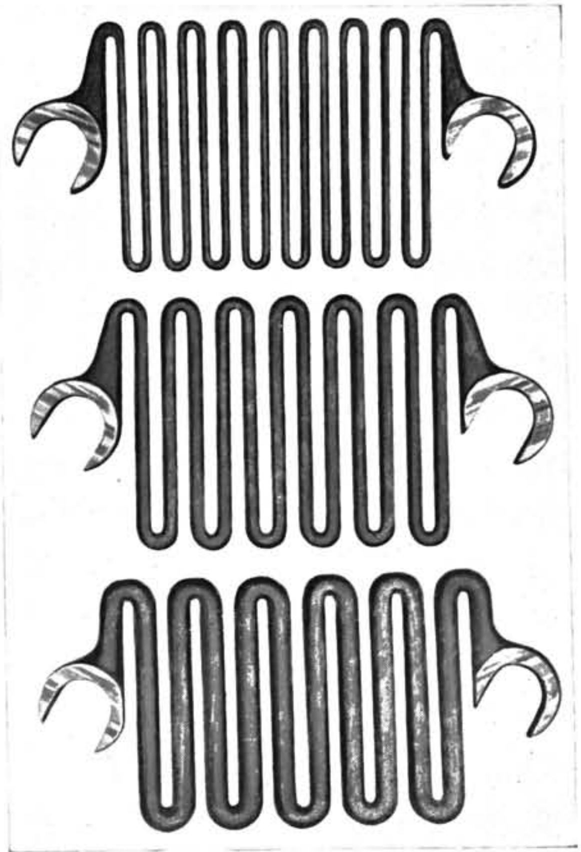


Fig. 14
RG RESISTANCE GRIDS

railway work, the only difference being the character of the end frames (Fig. 13). They consist of pressed steel end plates arranged for installing one above the other. This feature allows a great saving in floor space. The grids are assembled on supporting rods which have been covered with a mica insulating sleeve. They are supported at the top and bottom by means of slotted lugs and the openings are so arranged that the grids cannot drop out but must be raised when removed. It is only necessary to loosen the nuts of the supporting rods when the grid can be removed without disturbing the remaining units.

RATINGS OF FORM P RESISTANCE UNITS

SIZE A — 5½ in. long, 1 in. diam. Capacity: Less than 500 ohms, 35 watts. 500 ohms and above, 15 watts

Symbol	Ohms	Amp. Cont.
0.25 A	0.25	12.0
0.3 A	0.30	11.0
0.4 A	0.40	9.4
0.5 A	0.50	8.3
0.75 A	0.75	6.8
1 A	1	5.9
1.25 A	1.25	5.3
1.5 A	1.5	4.8
2 A	2	4.2
2.5 A	2.5	3.7
3 A	3	3.4
4 A	4	2.9
5 A	5	2.6
7.5 A	7.5	2.1
10 A	10	1.87
15 A	15	1.53
20 A	20	1.32
25 A	25	1.8
35 A	35	1.00
45 A	45	0.88
50 A	50	0.835
60 A	60	0.765
75 A	75	0.684
100 A	100	0.591
125 A	125	0.528
150 A	150	0.483
200 A	200	0.417
300 A	300	0.342
500 A	500	0.17
700 A	700	0.146
1000 A	1000	0.122
2000 A	2000	0.086
3500 A	3500	0.065

SIZE B — 7½ in. long, 1 in. diam. Capacity: Less than 500 ohms, 50 watts. 500 ohms and above, 20 watts

Symbol	Ohms	Amp. Cont.
0.25 B	0.25	14.0
0.3 B	0.30	12.9
0.4 B	0.40	11.2
0.5 B	0.50	10.0
0.75 B	0.75	8.15
1 B	1	7.07
1.25 B	1.25	6.31
1.5 B	1.5	5.75
2 B	2	5.0
2.5 B	2.5	4.46
3 B	3	4.07
4 B	4	3.5
5 B	5	3.16
7.5 B	7.5	2.58
10 B	10	2.2
15 B	15	1.83
20 B	20	1.5
25 B	25	1.4
35 B	35	1.2
45 B	45	1.05
50 B	50	1.00
60 B	60	0.915
75 B	74	0.815
100 B	100	0.706
125 B	125	0.632
150 B	150	0.576
175 B	175	0.535
200 B	200	0.500
250 B	250	0.45
300 B	300	0.41
350 B	350	0.38
400 B	400	0.35
500 B	500	0.20
600 B	600	0.18
700 B	700	0.168
800 B	800	0.158
900 B	900	0.148
1000 B	1000	0.141
1200 B	1200	0.129
1400 B	1400	0.120
1600 B	1600	0.112
1800 B	1800	0.105
2000 B	2000	0.1
3000 B	3000	0.081
4000 B	4000	0.07
5000 B	5000	0.063

SIZE C — 11½ in. long, 1 in. diam. Capacity: Less than 500 ohms, 80 watts. 500 ohms and above, 30 watts

Symbol	Ohms	Amp. Cont.
0.1 C	0.10	28.2
0.2 C	0.20	20.0
0.3 C	0.30	16.3
0.4 C	0.40	14.15
0.5 C	0.50	12.6
0.6 C	0.60	11.5
0.75 C	0.75	10.35
1 C	1	8.95
1.25 C	1.25	8.0
1.5 C	1.5	7.3
1.75 C	1.75	6.75
2 C	2	6.3
2.5 C	2.5	5.65
3 C	3	5.15
3.5 C	3.5	4.78
4 C	4	4.64
5 C	5	4.0
7.5 C	7.5	3.62
10 C	10	2.83
12 C	12	2.58
15 C	15	2.30
20 C	20	2.0
25 C	25	1.78
30 C	30	1.64
45 C	45	1.33
50 C	50	1.25
75 C	75	1.03
100 C	100	0.895
125 C	125	0.895
150 C	150	0.73
200 C	200	0.63
225 C	225	0.59
250 C	250	0.565
300 C	300	0.52
325 C	325	0.495
350 C	350	0.475
375 C	375	0.460
400 C	400	0.446
450 C	450	0.421
500 C	500	0.24
600 C	600	0.22
700 C	700	0.21
800 C	800	0.19
1000 C	1000	0.17
1200 C	1200	0.15
1400 C	1400	0.14
1600 C	1600	0.13
1800 C	1800	0.12
4800 C	4800	0.08
5000 C	5000	0.07

SIZE D — 11 in. long, 2 in. diam. Capacity 175 watts

Symbol	Ohms	Amp. Cont.
0.25 D	0.25	26.5
0.3 D	0.3	24.2
0.4 D	0.4	21.0
0.5 D	0.5	18.7
0.6 D	0.6	17.0
0.75 D	0.75	15.3
1 D	1	13.2
1.25 D	1.25	11.8
1.5 D	1.5	10.8
1.75 D	1.75	10.0
2 D	2	9.3
2.5 D	2.5	8.3
3 D	3	7.6
3.5 D	3.5	7.1
4 D	4	6.6
4 D	5	5.9
6 D	6	5.4
6.5 D	6.5	5.2
7.5 D	7.5	4.7
10 D	10	4.2
15 D	15	3.4
20 D	20	2.9
25 D	25	2.6
30 D	30	2.4
35 D	35	2.2
40 D	40	2.1
45 D	45	1.9
50 D	50	1.8
55 D	55	1.75
60 D	60	1.7
65 D	65	1.6
70 D	70	1.58
75 D	75	1.53
100 D	100	1.3
125 D	125	1.1
150 D	150	1.08
200 D	200	0.93
225 D	225	0.88
250 D	250	0.83
300 D	300	0.76
325 D	325	0.73
350 D	350	0.71
375 D	375	0.68
400 D	400	0.66
450 D	450	0.62

SIZE E — 22 in. long, 2 in. diam. Capacity 350 watts

Symbol	Ohms	Amp. Cont.
0.25 E	0.25	37
0.3 E	0.3	34
0.4 E	0.4	30
0.5 E	0.5	27
0.6 E	0.6	24
0.75 E	0.75	22
1 E	1	19
1.25 E	1.25	17
1.5 E	1.5	16
1.75 E	1.75	15
2 E	2	14
2.5 E	2.5	12
3 E	3	11
3.5 E	3.5	10.5
4 E	4	10
5 E	5	8.7
6 E	6	8
6.5 E	6.5	7.7
7.5 E	7.5	7.2
10 E	10	6.2
15 E	15	5
20 E	20	4.4
25 E	25	3.9
30 E	30	3.6
35 E	35	3.3
40 E	40	3.1
45 E	45	2.9
50 E	50	2.8
55 E	55	2.6
60 E	60	2.5
65 E	65	2.4
70 E	70	2.3
75 E	75	2.2
100 E	100	1.9
125 E	125	1.7
150 E	150	1.5
200 E	200	1.3
225 E	225	1.2
250 E	250	1.18
300 E	300	1.1
325 E	325	1.08
350 E	350	1.0
375 E	375	0.96
400 E	400	0.93
450 E	450	0.88

SIZE F — 7½ in. long, 2 in. diam. Capacity 115 watts

Symbol	Ohms	Amp. Cont.
0.25 F	0.25	21.4
0.3 F	0.3	19.6
0.4 F	0.4	17.0
0.5 F	0.5	15.2
0.6 F	0.6	13.7
0.75 F	0.75	12.3
1 F	1	10.7
1.25 F	1.25	9.6
1.5 F	1.5	8.75
1.75 F	1.75	8.1
2 E	2	7.5
2.5 F	2.5	6.75
3 F	3	6.2
3.5 F	3.5	5.7
4 F	4	5.4
5 F	5	4.8
6 F	6	4.3
6.5 F	6.5	4.2
7.5 F	7.5	3.9
10 F	10	3.4
15 F	15	2.8
20 F	20	2.4
25 F	25	2.1
30 F	30	1.9
35 F	35	1.8
40 F	40	1.7
45 F	45	1.6
50 F	50	1.5
55 F	55	1.4
60 F	60	1.38
65 F	65	1.33
70 F	70	1.28
75 F	75	1.24
100 F	100	1.07
125 F	125	0.96
150 F	150	0.87
200 F	200	0.75
225 F	225	0.71
250 F	250	0.68
300 F	300	0.62
325 F	325	0.59
350 F	350	0.57
375 F	375	0.55
400 F	400	0.53
450 F	450	0.5

4973-8 Resistance Units

RATINGS OF FORM R RESISTANCE UNITS

Size W

Symbol	Resist. Ohms	AMPERES		CONTINUOUS DUTY Amperes		
		½ Min. Duty	1 Min. Duty	100° C. Rise	150° C. Rise	250° C. Rise
21.0 W	21.0	5.9	5.5	2.4	2.8	4.0
15.5 W	15.5	6.9	6.6	2.7	3.2	4.6
12.0 W	12.0	8.0	7.9	3.1	3.7	5.2
9.7 W	9.7	9.0	8.7	3.4	4.0	5.8
8.4 W	8.4	10.0	9.5	3.7	4.4	6.2
6.2 W	6.2	12.5	11.5	4.2	5.1	7.1
5.0 W	5.0	10.0	9.5	4.9	5.8	8.1
3.5 W	3.5	12.5	11.5	5.7	6.8	9.5
2.6 W	2.6	15.0	14.0	6.6	7.9	11.2
2.2 W	2.2	18.0	17.0	7.2	8.6	12.1
1.5 W	1.5	19.0	17.5	8.6	10.2	14.5
1.2 W	1.2	23.0	21.5	9.8	11.8	16.7
0.95W	0.95	27.5	26.0	10.8	12.9	18.2

Size Y

Symbol	Resist. Ohms	AMPERES		CONTINUOUS DUTY Amperes		
		½ Min. Duty	1 Min. Duty	100° C. Rise	150° C. Rise	250° C. Rise
32.0Y	32.0	5.9	5.5	2.4	2.8	4.0
24.0Y	24.0	6.9	6.6	2.7	3.2	4.6
18.5Y	18.5	8.0	7.8	3.1	3.7	5.2
15.0Y	15.0	9.0	8.7	3.4	4.0	5.8
13.0Y	13.0	10.0	9.5	3.7	4.4	6.2
9.8Y	9.8	12.5	11.5	4.2	5.1	7.1
7.5Y	7.5	10.0	9.5	4.9	5.8	8.1
5.5Y	5.5	12.5	11.5	5.7	6.8	9.5
4.0Y	4.0	15.0	14.0	6.6	7.9	11.2
3.4Y	3.4	18.0	17.0	7.2	8.6	12.1
2.4Y	2.4	19.0	17.5	8.6	10.2	14.5
1.8Y	1.8	23.0	21.5	9.8	11.8	16.7
1.5Y	1.5	27.5	26.0	10.8	12.9	18.2

Size Z

Symbol	Resist. Ohms	AMPERES		CONTINUOUS DUTY Amperes		
		½ Min. Duty	1 Min. Duty	100° C. Rise	150° C. Rise	250° C. Rise
42.0Z	42.0	5.9	5.5	2.4	2.8	4.0
31.0Z	31.0	6.9	6.6	2.7	3.2	4.6
24.0Z	24.0	8.0	7.8	3.1	3.7	5.2
19.4Z	19.4	9.0	8.7	3.4	4.0	5.8
16.8Z	16.8	10.0	9.5	3.7	4.4	6.2
12.4Z	12.4	12.5	11.5	4.2	5.1	7.1
10.0Z	10.0	10.0	9.5	4.9	5.8	8.1
7.0Z	7.0	12.5	11.5	5.7	6.8	8.5
5.2Z	5.2	15.0	14.0	6.6	7.9	11.2
4.4Z	4.4	18.0	17.0	7.2	8.6	12.1
3.0Z	3.0	19.0	17.5	8.6	10.2	14.5
2.4Z	2.4	23.0	21.5	9.8	11.8	16.7
1.9Z	1.9	27.5	26.0	10.8	12.9	18.2

RATINGS OF IG UNITS

No.	Ohms	AMPERES	
		Continuous	30 Sec.
1	0.02	60	500
2	0.03	45	350
3	0.04	37.5	250
4	0.055	32	200
5	0.08	26.7	150
6	0.12	22	90
7	0.15	20	75
11	0.01	100	900
12	0.015	80	725
13	0.02	70	600
14	0.03	55	480
21	0.04	40	250
22	0.066	28	150
23	0.115	20	75
31	0.06	35	225
32	0.1	28	150
33	0.18	20	75

RATINGS OF RG UNITS

Frame Capacity Number of Grids	Size No. of Grids	Resistance per Grid at 25 Deg. C.	AMPERES	
			Continuous Capacity at 175 Deg. C. Rise	Intermittent Capacity 10 Sec. On; 0.20 Sec. Off at 250 Deg. C. Rise
36	1	0.01	80	160
36	3	0.015	70	140
36	5	0.022	60	120
36	7	0.033	50	100
36	9	0.05	40	80
48	10	0.05	35	70
48	12	0.075	30	60

General Electric Company
Schenectady, N.Y.

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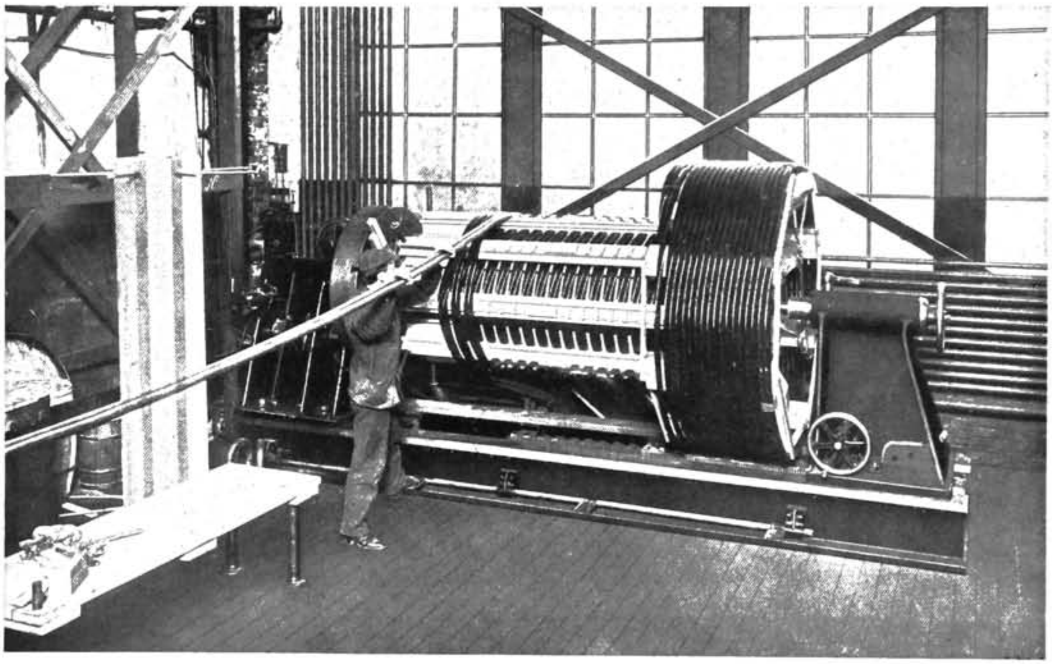
CURRENT LIMITING REACTANCES

The enormous increase in capacity of power stations, for supplying the demands of densely populated centers and large manufacturing districts, coupled with the decrease in the reactance of modern generators and transformers through improvement in design to obtain better regulation, has presented a problem in apparatus protection not contemplated in the earlier days of alternating current distribution. This problem is entirely separate and distinct from that of eliminating the tendency toward short circuit, incident to the high voltages now common to transmission service. It accepts that such short circuits must occasionally occur and considers only the protection of the connected apparatus against the mechanical forces due to the magnetic stresses of such enormous currents.

An example will indicate the conditions under which this protection is necessary. The present day transformer, intended for power purposes, has a reactance of approximately $2\frac{1}{2}$ per cent., which means that at normal load current $2\frac{1}{2}$ per cent. or 1/40 of the supply voltage is consumed by the reactance. Under short circuit the total voltage must be consumed by the reactance, therefore the short circuit current at full supply voltage is forty times the normal load current of the transformer. Since the mechanical forces developed within the trans-



WINDING 400 KV-A. 1750 AMP. CURRENT LIMITING REACTANCE

former are proportional to the square of the current flowing, they would amount in this instance to $(40)^2$, or 1600 times the forces existing under normal conditions of operation. In large units this may amount to several hundreds of tons. Similar forces may exist in generators.

In large generating systems the voltage drop due to short circuit of the feeder lines or busbar sections may be inappreciable. In fact there are at the present time power systems capable of giving momentarily 750,000 to 1,000,000 kilowatts without appreciable voltage drop. The effect of strains on the apparatus delivering such power can scarcely be estimated beyond the point of realization that such strains can not be withstood by the mechanical structure of the apparatus. Obviously the only solution is to prevent the existence of such strains by limiting the momentary power delivery of a generator or transformer when a short circuit occurs.

The logical method of accomplishing such limitation consists in the increase of the reactance of the circuit. This is most effectively done by placing in series with generators or transformers reactive coils which, under short circuit conditions, shall limit the flow of current in the circuit to values which can be safely withstood by both generators and transformers and the reactances themselves.

To meet the rapidly increasing demand for such a protective device, the General Electric Company has developed its current limiting (concrete core) reactance which, in order to avoid the prohibitive expense of high voltage insulation, is designed for the low tension circuits. This requirement prohibits the use of a magnetic core which, if economically designed for normal operation, would become saturated at higher densities, or, if designed large enough to avoid saturation at short circuit conditions, would become prohibitive in cost and dimensions. The elimination of all magnetic material from the construction of the concrete core reactance permits of no saturation, and assures a straight line voltage characteristic at all current loads.

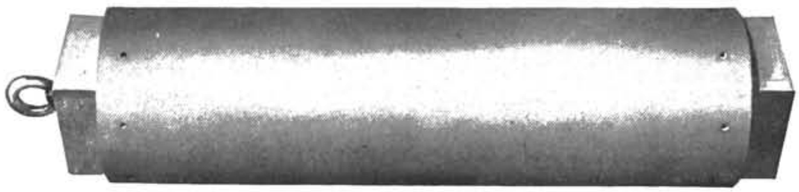


Fig. 1
CONCRETE CORE FOR CURRENT LIMITING REACTANCE WITH SQUARE EXTENSION

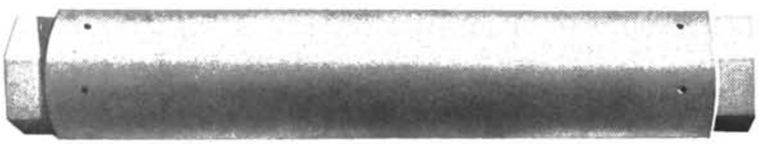


Fig. 2
CONCRETE CORE FOR CURRENT LIMITING REACTANCE WITH HEXAGONAL EXTENSION

It is believed that the design developed by the General Electric Company, and represented in the present current limiting reactance, will satisfactorily protect apparatus from mechanical stresses due to heavy current overloads.

Core

The core consists of a hollow concrete cylinder composed of the best proportions of concrete materials. The concrete is carefully mixed to insure uniformity throughout and the greatest density consistent with good mechanical construction. The core is cast in an iron mould with accurately machined surfaces. Alloy anchor plates or sockets are embedded in the core near the ends to receive the radial brass bolts.

The mould is constructed so as to provide an extension at each end of the core for clamping and bracing the reactance in installation. In service the cores are placed in a vertical position and are clamped and braced to one another to prevent any possible movement. In the larger cores the extension

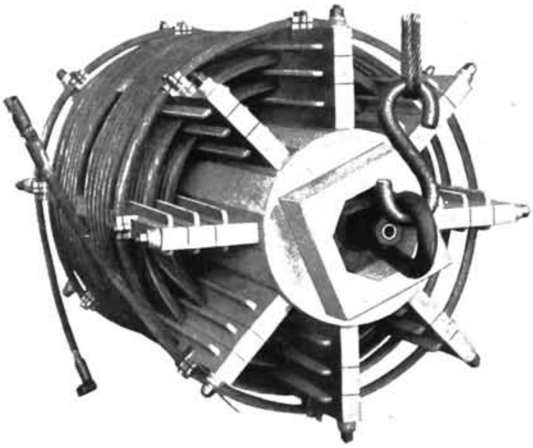


Fig. 3
VIEW OF CURRENT LIMITING REACTANCE SHOWING DETAIL OF CONSTRUCTION

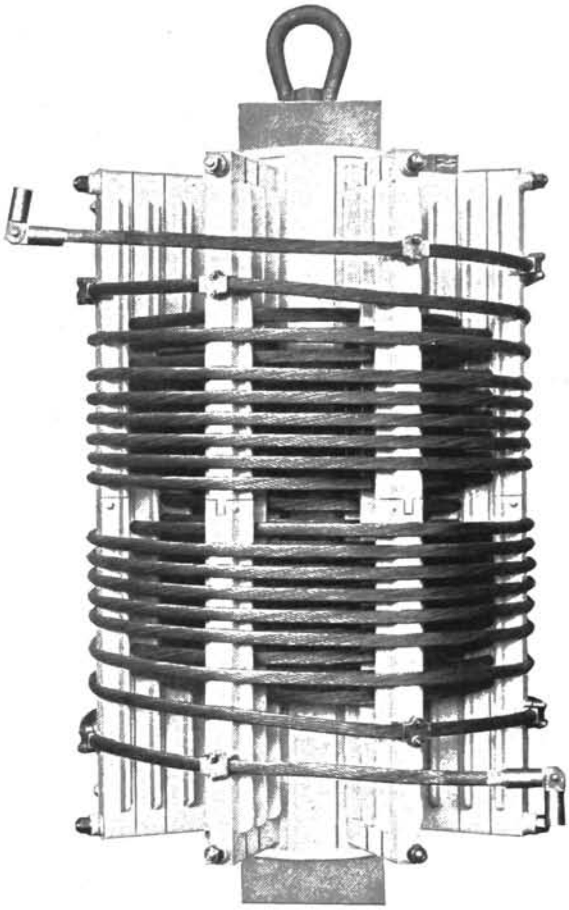
is square (Fig. 1). In the smaller ones it is hexagonal (Fig. 2). The wall of the extension is in no case less than 2½ in. thick.

After the core is removed from the mould its surface is brushed with a thin mixture of cement and rubbed to a smooth finish. It is then painted inside and out with several coats of a light yellow creosote paint.

Winding Supports

The supports for the windings are made of selected resin treated maple and are located upon the core by radial brass studs screwed into the alloy sockets. The studs are insulated with mica tubes. The nuts by which the structure is tightened rest upon heavy fiber washers.

Wooden barriers fitted and shellaced into the supports add to the creepage surface between layers of the winding and between the winding and the core. This is clearly shown in Fig. 3. The supports of the layer



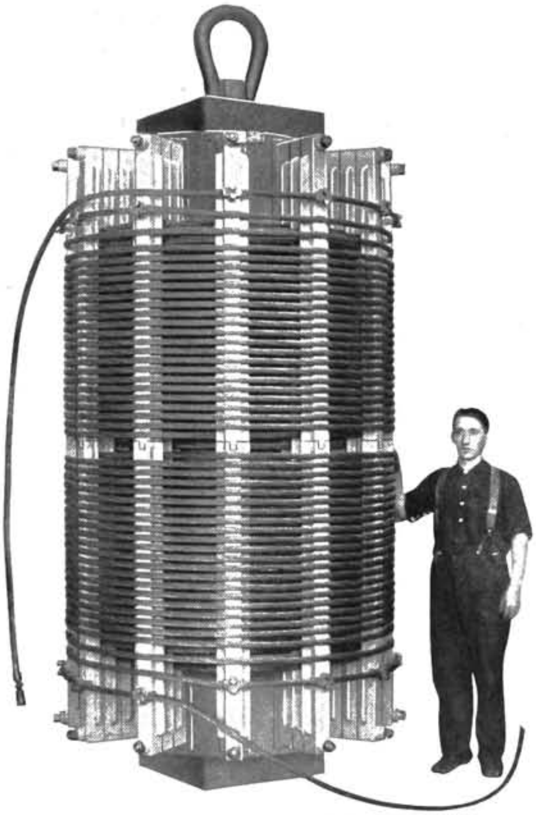
50 CYCLE, 300 KV-A. 788 AMP. CURRENT LIMITING REACTANCE

next to the core are separated from the core by strips of treated pressboard. All wooden parts and also those of fiber and pressboard are finished with several coats of specially prepared high grade enamel of a color to match the core. This enamel is in itself a good insulator. Its light color makes evident the collection of dust and dirt on the reactance, thus making an easy inspection.

4974-4 Current Limiting Reactances

Winding

The operation of winding is shown on page 1. The conductor consists of bare stranded cable in several layers, usually three in number. It is wound into grooves in the treated wood supports, which are protected from contact with the cable by heat shields of asbestos shellaced into the grooves. The winding is usually in the form of two back-turn sections, thereby allowing the terminals



25 CYCLE, 720 KV-A. 600 AMP. CURRENT LIMITING REACTANCE

of the coil to be brought out at the ends of the outside layer. This assures accessibility and ease of connection, and the removal of the leads from proximity to the core. Two turns at each end of the winding are given extra spacing for the purpose of additional insulation. The final turn at each end of the coil is securely held in place by alloy clamps bolted to the supports. The wood is protected from contact with the clamps by shields of asbestos.

Unless otherwise specified, standard interleave terminals are supplied. These are attached to the winding with a solder of high melting point. The ends of the cable between the two sections are welded by the oxyactylene process.

Handling and Mounting

Each reactance is lifted by means of a steel stud passing through the hollow core and engaging with a threaded alloy nut at the lower end. The stud passes through a removable cast iron washer in the upper end of the core. The stud and all other iron or steel accessories are removed during installation.

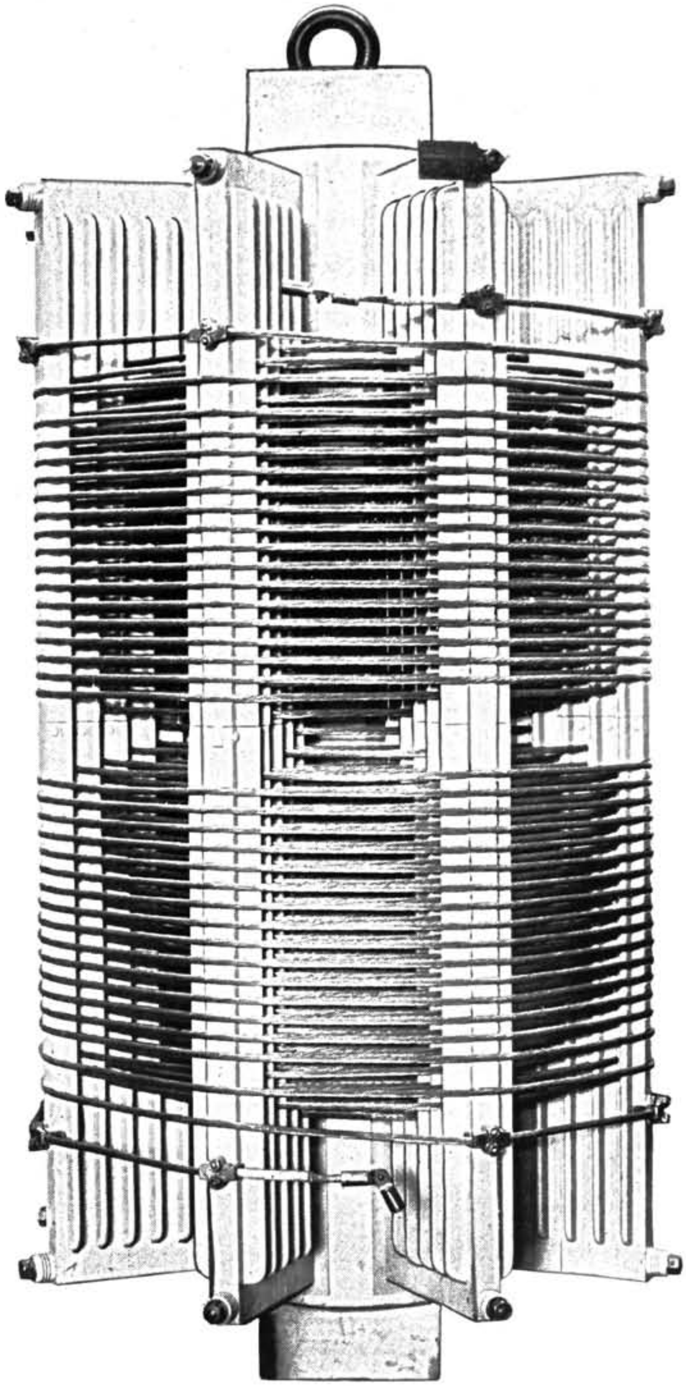
These reactances are usually supplied in sets, the number corresponding to the number of phases of the apparatus protected. Since the tendency to movement is limited to an attraction between coils, only the bracing between them is necessary.

Temperature and Losses

The reactances are designed for a temperature rise not to exceed 40 degrees C. under normal current conditions. Local heating in the necessary metal parts is avoided by the use of brass and other non-magnetic alloys. In terms of kv-a. capacity of transformer or generator protected, the total losses in the coils vary approximately from 0.4 per cent. in the smaller sizes to 0.12 per cent. in the larger. A high potential test of at least twice the potential of the circuit in which a reactance is connected is applied between the winding and the concrete core.

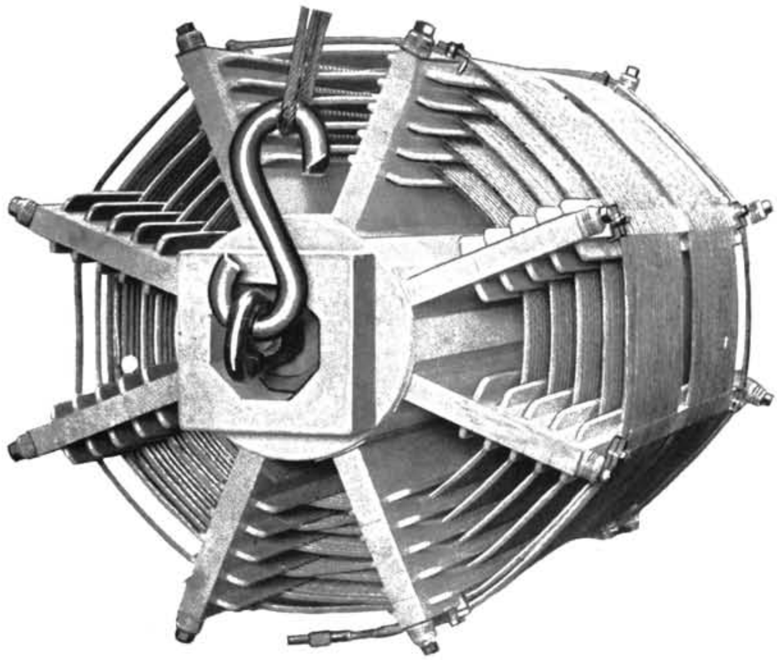
Reactances Installed

Reactances of the type herein described have already been built for capacities ranging from 30 kv-a., for the protection of 1500 kv-a. three-phase generators, to 720 kv-a. for the protection of busbar sections or groups of generators in one of the largest central stations in the country. The fact that the use of these reactances serves as an insurance of the system against the disastrous results of short circuits, makes them particularly desirable. Their low losses and sturdy construction make their maintenance and operating cost inappreciable.



CURRENT LIMITING REACTANCE, TYPE AS, 25 CYCLES 100 KV-A. 457 VOLTS 219 AMPERES
FORM F, FOR USE WITH 5000 KV-A. 13200 VOLT TURBO-GENERATOR

4974-6 Current Limiting Reactances



END VIEW OF CURRENT LIMITING REACTANCE, TYPE AS, 25 CYCLES 100 KV-A. 457 VOLTS 219 AMPERES FORM F. SHOWING FIVE-LAYER CONSTRUCTION

LIST OF POWER LIMITING REACTANCES FURNISHED BY THE GENERAL ELECTRIC COMPANY

NO.	CYCLES	KV-A.	CUSTOMER
18	25	30	Isthmian Canal Commission
9	25	42	Isthmian Canal Commission
3	25	43	Indiana Steel Company, Gary, Ind.
12	25	66⅔	Commonwealth Edison Co., Chicago, Ill.
6	25	100	Public Service Electric Co., Newark, N. J.
3	25	176⅔	Lehigh Valley Electric Co.
6	25	180	Public Service Electric Co., Newark, N. J.
27	25	240	Commonwealth Edison Co., Chicago, Ill.
12	25	240	Mississippi River Power Company
6	50	250	Pacific Light & Power Company
12	25	280	Commonwealth Edison Co., Chicago, Ill.
3	50	300	Southern California Edison Company
3	60	300	Pacific Gas & Electric Company
3	50	375	Southern California Edison Company
3	60	500	San Francisco Gas & Electric Company
6	25	720	Commonwealth Edison Co., Chicago, Ill.

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

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BOSTON, MASS.	84 State Street
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Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Electric Building
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New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
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Youngstown, Ohio	Wick Building
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Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Schwind Building
Toledo, Ohio	Spitzer Building
Chattanooga, Tenn.	James Building
Knoxville, Tenn.	Bank & Trust Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
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Keokuk, Iowa	Monarch Building
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St. Louis, Mo.	Wainwright Building
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Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
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Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For Texas and Oklahoma Business refer to
General Electric Company of Texas,

Dallas, Tex.	1911 No. Lamar St.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E. C., England, 83 Cannon St.

For all Canadian Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

General Electric Company
Schenectady, N.Y.

SUPPLY DEPARTMENT

July, 1912 **Bulletin No. 4975*

THE SYNCHRONISM INDICATOR

ANY device used for synchronizing two or more alternating current machines should perform three distinct functions, as follows:

1st. It should indicate whether the starting machine is rotating slower or faster than the running machine.

2d. It should indicate the amount of the difference in speed.

3d. It should accurately indicate the moment of synchronism and coincidence in phase of the running and starting machines. Synchronising lamps do not perform the first function. They perform the second function well and the third function approximately. All the requirements have been successfully met in the synchronism indicator manufactured by the General Electric Company. The pointer of this instrument moves around a dial—like the hand of a clock—and the angle of the pointer's displacement from the vertical position is a measure of the angle of phase difference between the two sources of electro-motive force to which the device is attached. If, therefore, the incoming machine is running too fast, the pointer rotates in one direction, and if too slow, in the opposite direction.

Coincidence in phase is shown when the pointer remains stationary in a vertical position and indicates that the machine should be thrown in. A complete revolution of the pointer indicates a gain or loss of one cycle in the starting machine as compared with the running machine.

SYNCHRONISM INDICATOR

Those who have actually "thrown in" alternators can best appreciate the advantages of having an exact indication of phase coincidence instead of being obliged to estimate as with the ordinary synchronism devices.

Particular attention is called to the fact that the synchronism indicator shows whether the incoming machine is running *too fast* or *too slow*.

The time saving possibilities of this feature are evident.

DETAILS OF THE SYNCHRONISM INDICATOR

The diameter of the dial of the standard instrument is 8 inches, thus permitting observation by the operator of the engine or waterwheel as well as by the switchboard attendant.

Operation

The synchronism indicator is a motor whose field is supplied single-phase from one of the machines to be synchronized, and its armature

Second Edition.

* *Supersedes Bulletin No. 4613.*

NOTE.—The prices and data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Both prices and data are subject to change without notice.

4975-2 The Synchronism Indicator

from the other. The armature carries two coils placed at a large angle, one supplied through a resistance, the other through a reactance. This arrangement generates a rotating field in the armature, while the stationary field is alternating. The armature

SYNCHRONISM INDICATOR WITH PIVOTED BRACKET

tends to assume a position where the two fields coincide when the alternating field passes through its maximum; hence, the armature and pointer move forward or backward at a rate corresponding to the difference of frequency, and the position when stationary depends on the phase relation. When the machines are running at the same frequency and in phase the pointer is stationary at the marked point.

In construction, it is like a small, two-phase, bipolar synchronous motor, the field or stator being supplied with alternating instead of direct current. The rotor is mounted in ball bearings in order to make it sufficiently sensitive and smooth in operating. The rotor coils are not exactly 90 degrees apart, since it is not possible to get the current in the two rotor coils exactly in quadrature without introducing condensers or other complicated construction.

Synchronism indicators are made for 110 and 220 volt circuits unless otherwise specified but will operate properly on any voltage which does not differ more than 10 per cent. from these ratings. The reactance furnished with 110 volt indicators is contained in a metal case on the outside of which is fastened a socket holding an incandescent lamp which serves as resistance. The 220 volt indicators have a separate resistance and reactance box, the former taking the place of the lamp furnished with the 110 volt indicator. Both the reactance and resistance are intended to be placed behind the board.

For voltages about 220-240 volts the 110 volt indicator should be used with potential transformers having 110 volt secondary. All indicators should be disconnected from the circuit when not in use.

Synchronism indicators should be ordered for the frequency of the circuit on which they are to be operated, although the instruments may be used on circuits varying 10 per cent. to 15 per cent. from the normal.

The words "Fast" and "Slow" on the dial indicate that the frequency of the electromotive force on binding posts E and F is respectively higher or lower than that on A and B; or, in other words, clockwise rotation of the pointer means that the incoming machine is running at too high speed, counter-clockwise rotation indicating too low speed.

SYNCHRONISM INDICATOR ON SWINGING BRACKET

Attention is called to the fact that the synchronism indicator is equally adaptable to single-phase, two-phase or three-phase apparatus. The phase displacement necessary for operation of the instrument is accomplished

ERRATUM

To accompany Bulletin No. 4975

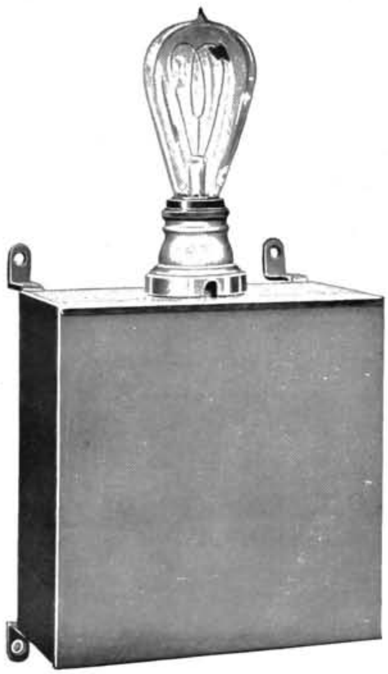
THE SYNCHRONISM INDICATOR

Page 2: right hand column, ninth line, should read: "For voltages abcve 220-240 volts."

by suitable reactance and resistance mounted in the external cage.

The *standard* finish is dull black case with glass front and polished copper rim.

Standard synchronism indicators are made for back connections only.



EXTERNAL REACTANCE AND RESISTANCE FOR 110 VOLT SYNCHRONISM INDICATOR

DIRECTIONS FOR INSTALLING

With grounded secondaries on potential transformers connect as shown on page 5.

With ungrounded secondaries on potential transformers connect as shown on page 5.

The 220 volt indicators are connected as shown on page 6.

The various letters referred to on the diagram will be found marked on the ends of the instrument studs and back of reactance coil box.

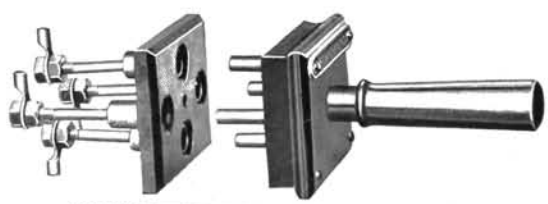
Synchronism indicators are always sent out to indicate synchronism (when connected as shown on pages 5 and 6) with the pointer up.

It is very important that the instrument be connected in circuit in the proper manner so that the needle will come to the mark on the upper part of the scale when synchronism is obtained. In case the pointer becomes moved or a change in its position is necessary, it is advisable to make a check on the indication before relocating the needle. This test can be made as follows: Connect together studs marked B and E and connect stud A to terminal F on the external reactance box. When these connections are made, the instrument can be connected to a single-phase circuit of normal voltage and if the instrument is correct, the pointer will stand vertically at the point of synchronism. If it does not, the needle can be moved and should be fastened in the correct position. The connection for this test should be as shown on page 6.

The synchronizing lamps when connected as on pages 5 and 6 show dark when synchronism is reached. This is the only connection possible when grounded secondaries are used as in the diagram on page 5, and for the high voltage indicators when used as in diagram on page 6; but with ungrounded secondaries, as shown on page 5, the lamps may be connected as indicated by the dotted lines, when they will show bright at the moment of synchronism. The connections to the synchronism indicator remain the same as before.

RECEPTACLES, PLUGS AND BRACKETS

Synchronism indicators are furnished without receptacles, plugs or brackets, unless otherwise ordered. On page 4 will be found catalogue numbers for these parts.



SYNCHRONIZING RECEPTACLE AND PLUG

RECEPTACLES

Three styles of plug receptacles are necessary in synchronizing. Cat. No. 13289 is used with grounded secondaries on potential transformers as shown on page 5.

4975-4 The Synchronism Indicator

With ungrounded secondaries on potential transformers, two receptacles are necessary, Cat. No. 13289 and Cat. No. 29658, as shown on page 5.

For 220 volt circuits a six-point receptacle, Cat. No. 60429, is used.

CONNECTION PLUGS

Five styles of connection plugs can be furnished for use in synchronizing. Cat. No. 27368 and Cat. No. 27369 are used with the grounded secondaries on potential transformers, as shown on page 5.

Cat. No. 27368 and Cat. No. 29654 are used with ungrounded secondaries on potential transformers, as shown on page 5.

Cat. Nos. 59645 and 59646 are used in connection with receptacles shown on page 6.

SYNCHRONISM INDICATORS

WITHOUT BRACKET

110 Volts

Cat. No.	Cycles	List Price
28900	25	$90.00
28901	40	90.00
28902	60	90.00

220 Volts

Cat. No.	Cycles	List Price
60613	25	$110.00
60624	40	110.00
60627	60	110.00

WITH PIVOTED BRACKET AND LAMPS FOR TOP OF PANEL

110 Volts

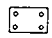
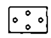
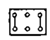
Cat. No.	Cycles	List Price
30303	25	$100.00
30304	40	100.00
30305	60	100.00

BRACKETS

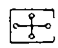
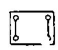
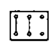
Synchronism indicators can, when desired, be supplied with swinging brackets and lamps for mounting on the side of the panel, or pivoted brackets and lamps for mounting at the top of the panel.

Catalogue numbers including indicator with both styles of brackets, will be found in the following tables:

SYNCHRONIZING PLUG RECEPTACLES

Cat. No.	*Style	List Price
13289		$1.50
29658		1.50
60429		2.00

SYNCHRONIZING PLUGS

Cat. No.	*Style		List Price
27368		*Starting*	$2.50
27369		*Running*	2.50
29654		*Running*	2.50
59645		*Starting*	3.50
59646		*Running*	3.50

*Front view.

WITH SWINGING BRACKET AND LAMPS FOR SIDE OF PANEL

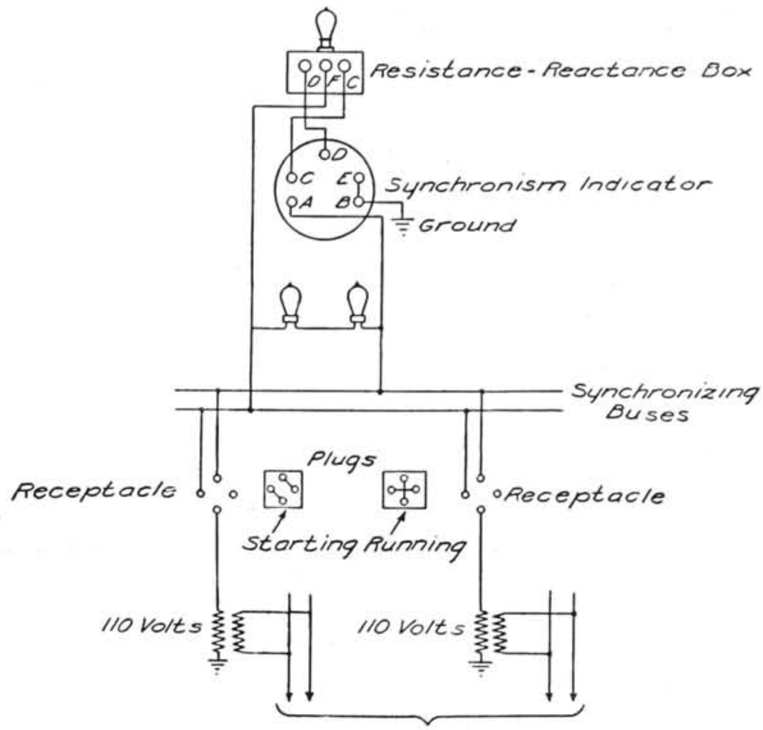
110 Volts

Cat. No	Cycles	List Price
59712	25	$111.00
59713	40	111.00
59714	60	111.00

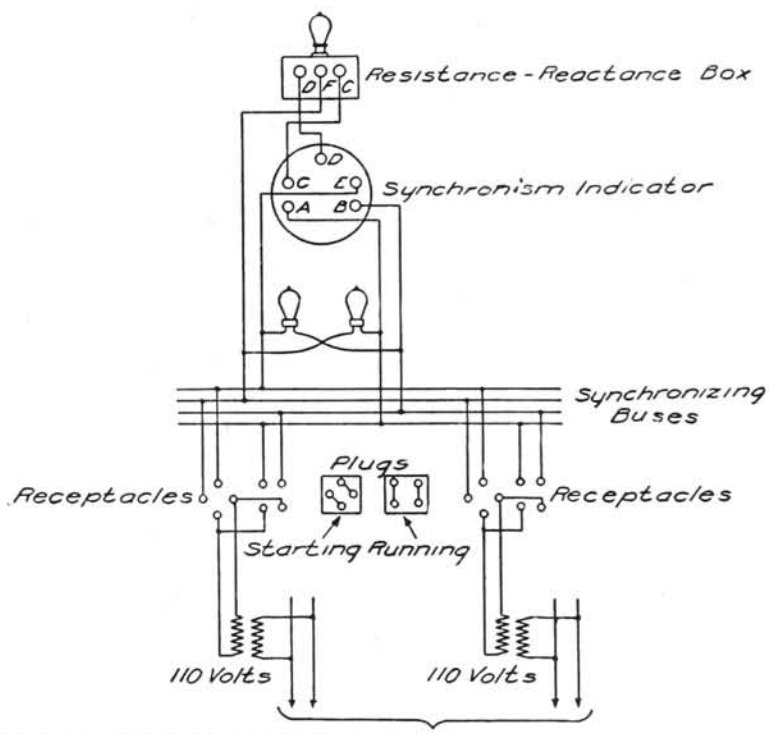
220 Volts

Cat. No	Cycles	List Price
59717	60	$133.00

CONNECTIONS OF SYNCHRONISM INDICATOR



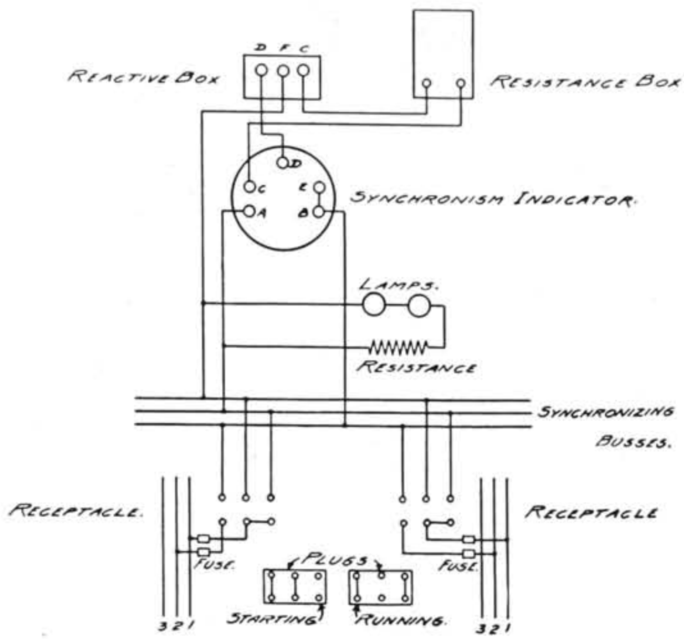
WITH GROUNDED SECONDARIES ON POTENTIAL TRANSFORMERS



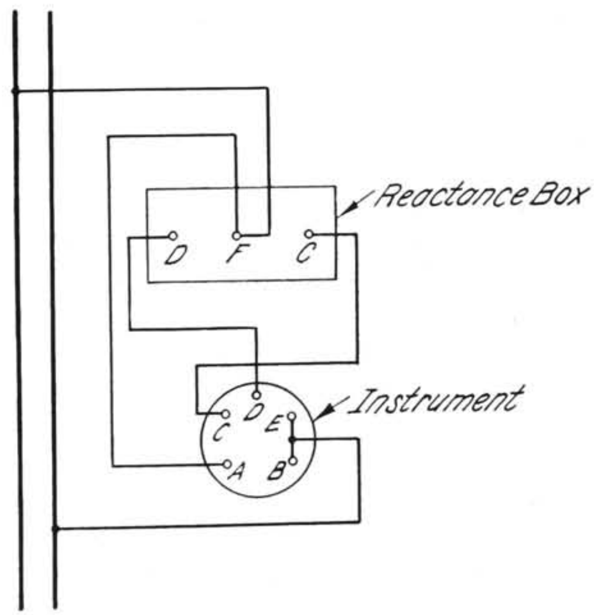
WITH UNGROUNDED SECONDARIES ON POTENTIAL TRANSFORMERS

As connected above, synchronism is indicated when lamps are dark
Connections shown from back of switchboard

CONNECTIONS OF SYNCHRONISM INDICATOR



For 200–240 Volt Circuits, with Six-point Receptacles

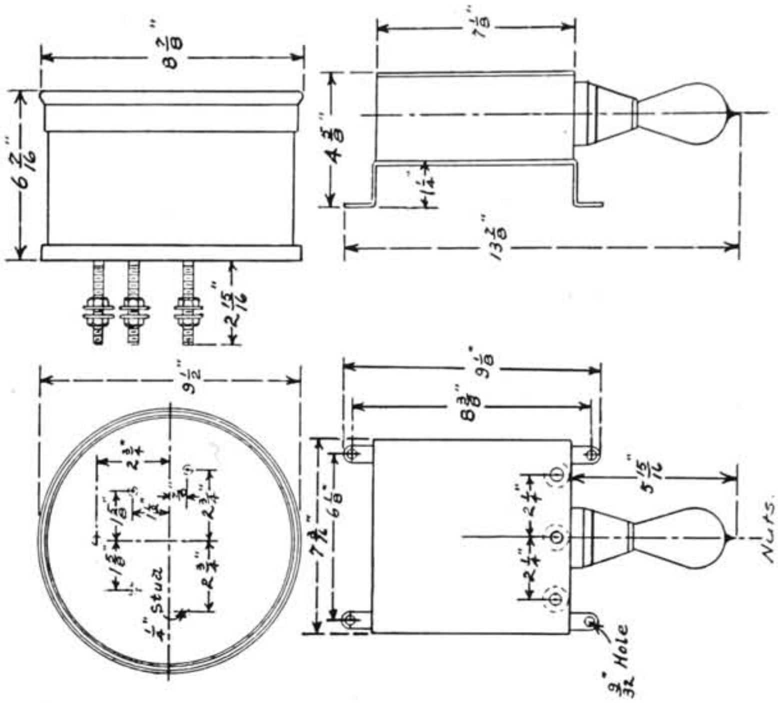


CONNECTIONS FOR CHECKING LOCATION OF NEEDLE

(See page 3)

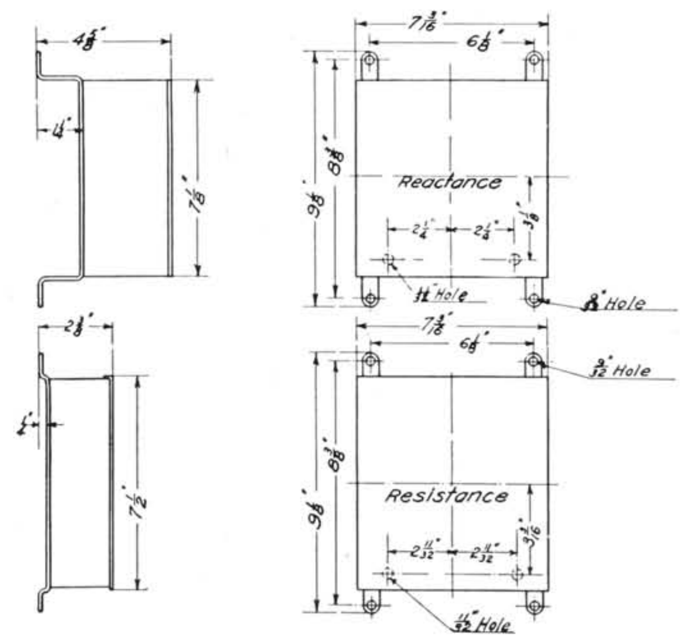
DIMENSIONS OF BACK-CONNECTED TYPE M SYNCHRONISM INDICATOR

With 110 Volt Resistance and Reactance Box



DIMENSIONS OF RESISTANCE AND REACTANCE BOXES

For Use With 220 Volt Type M Synchronism Indicators



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5

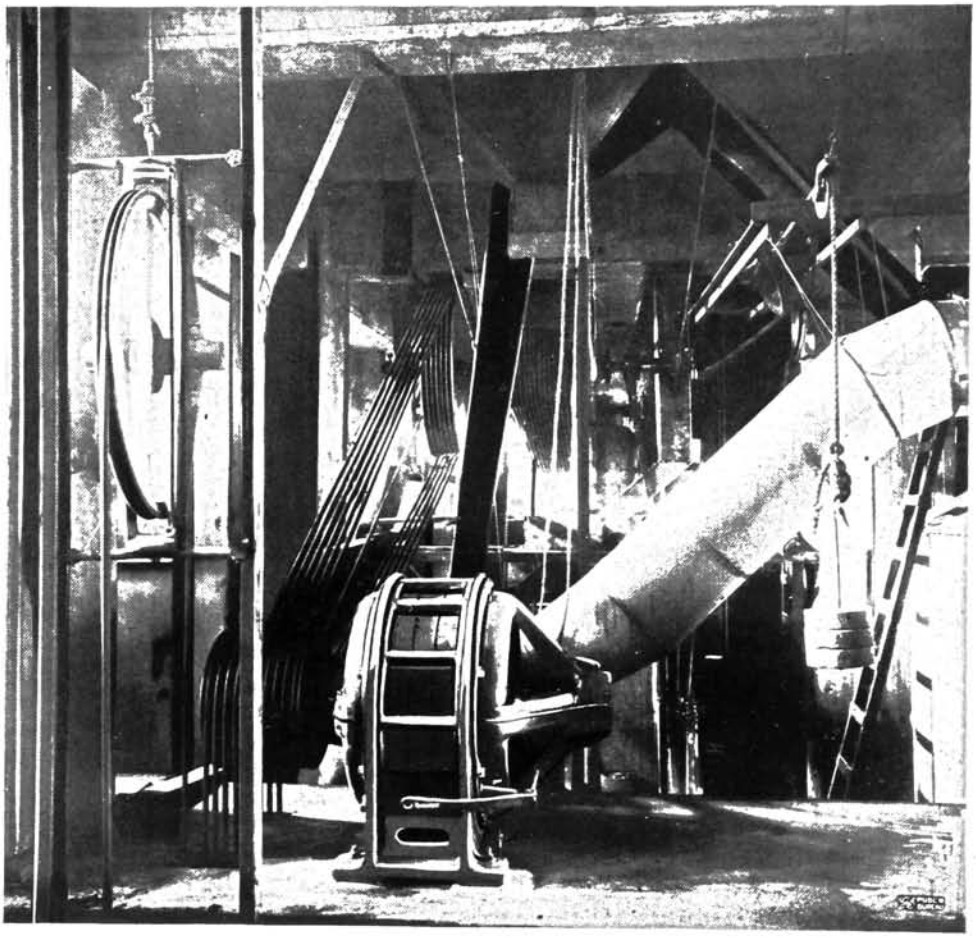
General Electric Company

Schenectady, N.Y.

POWER AND MINING DEPARTMENT

August, 1912 **Bulletin No. 4976*

ELECTRIC DRIVE IN GRAIN ELEVATORS AND FLOUR MILLS



100 H.P. INDUCTION MOTOR OPERATING THREE ROLLER MILLS, TWO ELEVATOR LEGS, CLEANERS, CAR PULLER AND POWER SHOVEL IN F. C. AYERS' MERCANTILE COMPANY ELEVATOR

In order to secure the most economical operation of modern grain elevators and flour mills, it is essential that thorough analytical consideration be given to those factors which determine the cost of power and the methods to be adopted in its application.

Among these, perhaps the most important is the type of drive employed for the grain handling and milling machinery, as this has a direct bearing on the quantity of product obtained for a given investment, and determines largely the percentage of profit which

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

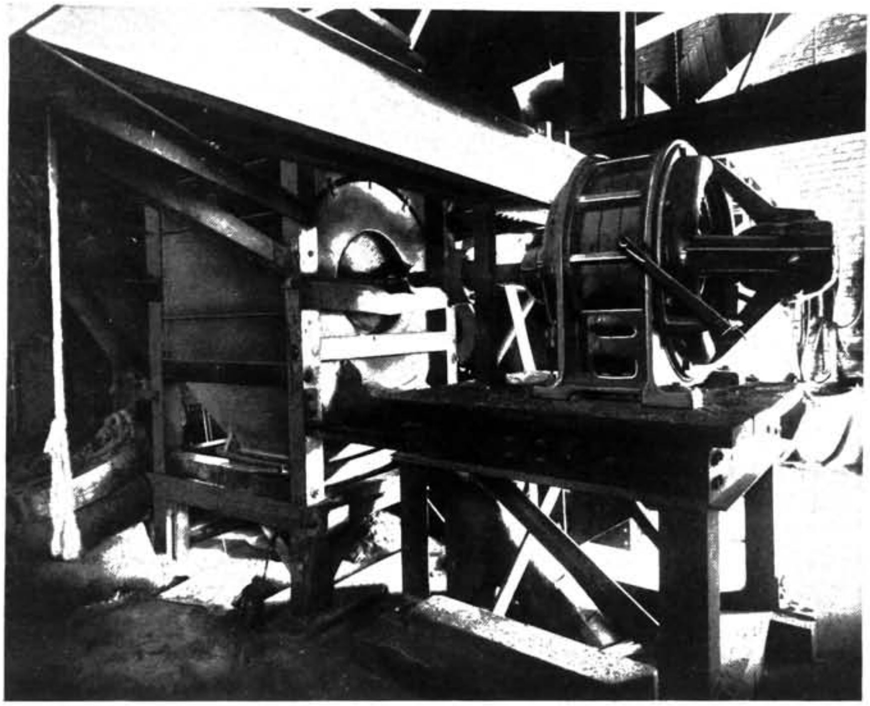
* *Supersedes Bulletin No. 4742.*

can be realized from the grain passing through the elevators and mills.

Heretofore in grain elevators, it has usually been the practice to drive the legs and conveyors by means of long lines of shafting, or by rope or belt transmission, operated by reciprocating engines or other prime movers. Where these conditions exist, especially in elevators of large capacity having numerous legs and conveyors, it is evident that the friction loss in transmitting power to the various sections represents a large percentage of the total power required for operation, and that any reduction in this loss will directly affect the cost of handling the grain.

In the operation of grain elevators where constant speed is required, it will be found that for the driving of grain handling apparatus induction motors have advantages that render them superior to any other type for this service.

It is evident that by using an individual motor, either direct connected, belted, or provided with a relatively short rope drive, for each elevator leg, conveyor, car puller or exhaust fan, the friction loss, which is inevitable where long lines of shafting or long rope or belt connections are necessary, is to a very large extent done away with, and that the total horse-power required for a given amount of work is greatly reduced. Due to the fact that the modern induction motor is an extremely simple device, consisting of a stator and a practically indestructible rotating element, it requires no expert attention, and when once started will operate continuously at a uniform speed. If the power is received from a central station, the expense of engineers, firemen, etc., is altogether eliminated, and the cost of operation becomes directly proportional to the amount of work performed, and ceases the moment the motor is stopped.



75 H.P. INDUCTION MOTOR DIRECT CONNECTED TO OAT CLIPPER
MULLER AND YOUNG GRAIN ELEVATOR, CHICAGO, ILL.

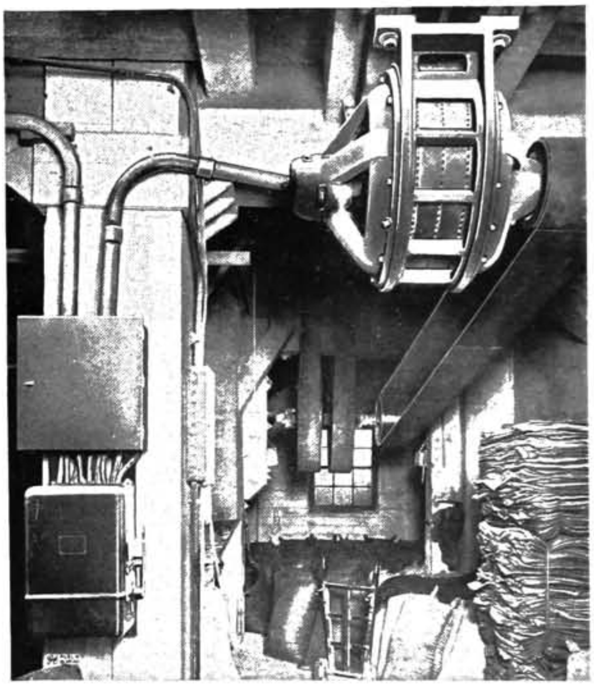
The polyphase induction motor, which is recommended for work of this kind, has no commutator, and as a consequence there is no sparking to be provided against.

This latter feature is of considerable importance as it has a direct bearing on the question of fire risk and insurance rates.

75 H.P. INDUCTION MOTOR SUSPENDED FROM CEILING DRIVING ELEVATORS, MILLS AND CLEANERS. ADY AND CROWE MERCANTILE COMPANY

The liability of fire is always increased wherever long lines of shafting with their necessary journals, bearings, etc., exist; for, in case of faulty hanger alignment, accidental distortions, or imperfect lubrication, flames are liable to develop, due to excessive friction. It is true that these fire risks have been somewhat reduced by the use of brick, steel, concrete and other fireproof construction, and by the installation of modern fire-fighting apparatus. The amount of dust in grain elevators and flour mills has also been lessened considerably by the installation of exhaust fans, but it has not been eliminated and is still potentially dangerous where the heavy shafting and belting, inseparable from mechanical drive, are used.

The matter of determining the amount of power required for driving grain elevators with induction motors involves a simple mathematical problem: given the height to which the grain is to be elevated and the bushels capacity per minute, the foot-pounds per minute required to elevate this quantity can be readily calculated. To this result it is necessary to add, of course, a certain percentage to cover the friction loss caused by the belt or rope connections, this percentage varying with the form of connection used between the motor and the elevator leg, conveyor, or exhaust fan. Even under the most



50 H.P. INDUCTION MOTOR SUSPENDED FROM CEILING DRIVING CHOP MILL. ADY AND CROWE MERCANTILE COMPANY

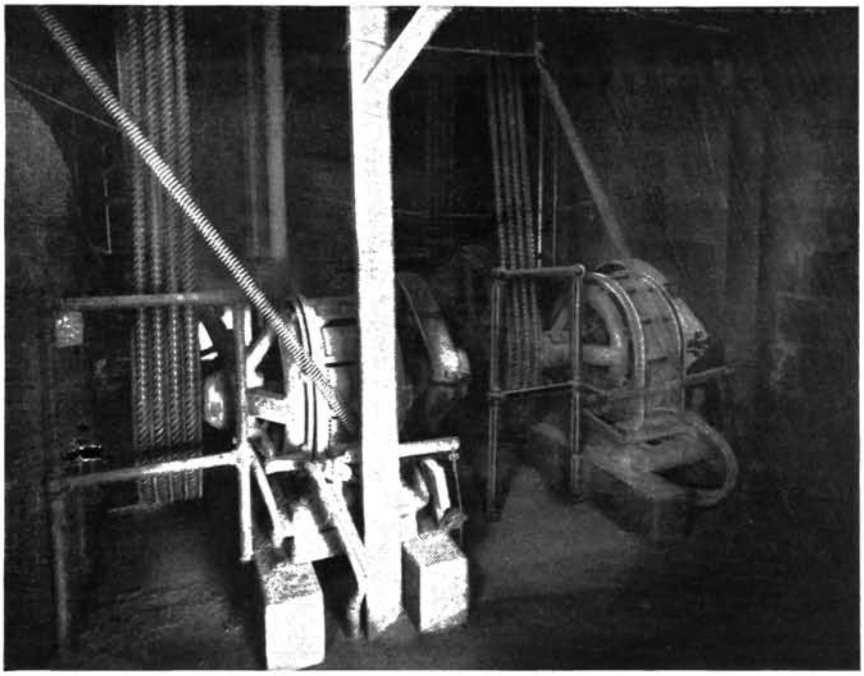
unfavorable conditions, however, this friction loss with motor drive will be far less than that which results from driving the various units from a single source of power through long lines of shafting or by other mechanical means of power transmission.

The simplicity, compactness and relatively light weight of the polyphase induction motor render it unnecessary to provide special foundations for the sizes usually employed in grain elevators.

In some instances where motors are used to operate car pullers or conveyors, space economy may be an important factor, and the fact that the induction motor can be installed on the floor, wall or ceiling, should be taken into account when providing for the adoption of motor drive.

The use of the induction motor for this work not only reduces the friction loss, but curtails to a large extent the expense involved in the first cost of shafting and belting, at the same time minimizing the labor cost of maintenance, replacements and repairs, and effecting a cleanliness and safety in operation not otherwise obtainable.

In erecting new elevators, the adoption of electric drive will frequently affect the cost of building construction, as the supports necessary for heavy line shafting, hangers, pulleys, etc., need not be provided where induction motors, with their relatively short belt or rope connections, are used. Where the motor is direct connected this expense is entirely eliminated. In many cases, this saving will amount to about five per cent. of the total cost of the building.



2-35 H.P. BACK GEARED INDUCTION MOTORS DRIVING LARGE ELEVATOR LEGS—MUELLER AND YOUNG GRAIN ELEVATOR, CHICAGO, ILL.

The only valid objection which has heretofore existed to the operation of elevator legs by induction motors, has been the liability of the leg to run backward when the power was shut off from the motor, due to the weight of the grain. This back legging or forming of a "choke" is now rendered impossible by the use of an attachment which permits the motor to run only in one direction; the instant it is stopped, a powerful friction clutch holds the leg stationary. In order that the elevator may start on full load, motors for driving this apparatus are generally provided with a friction clutch which is thrown in after the motors have attained full speed.

While theoretically the best method of operating grain handling machinery is to use individual motor drive throughout, the practice in most of the grain elevators which have adopted electric drive has been to combine the individual and group systems. Ordinarily induction motors are supplied for each elevator leg, car puller, and exhaust fan, while the cleaning machinery, such as separators, screw conveyors, dust collectors, etc., is generally driven in groups by single motors. This system of group drive has much to recommend it, especially in cases where the machinery is compactly grouped, and where the various operations are interdependent. The motors may be controlled either directly at the point of operation—in which case small panels with starting compensators are provided for each motor—or the control of all the motors may be centered at some distant point.

In the modern flour mill the several milling processes are interdependent, and it is therefore necessary that the different sections of the machinery should move as a unit, the required variations in the speeds of the individual machines being attained by means of belts or gears. In order to accomplish this result, the use of an immense amount of shafting and belting is unavoidable, notwithstanding the fact that the men who perfected the present milling machinery used every endeavor to reduce the friction loss to a minimum. In most of the commercial mills great care is taken to obtain as nearly as possible a perfect alignment of the shafting; to secure proper lubrication, and to largely reduce the friction loss in the bearings by the liberal use of roller or ball bearings. Under these conditions it is evident that the amount

25 H.P. BACK GEARED INDUCTION MOTOR DRIVING SMALL ELEVATOR LEG
MUELLER AND YOUNG GRAIN ELEVATOR, CHICAGO, ILL.

of friction loss which can be eliminated by the adoption of motor drive is far less in the milling process than in the grain handling end of the industry.

In spite of these conditions, however, the use of motor drive has many positive advantages; without inconvenience, the motor or motors can be located in the mill close to the machinery and apply their power centrally on the main shaft, the length of shafting and belting being thereby reduced. The speed is constant, and when the motor is connected with a reliable source of power, there is entire freedom from interrupted service.

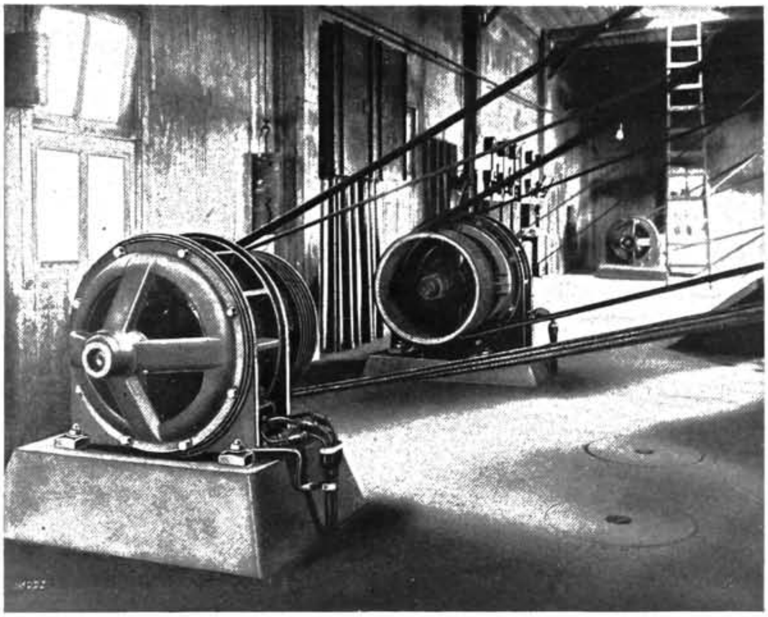
Where a mill contains several groups of machinery it will usually be found advisable to install a separate motor for each group, and where additions are made to the mill the new machinery can be set up and connected to its own motor without in any way interfering with the operation of the original equipment.

The perfection attained in the construction of the modern induction motor and its ability to maintain constant speed even under heavy overloads, render it theoretically possible to economize in power by driving the various sections of the milling machinery by means of individual motors; the adoption of this method would depend on the relative value of the power saved as compared with the increased first cost of the additional motors.

Fire Pumps

The electric motor constitutes an ideal medium for the application of power to fire pumps, inasmuch as it entails practically no expense for up-keep while it is idle, and upon the breaking out of a fire, by simply throwing a switch, the full water pressure is available.

A factor which may be of considerable importance is the ease with which a motor-driven fire pump may be made to operate automatically or be manually controlled from a distance. As in other types of pumps, those intended for fire service, either reciprocating or centrifugal type, can be designed to develop the highest possible efficiency when operated by motors especially constructed for this service.



INDUCTION MOTORS DRIVING ELEVATOR LEGS
WASHBURN-CROSBY COMPANY

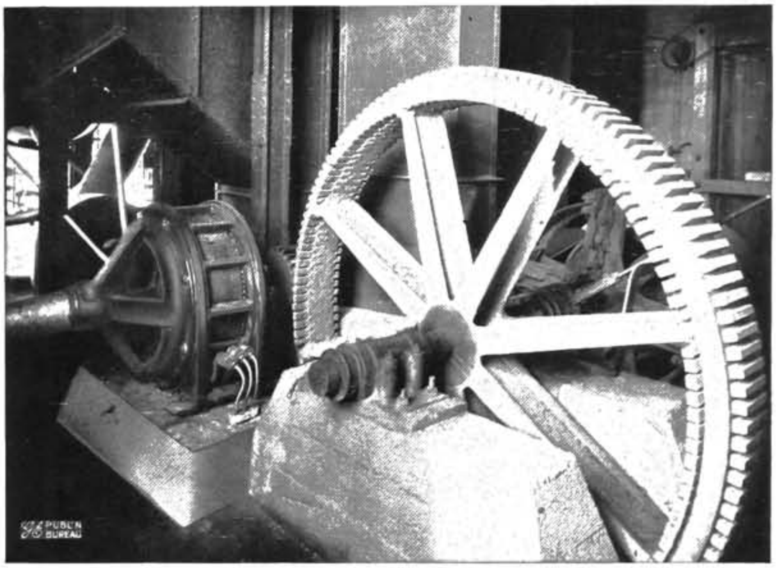
In comparing motor-driven fire pumps with the steam-driven type, the very great economy of the former is demonstrated by the fact that the cost of operation is entailed only during those periods when the pump is actually in service. It is unnecessary to maintain steam continuously for these units as is the case with steam-driven pumps, and if the plant is equipped with a generating outfit an additional factor of safety may be obtained by connecting the motor-driven pump with a central station circuit. In the event of a shut-down of the plant or injury to the generators the efficiency of the fire fighting equipment will by this means remain unaffected.

The cost of installing a motor-driven pump is usually less than with other systems and there is far less waste of power than that involved in friction and leakage on steam lines, as well as a reduction in the amount of space required.

As the electric motor is not dependent upon the location of boilers and the running of steam pipes, a motor-driven pump may be installed with entire freedom as to location, and in many instances can be used where the application of steam-driven pumps would be both difficult and costly.

CENTRAL STATION POWER: VS. ISOLATED PLANTS

In changing over a mill or elevator from mechanical to electrical drive the practical operator has to consider whether it will be true economy to discard the existing power plant and take current from a central station, or to utilize the engine equipment already installed for driving generators.



30 H.P. INDUCTION MOTOR DRIVING BELT CONVEYOR
WASHBURN-CROSBY COMPANY

Where new mills are constructed it is usually advisable to take power from central stations, as they can generally grant low rates for this service, due to the steady demand on their equipment. In this way the mill operator avoids the first cost of power house and machinery, the expense of maintenance and supervision, and the interest and depreciation charges.

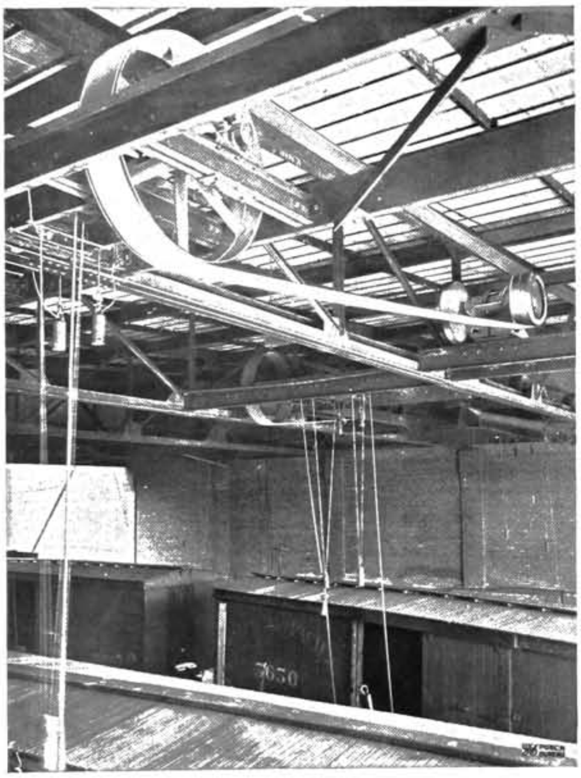
The up-to-date central station is provided with reserve machines, and the possibility of interrupted service, such as might occur by reason of the failure of a generator in an isolated plant, is thereby reduced to a minimum. That these factors are fully appreciated by mill men, is indicated by the fact that among the flour mills and grain elevators of Minnesota, about 70 per cent. of those electrically operated are using central station power.

To meet the conditions existing in mills and elevators of large capacity, which are provided with modern reciprocating engines and are so situated that central station current is not available, a complete line of apparatus suitable for isolated plants has been developed by the General Electric Company; the generators being designed to operate at the usual engine speeds.

For prime movers in new plants so located, the use of Curtis steam turbine is recommended, and compact turbine-generator sets will ensure economy in both steam consumption and required floor space.

In isolated plants equipped with reciprocating steam engines, the power developed may be greatly increased without adding to the boiler equipment, by using low pressure Curtis steam turbines in combination with the engines. The turbines render possible the utilization of all the available energy incident to the use of high vacuum, and take the steam directly from the exhaust pipes of the reciprocating engines without valves or other governing mechanism.

The adoption of electric drive for grain elevators and flour mills is steadily progressing in spite of the many improvements made in the various prime movers used for mechanical drive, principally because the simple construction and high efficiency of the induction motor insures the closest possible approximation to the direct application of the total initial power developed.



CAR SHOVELS OPERATED BY BACK GEAR INDUCTION MOTOR. NORTHWESTERN CONSOLIDATED MILLING COMPANY

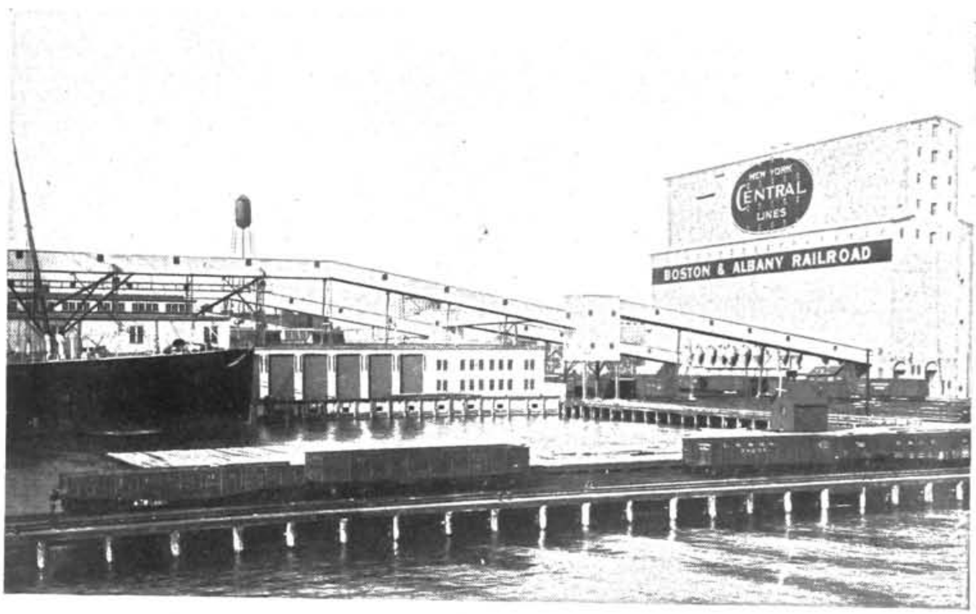
BOSTON & ALBANY GRAIN ELEVATOR, EAST BOSTON, MASS.

This plant, consisting of a grain elevator, grain-dryer house, dust house and wharf conveyor system, has recently been completed and put into regular service.

The grain elevator is a fireproof structure seventy-three feet wide, 269 feet long and 185 feet high. Seventy-two feet of the height is taken up by the storage bins, which have a capacity somewhat in excess of one million bushels. The general arrangement of the elevator and the machinery equipment, while representing the most modern practice and embodying the latest improvements, is very similar to that found in other elevators designed and built for this particular class of service. The elevator stands on the street side of the railroad property about 244 feet from the dock line, the yard tracks and a team driveway to the wharf buildings, occupying the space between. There are three wharf buildings, affording berth accommodations for six vessels at one time; three of the wharf fronts are approximately 600 feet long, the other three being approximately 800 feet long.

The wharf conveyor system consists of a number of overhead galleries with towers at the various connecting points, as shown below, housing belt conveyors which carry the grain from the elevators and distribute it to convenient locations over the various wharf buildings, where, by means of suitable loading spouts, it is conducted to the hatches of the vessels loading at the wharfs. Within, and for the full length of the elevator, there is a shipping-conveyor gallery, which is connected by two inclined galleries bridging the yard tracks to the main trunk of the distributing system. The main-trunk gallery is located over the driveway which skirts the water front, and from this main trunk, two wharf galleries branch off at right angles over each of the wharf buildings.

These wharf galleries extend practically the full length of the wharf buildings and afford some fifty loading points, at each of which an adjustable wharf loading spout is provided. The aggregate length of all the galleries is something over 6000 feet.

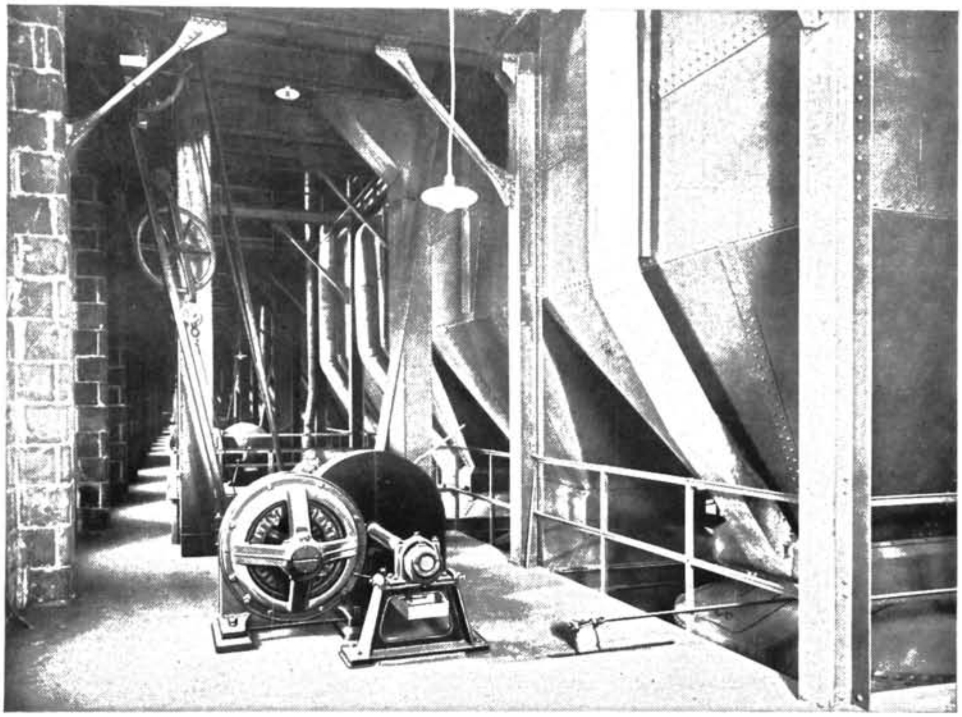


GENERAL VIEW OF WHARF GALLERIES AND GRAIN ELEVATOR

The main trunk and each of the connecting galleries contain two 36 in. belt conveyors. Each of the wharf galleries contains one 36 in. belt conveyor. The motors and the machinery required for driving the belt conveyors are located in the various towers, which also contain the distributing valves and spouts for diverting the grain from one belt to another. It is possible to so arrange the operation of the belt conveyors and distributing spouts that grain may be delivered to four vessels at one time, furnishing 10,000 bushels per hour to each. The distance from the elevator to the motor in the farthest tower is approximately 1,200 feet, and there are five motors in the intermediate towers. It is no exaggeration to say that the development of this remarkable and extensive wharf conveyor system is rendered possible only by the use of motor drive.

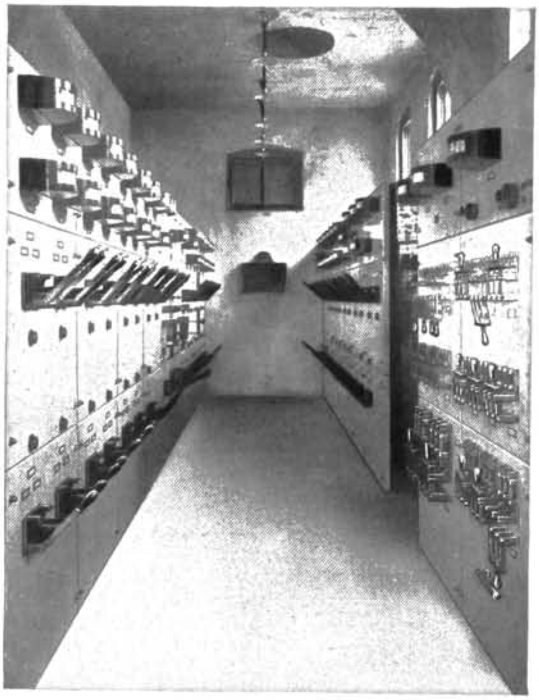
With but few exceptions, individual motor drive has been applied to all of the machinery throughout this plant, and the most casual observer cannot fail to notice the simplicity and compactness of the power transmission arrangements by the absence of line shafting, belting and other equipment incidental to mechanical drives.

The use of the individual motor drive under the low load factor conditions existing in grain elevator service demands, if the installation is to be successful from the commercial standpoint, that motors of relatively small rated capacity be used and that full advantage be taken of whatever inherent capacities for overloads the motors possess. The characteristics of the induction motor make this type almost an ideal one for this service, especially where, as in this case, the load can be applied through the medium of friction clutches. Full advantage has been taken of the characteristics of these motors in the selection of the sizes of the motors used in this installation, and



55 H.P. INDUCTION MOTOR DRIVING RECEIVING ELEVATOR

it is probable that the motor equipment installed in this plant has the smallest rated capacity in proportion to the capacity of the grain handling machinery of any comparative plant now in existence.

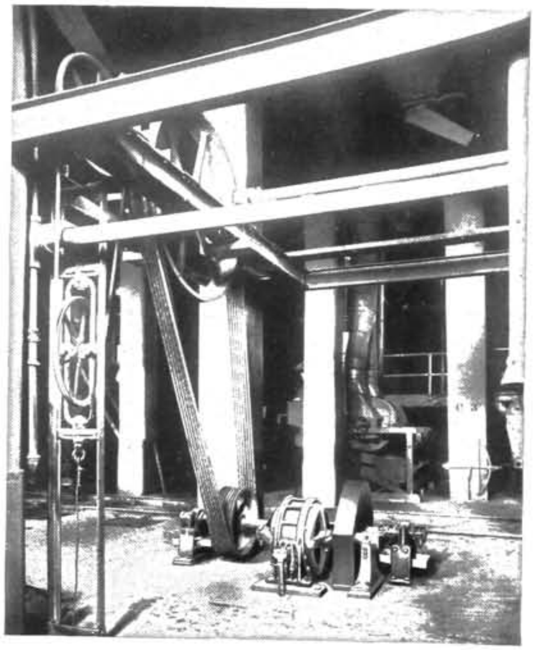


SWITCHBOARD SHOWING LIGHTING, SIGNAL SYSTEM AND POWER CIRCUIT PANELS

A feature of design, almost peculiar to these grain elevators, is the necessity of providing the means of supplying and distributing a large amount of power over a large floor area, some 175 feet or so above the ground. The total amount of power available for distribution about the top floor of this elevator, based on the motor ratings, is 1045 h.p. The aggregate rated capacity of the motors installed throughout the plant is 2215 h.p.

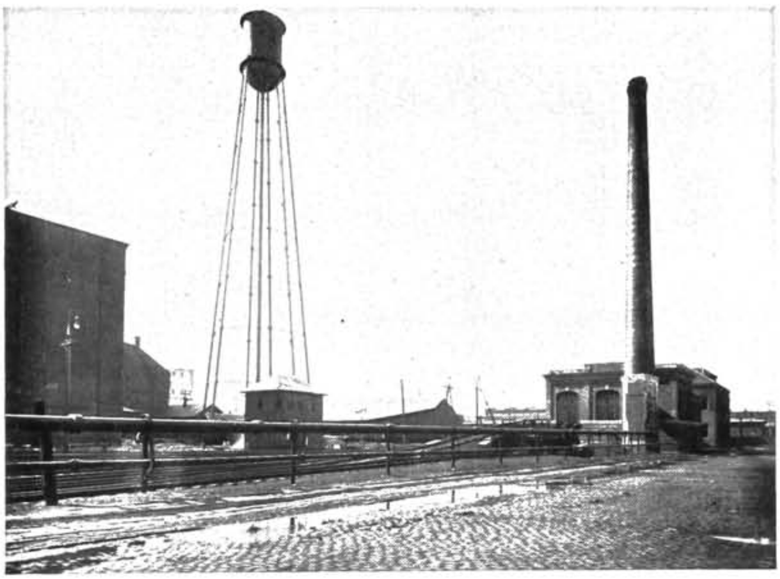
The motors are of standard design and construction, wound for operation on three-phase 60 cycle alternating current circuits, having a normal potential of 440 volts. With the exception of the passenger elevator motor, all motors are of the squirrel cage rotor type.

Undoubtedly, the most interesting feature of this electrical installation is the method employed for the operation of the motors. The necessity of providing for the remote control of many of the motors, together with other conditions of grain elevator operation required to be met by the electrical equipment, rendered desirable the locating of all the switching arrangements at one point, and the placing of them under the control of an attendant trained for the work. The operations required for motor starting are performed solely by this attendant, while the stopping of the motors can be effected by pressing a number of push buttons, which are conveniently located throughout the



35 H.P. INDUCTION MOTOR DRIVING SIX PAIRS OF GRAIN SHOVELS

plant and are connected to independently excited trip coils attached to corresponding switches. Each motor has an independent set of feeders and a separate control switch. The control switches are mounted upon a switchboard which has two sets of busbars, one set for the main or running potential, and the other for the compensators through a combination of switches, which permit of the compensators being used either independently or in multiple, and furnishing either 40 per cent. or 58 per cent. of the main busbar potential to the compensator busbars. The motor-control switches, which are of the double-throw type, are connected to the two sets of busbars so that the starting and running potentials may be applied to the motors in turn. The switches are non-locking on the starting side, and arranged so that only one side can be closed at a time. Each switch is provided with two series-overload trip coils, and one of the remote control trip coils previously referred to.



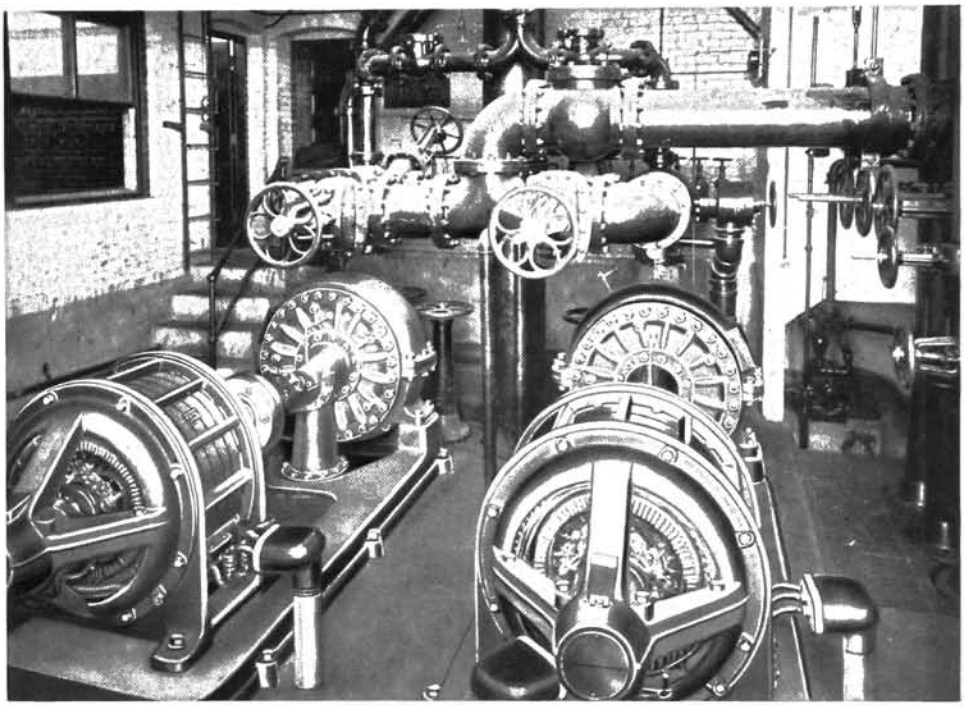
PUMPING STATION AND PIPE LINE

Signals indicating to the switchboard attendant which motors are required to be put into service are transmitted by means of a push button and annunciator signal system. The decrease of the starting current with the increase in the speed of the motor is taken advantage of to furnish a means of indicating to the operator when to make the transfer from the starting side to the running side of the switch. Each motor circuit is provided with an ammeter, having the scale graduated proportionately to the load readings. To admit of these meters being used as starting current indicators necessitated the use of four-pole switches and an ammeter by-pass arrangement, which is in service only when the switch is on the starting side. By means of push buttons located near the switches, and bells located over the push buttons for the annunciator signal system, return signals are transmitted to the machinery operators, which notify them that the starting operations have been carried out and that the load may be applied. The average time required to carry out the motor-starting operations is about thirty-five seconds. The control switches for the ten motors, which operate the belt conveyors in the wharf conveyor system, are, in addition to being subject to the individual remote control previously referred to, subject to a collective remote control, the purpose of which is to shut down the entire shipping system in case of an emergency. The remote control trip coils of these switches are connected to the contact studs of an automatic, adjustable time element, multiple contact switch. This switch is brought into operation upon pressing any one of about sixty push buttons, which are located at the wharf loading spouts and in the towers. The connections to the contact studs are made in such order, and the time element is so adjusted, that the motors come to a stop in an established sequence.

The purpose of this arrangement is to prevent the discharge of grain from a moving belt conveyor to a stationary one ahead of it. Less than ten seconds are required to bring the entire shipping conveyor system to a standstill. Forty-eight annunciator drops, sixty-three bells and two hundred and forty-seven push buttons variously connected to one hundred and forty independent circuits make up the auxiliary systems required for this method of operating the motors.

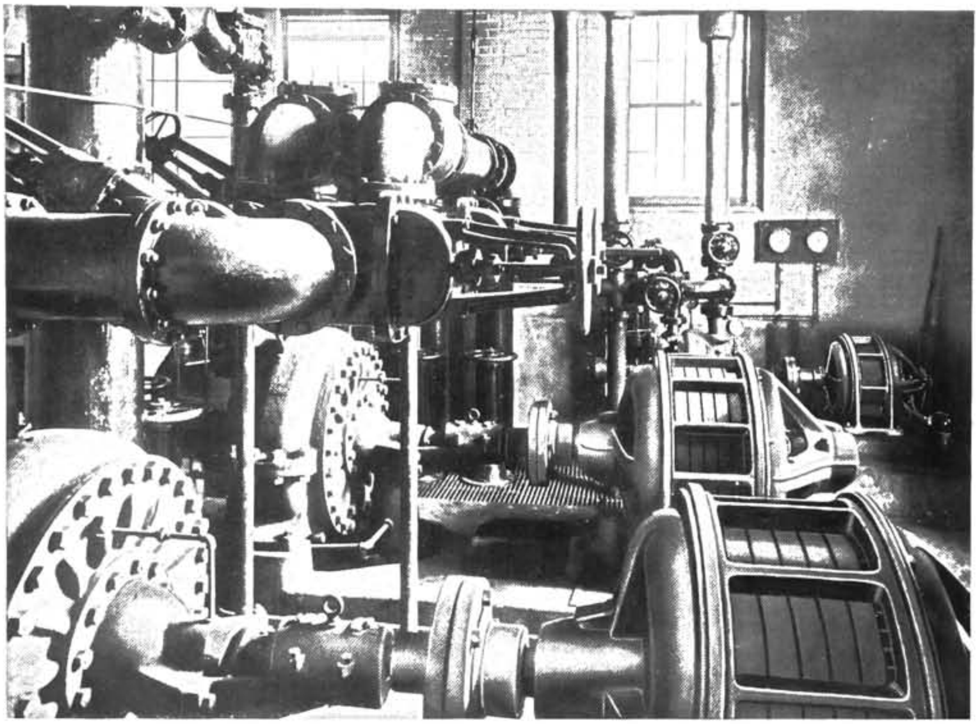
Effective artificial illumination is provided by means of some eight hundred 16 c-p. incandescent lamps, well distributed throughout the plant. Fifteen panel boards in steel cabinets form convenient centers of control for the lighting system. Electric radiators are used for heating the switchboard room, and the superintendent's and weighman's offices.

Signals are transmitted from the scale floor and vice versa in connection with the operation of the elevators by means of a colored lamp signal system. Each elevator is provided with a red and blue lamp on each of these floors, the lamps of the same color being connected in series and controlled by three-way switches.

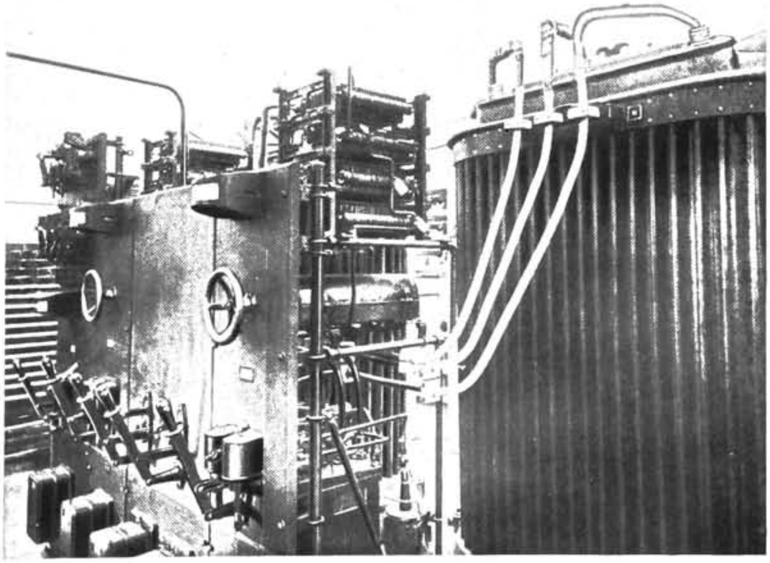


2-200 H.P. INDUCTION MOTORS DIRECT CONNECTED TO CENTRIFUGAL PUMPS

A thirty-two station inter-communicating telephone system with extension bells provides a convenient means of communication between the widely scattered operators throughout the plant. The following summary presents the most important data of the motor equipment, and the machinery to which it is applied:



ARRANGEMENT OF MOTOR-DRIVEN CENTRIFUGAL PUMPS IN PUMP STATION



CONTROLLING PANELS FOR PUMP MOTORS

All of the wiring throughout the plant, including the signal and telephone systems, is installed in conduit, of which there is something like seventy thousand feet of various sizes.

Sixty cycle alternating current is furnished to this property by the Edison Electric Illuminating Company of Boston, Mass., three-phase nominal 440 volt current being furnished for the power service and single-phase regulated 230 volt current for lighting and other services. The signal systems and the telephone bell ringing circuits operate on a seventy-five volt service, obtained by the use of auxiliary transformers connected to the busbars of the lighting switchboard.

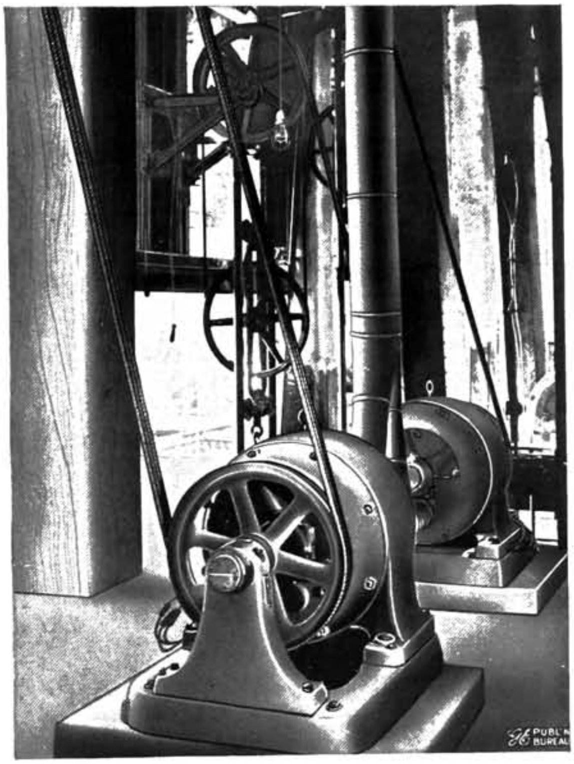
The pump station connected with this plant is located in a separate brick building. There are two 1500 gallon fire pumps, each designed to work against a pressure of 125 pounds, and each having a capacity sufficient for six 1⅛ nozzle streams. They are of the two-stage turbine type, operate at a speed of 1165 revolutions per minute, and each is direct coupled to a 200 h.p. 440 volt motor of the collector-ring type.

MOTOR DISTRIBUTION

No. of Motors	H.P.	R.P.M.	Service	Speed of driven shaft	Transmission
1	100	720	Dust fans—double, 80-inch	700	Belt
1	75	720	Dust fans—double, 70-inch	700	Belt
6	55	514	Six receiving elevators—185-foot centers, 7 by 7 by 20-inch buckets	29	Gear and rope
6	55	514	Six shipping elevators—190-foot centers, 7 by 7 by 20-inch buckets	29	Gear and rope
5	53	514	Five cleaner elevators—181-foot centers, 7 by 7 by 20-inch buckets	29	Gear and rope
1	36	900	Two dryer elevators—181-foot centers, 7 by 7 by 12-inch buckets	32	Gear and rope
1	35	600	Six pairs Clark car shovels	66	Gear and rope
1	35	900	Two double drum car pullers	16	Gear and rope
1	20	1200	One 36-inch transformer belt conveyor, 253-foot centers	146	Gear and rope
5	20	1200	Five double cleaning machines	575	Belt
5	15	1200	Five single cleaning machines	575	Belt
1	10	1200	Passenger elevator—direct connected		Worm gear
1	75	720	Three dryer fans—double, 90-inch	384	Rope and gear
			One 24-inch dryer belt conveyor, 75-foot centers	193	Rope
1	5	1200	Dust packer	150	Belt
			Dust agitator	160	Belt
1	100	720	One 36-inch belt conveyor, 619-foot centers	117	Gear and rope
			One 36-inch belt conveyor, 387-foot centers	147	Gear and rope
1	100	720	One 36-inch belt conveyor, 754-foot centers	117	Gear and rope
			One 36-inch belt conveyor, 203-foot centers	196	Gear and rope
1	100	720	One 36-inch belt conveyor, 564-foot centers	117	Gear and rope
			One 36-inch belt conveyor, 184-foot centers	196	Gear and rope
			One 36-inch belt conveyor, 180-foot centers	196	Gear and rope
1	75	720	One 36-inch belt conveyor, 496-foot centers	147	Gear and rope
			One 36-inch belt conveyor, 283-foot centers	196	Gear and rope
			One 36-inch belt conveyor, 207-foot centers	196	Gear and rope
1	75	720	One 36-inch belt conveyor, 614-foot centers	117	Gear and rope
			One 36-inch belt conveyor, 233-foot centers	198	Gear and rope
1	75	720	One 36-inch belt conveyor, 229-foot centers	144	Gear and rope
			One 36-inch belt conveyor, 224-foot centers	144	Gear and rope
			One 36-inch belt conveyor, 99-foot centers	196	Gear and rope
1	75	720	One 36-inch belt conveyor, 229-foot centers	144	Gear and rope
			One 36-inch belt conveyor, 224-foot centers	144	Gear and rope
			One 36-inch belt conveyor, 99-foot centers	196	Gear and rope
2	50	900	Two 36-inch belt conveyors, 740-foot centers	116	Gear and rope
1	15	1200	One 36-inch belt conveyor, 193-foot centers	192	Gear and rope

NEW YORK GRAIN ELEVATOR No. 7, WEEHAWKEN, N. J.

Since its completion in 1905, this elevator has been operated with electricity as the sole source of applied power. It has a capacity of 2,000,000 bushels of grain and is operated with three-phase, 25 cycle, 550



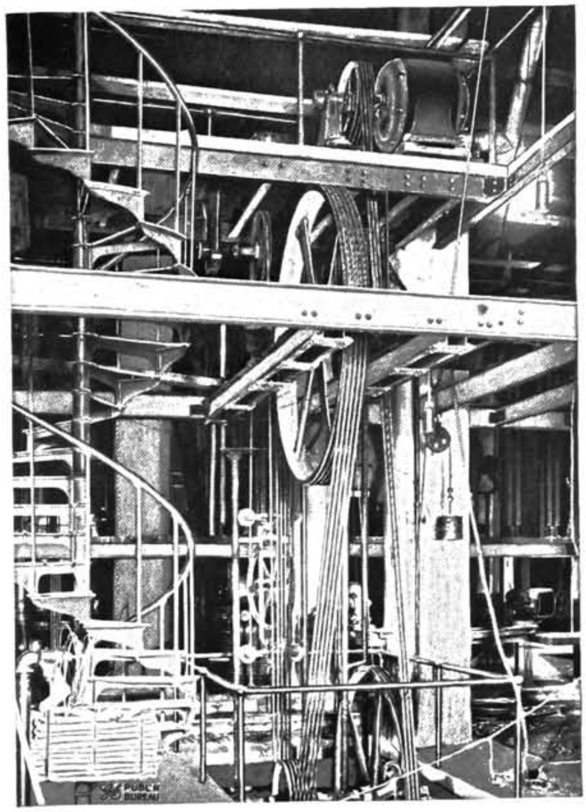
INDUCTION MOTORS DRIVING CONVEYOR BELTS

volt induction motors having an aggregate capacity of approximately 3300 h.p., and no interruptions to service, due to electrical apparatus, have been experienced since the elevator was first placed in service.

Current is supplied from a nearby isolated generating plant equipped with engine-driven alternators, and all motors are controlled from a central switchboard having two sets of busbars, by means of which the starting and operating speeds of the motors are controlled in the same manner as those installed in the Boston & Albany Elevator, at East Boston, Mass., already referred to. The motors at Weehawken are, however, installed in a single building and, due to their relatively compact arrangement, the system of inter-communicating signals is not so elaborate as that at East Boston.

The eight receiving elevators, each having a capacity of 10,000 bushels of wheat elevated at the rate of 210 feet per hour, are individually driven by 100 h.p. induction motors, through rope drive. It has been found that for normal operation, the load demand on these motors is about 78 h.p.

There are seven cleaning elevators, practically identical with the receiving elevators



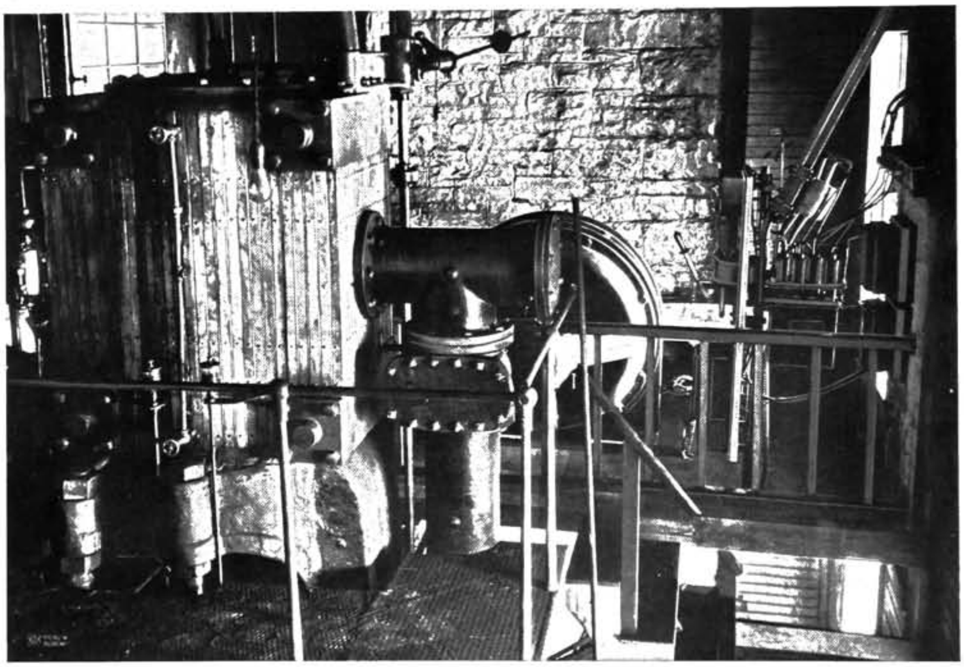
INDUCTION MOTOR AND DRIVE FOR AUTOMATIC POWER SHOVELS

and similarly operated by 100 h.p. motors. These serve to bring the grain to the top of the building, when once it has dropped either into freight cars, or vessels, for shipment, or carries it into the bins for storage.

Eight motors, each of 100 h.p. rating, are utilized for driving the shipping elevators, which deliver the grain from storage bins to the cars or lighters, and for transferring the grain from the storage bins to these shipping elevators there are eight 22-inch belt conveyors, group-driven by two 40 h.p. induction motors. There is also a longitudinal conveyor for transferring grain from one bin to another, or from a bin to a vessel. This elevator utilizes a 75 h.p. motor, which drives a 36-inch belt having a capacity of 10,000 bushels per hour, at the rate of from 600 to 800 feet per minute. It can be operated in either direction.

There are numerous smaller motors applied in driving fans, water supply and drainage pumps and the passenger elevator is also motor-driven.

All the motors used for handling the grain are of the General Electric enclosed ventilated type.

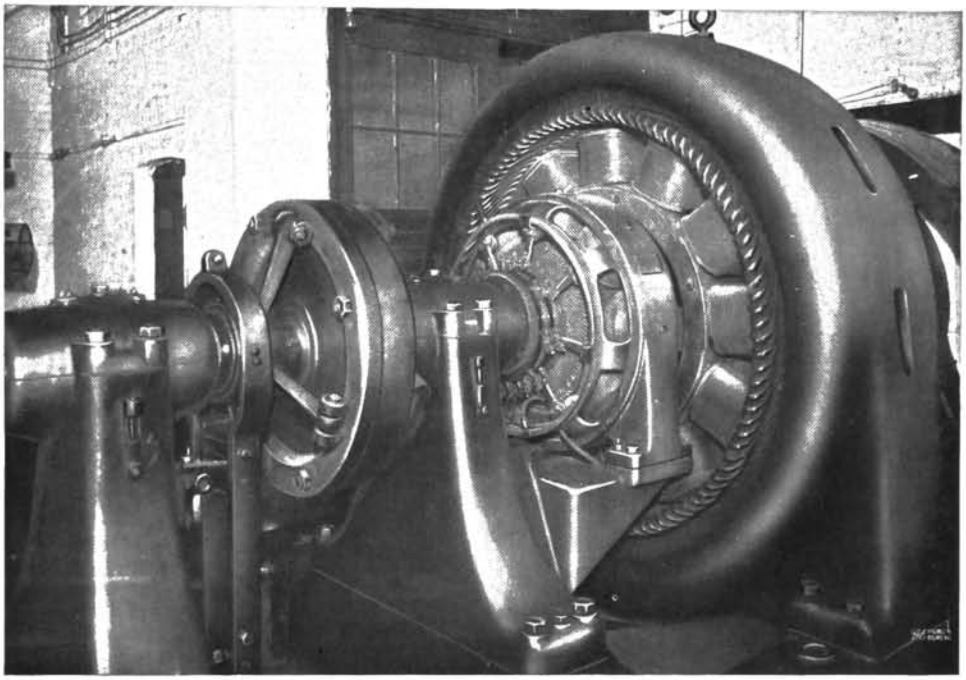


150 H.P. FORM L GENERAL ELECTRIC MOTOR REPLACING ENGINE DRIVE
OGDENSBURG ROLLING MILLS, OGDENSBURG, N, Y,

THE GEORGE URBAN MILLING COMPANY, BUFFALO, N. Y.

An excellent example of group motor drive is found in the plant of the George Urban Milling Company of Buffalo, N. Y. This plant has an output of 1300 barrels of flour per 24 hours, and its elevator facilities provide for the storage of 150,000 bushels in two tanks; one of 100,000 bushels, and the other of 50,000 bushels capacity.

The main motor which operates practically all the machinery of the plant is a 400 h.p. General Electric synchronous motor, taking current at 2200 volts, three-phase, 25 cycles. Current is received from Niagara, being transmitted at 11,000 volts, and stepped down for use in the motor at 2200 volts. This motor with its controlling panel is centrally located in a fireproof brick walled room, and provided with a pulley and clutch on either end of the shaft. One end drives all the machines in the headhouse and the grain receiving, handling and cleaning apparatus; the other end drives all the milling machinery. Prior to the installation of this motor the plant was driven from a steam engine through the usual shafting, and tests showed that under normal operating conditions the power loss, due to friction, varied from 200 to 225 h.p. This friction loss has been considerably reduced by the installation of this synchronous motor, which has now been running for a period of about 6 years, during which time it has given entire satisfaction, operating on the usual 24 hour service. It is frequently subjected to temporary overloads, which cause the motor to develop as high as 550 h.p., and this excess load is carried without injury or unsafe heating.



400 H.P. SYNCHRONOUS MOTOR DRIVING MILLING MACHINERY

In addition to the main motor, a 20 h.p., 220 volt, Form K motor is used for operating the packing machinery, including flour packer, belt conveyor and freight elevator. A small stepdown transformer is provided for the operation of this motor, as well as for a portable motor-driven air compressor set, which is used for cleaning the machinery.

MUELLER & YOUNG GRAIN ELEVATOR, CHICAGO, ILL.

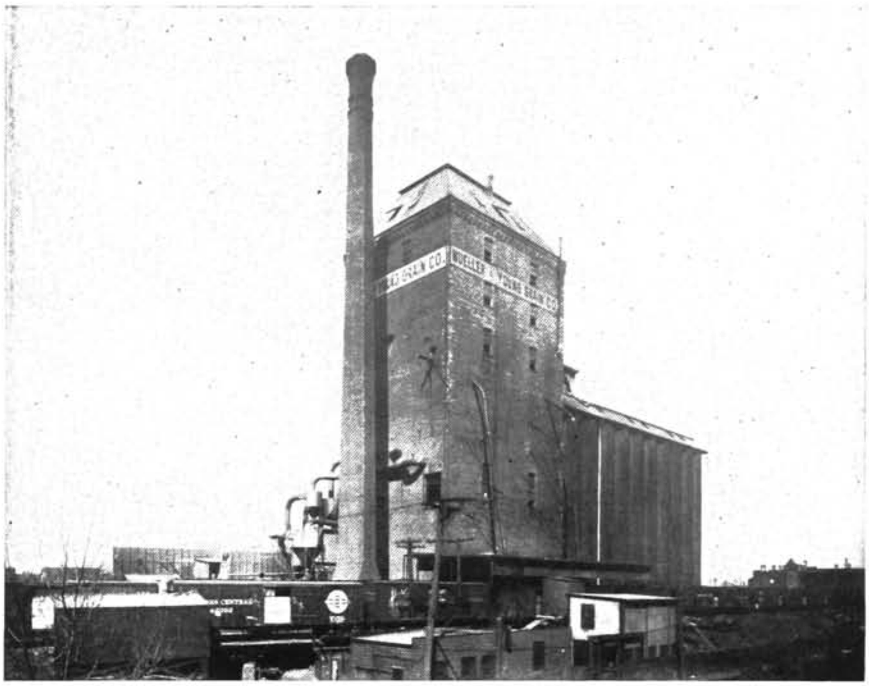
Situated between 55th and 56th streets, in the heart of Chicago, this elevator is of thoroughly modern fireproof construction, brick, reinforced concrete and steel being used throughout.

The unloading capacity is 45,000 bushels per day, shipping capacity 50,000 bushels per day, storage capacity 500,000 bushels. Electric drive is used for all power applications, and about 40 motors, ranging in size from ½ h.p. to 75 h.p. are used; the aggregate rating being 743 h.p. These motors replace a system of engine drive, and the type adopted as a standard was the three-phase induction motor manufactured by the General Electric Company.

Current is purchased from the Commonwealth Edison Company, and maximum safety from fire risk is insured by running all the wiring in iron conduit.

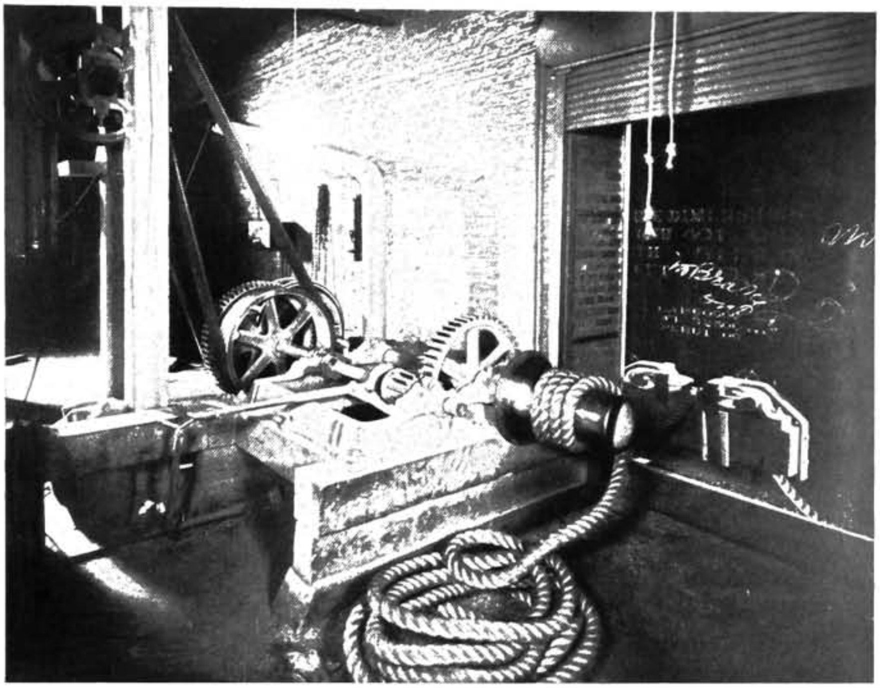
In receiving the grain, cars are pulled over receiving hoppers by means of a 37½ h.p., 540 r.p.m. motor, which operates two car pullers, while the car unloaders are driven through shafting by a 15 h.p., 1200 r.p.m. back geared motor. Two 5 h.p. motors are used to drive belt conveyors from receiving hoppers to the elevator legs, and the four large elevator legs are each driven by a 35 h.p. motor.

The scourers, separators, oat clippers, and cleaners are driven by motors ranging from 7½ to 75 h.p. in capacity, while two small motors, rated at ½ h.p. each, drive a purifier reel and a mustard cleaner; the latter application utilizing a back geared type of motor.

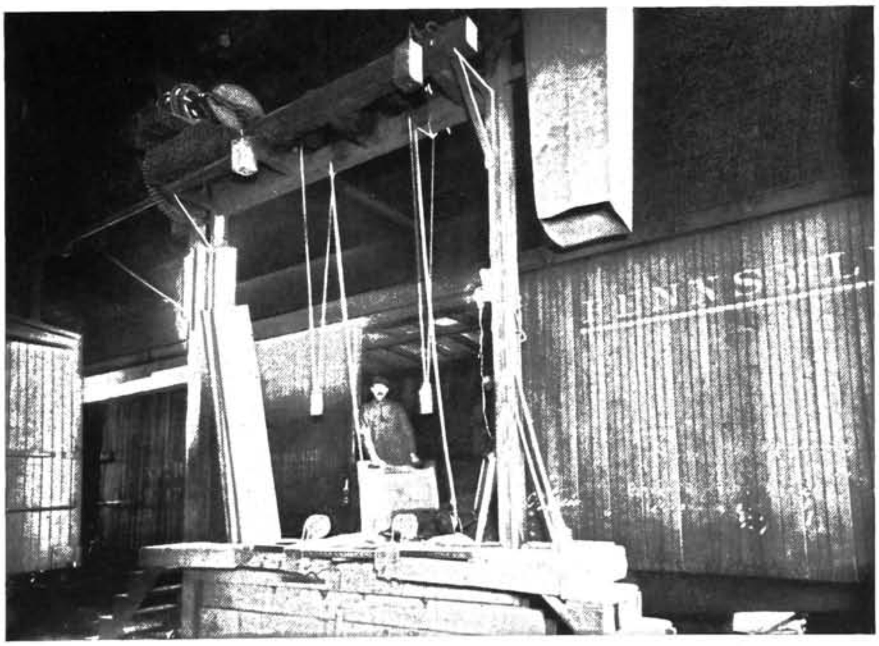


GENERAL VIEW OF GRAIN ELEVATOR

The grain flows by gravity to bins and from there to two transfer legs, each operated by a 25 h.p. back geared motor; the pony leg elevator utilizing a 5 h.p. motor. For elevating the grain from the transfer legs to the belt conveyor on the top floor, the grain passes to receiving legs where it is lifted to the belt conveyor, which is driven by two 10 h.p.



37½ H.P. MOTOR OPERATING TWO CAR PULLERS



15 H.P. BACK GEARED MOTOR OPERATING CAR UNLOADERS

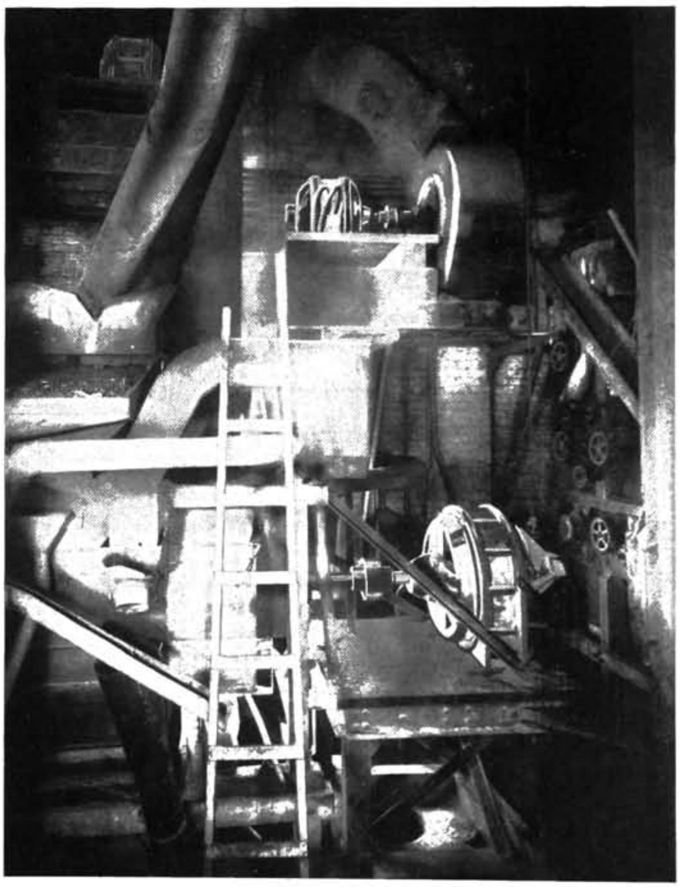
motors and conveys the grain to the storage bins.

In shipping the grain it passes from the bottom of the storage bins by gravity to two belt conveyors in the basement, each of which is driven by a 10 h.p. motor. It then passes into a large elevator leg where it is raised to the garner, flowing thence to the scales by gravity and from the scales is spouted directly to the cars.

Among the auxiliary apparatus is an oats bleacher driven by a 7½ h.p., 1200 r.p.m. back geared motor; a circular saw, centrifugal pump and passenger elevator, driven respectively by 3 h.p., 5 h.p. and 11 h.p. motors.

On account of its location in the city of Chicago, the dust must be carefully handled. There are three large fans for this service, each driven by a 25 h.p. motor, with a 5 h.p. motor driving the fan on the cleaning floor. There is also a 7½ h.p. back geared motor operating a screw conveyor and dust packer, and a 2 h.p. motor driving a sacking elevator. The dust is ordinarily blown direct into freight cars, but when these are not available the dust is blown into a storage bin to be thereafter blown into the cars.

The control of all motors is centered in a switchboard located on the main floor and communicating with the various parts of the building by speaking tubes and bell signal system. Each motor is provided with a totally enclosed fuse switch in conjunction with the starting controller.



ARRANGEMENT OF MOTORS FOR DRIVING CLEANERS AND BLOWERS

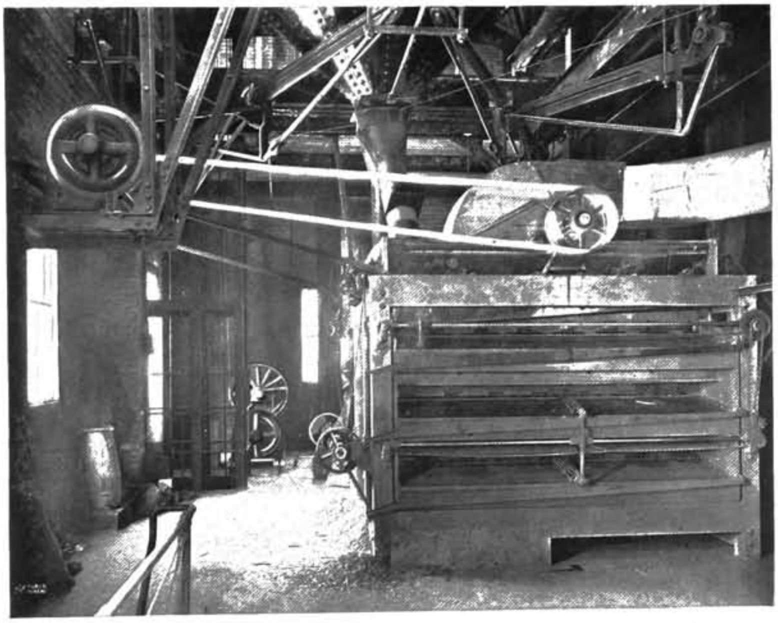
NORTHWESTERN CONSOLIDATED MILLING COMPANY

The recently constructed elevator of the Northwestern Consolidated Milling Company has a capacity of one and a quarter million bushels. The elevator is built of brick and is operated throughout by twenty Form K General Electric induction motors ranging in size from 5 h.p. to 50 h.p.

For unloading the grain, four pairs of grain shovels are employed, each of which is operated by a 15 h.p. back geared motor. From the cars the wheat is conveyed to the elevator legs by two belt conveyors driven by one 25 h.p. back geared motor. The motors on the legs are 50 h.p., 900 r.p.m. machines, geared through a clutch to an Evans backstop device and to a shaft on which is mounted a sheave pulley with a rope drive. The Evans backstop device is essentially a friction clutch which permits the elevator leg to run in one direction only. Should the electric power supply suddenly fail while grain is being elevated, this clutch automatically sets and prevents the leg from running backwards, due to the weight of the grain. The second clutch is an ordinary friction clutch which permits the motor to be started without load.

The receiving separators are belted to 15 h.p., 900 r.p.m. motors and for transferring grain to the various bins and mills a number of short conveyor belts are used, direct connected to back gear motors.

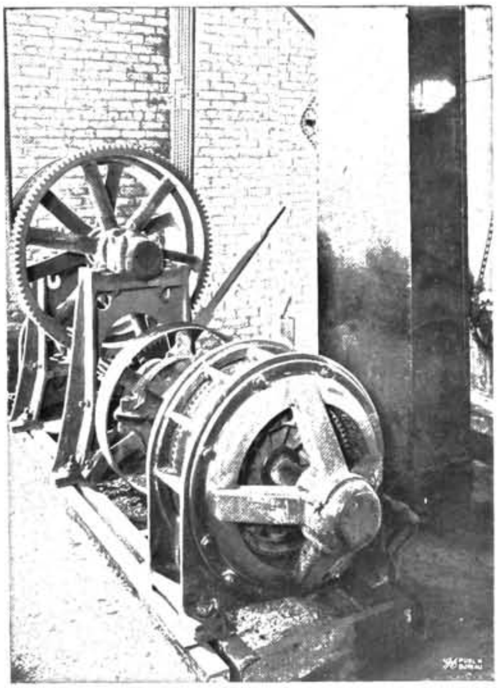
This elevator is equipped with a very complete dust collecting system, and is practically free from dust. The fan for this system is direct connected to a 35 h.p., 1200 r.p.m. motor.



INDUCTION MOTOR BELT CONNECTED TO CLEANER

All of the motors in this elevator are operated from a 750 kw., 480 volt, 2 stage Curtis turbine generator. The entire power station equipment consists of this turbine, a 35 kw. turbine exciter set, one 40 kw. motor-generator set, and an eight panel switchboard, all of which were furnished by the General Electric Company.

The available capacity of the power station has been augmented by a method which is of particular interest as illustrating a combination of waterwheel and electric drive for the operation of flour mills. The mills of this company are arranged for either waterwheel or group motor drive, and the water power station is connected with the turbo-generator power station by means of a 1000 ft. transmission line of 1500 ampere capacity.



INDUCTION MOTOR DRIVING ELEVATOR LEGS THROUGH FRICTION CLUTCH AND GEAR DEVICE

Two pairs of horizontal waterwheels are used, one set being coupled to a 600 kw., and the second to a 450 kw., 480 volt alternator, the waterwheel sets being also coupled direct to the main driving shafts of the two mills. This system insures continuous operation and at the same time renders it possible to obtain full value from the available water power. It is obvious that with the arrangement described above the waterwheels may take on part or all of the mill load, according to the condition of the water supply, while during periods of low water these generators may be operated as synchronous motors with current from the main power station.

The power developed by the waterwheels at full opening of the gates is considerably in excess of the energy required to drive the mills, so that with a full head of water the generators can deliver current to the electrical system up to a maximum of 200 kw.

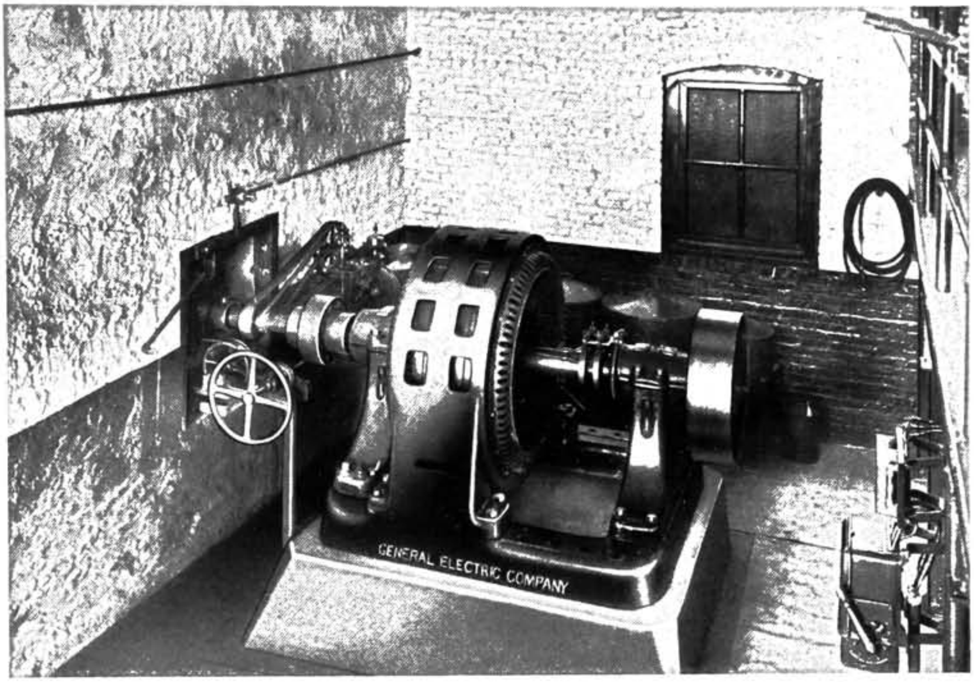
During periods when the available head is diminishing the generators are run as synchronous motors to neutralize the loss of power, and as they are, under these conditions, only partially loaded, their excess capacity may be utilized to supply leading current to the line, and thereby raise the power-factor of the entire system. This combination is of special value as only induction motors are used in the elevator.

The fact that these are synchronous machines makes it possible to change the load from the waterwheels to the motors

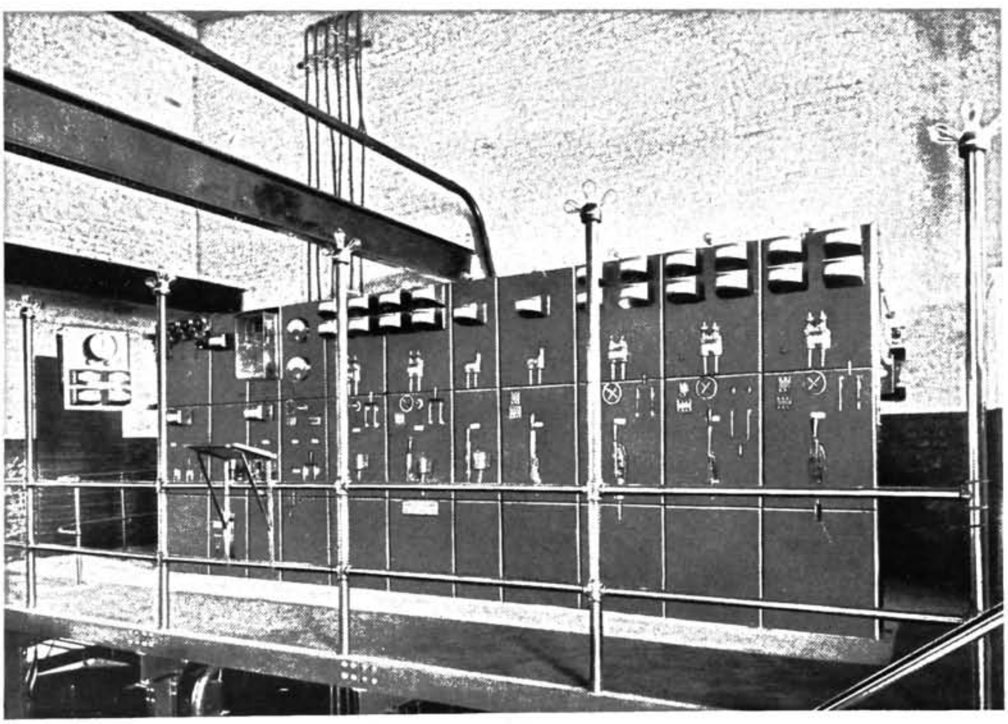
BACK GEARED INDUCTION MOTOR DRIVING TWO CONVEYOR BELTS

without altering the speed of the mills, and this is a most important consideration in the operation of flour milling machinery.

The control of both waterwheels and generators is centered in a switching station, which contains an eleven panel switchboard.



WATERWHEEL DRIVEN ALTERNATOR



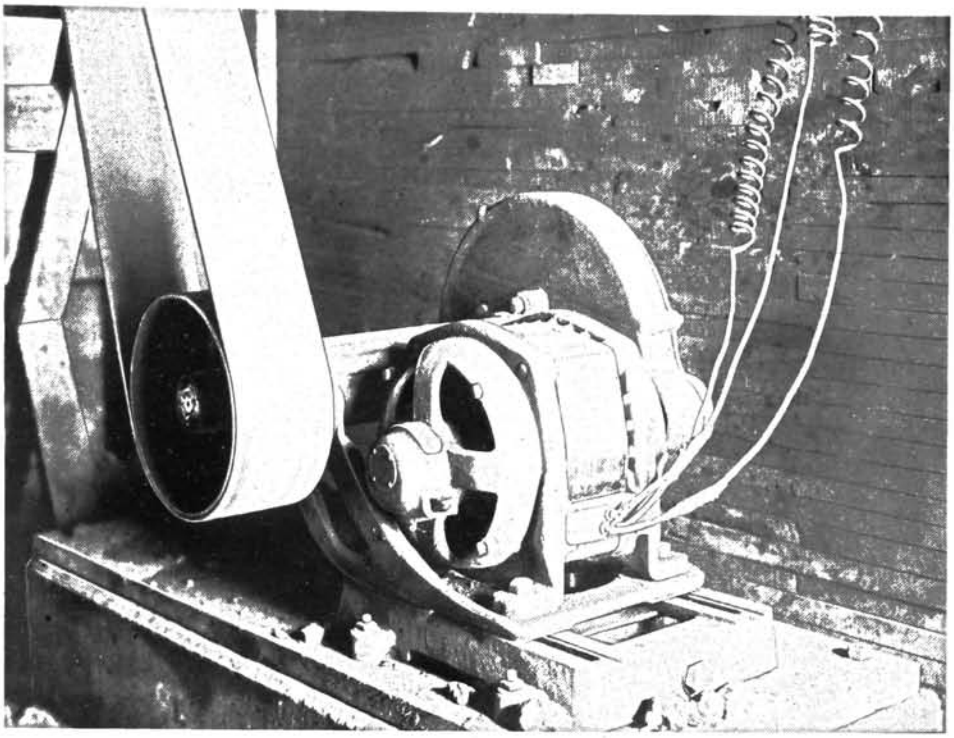
ELEVEN PANEL SWITCHBOARD IN WATER POWER STATION

ZEUGNER, HOFMANN COMPANY, FORT ATKINSON, WIS.

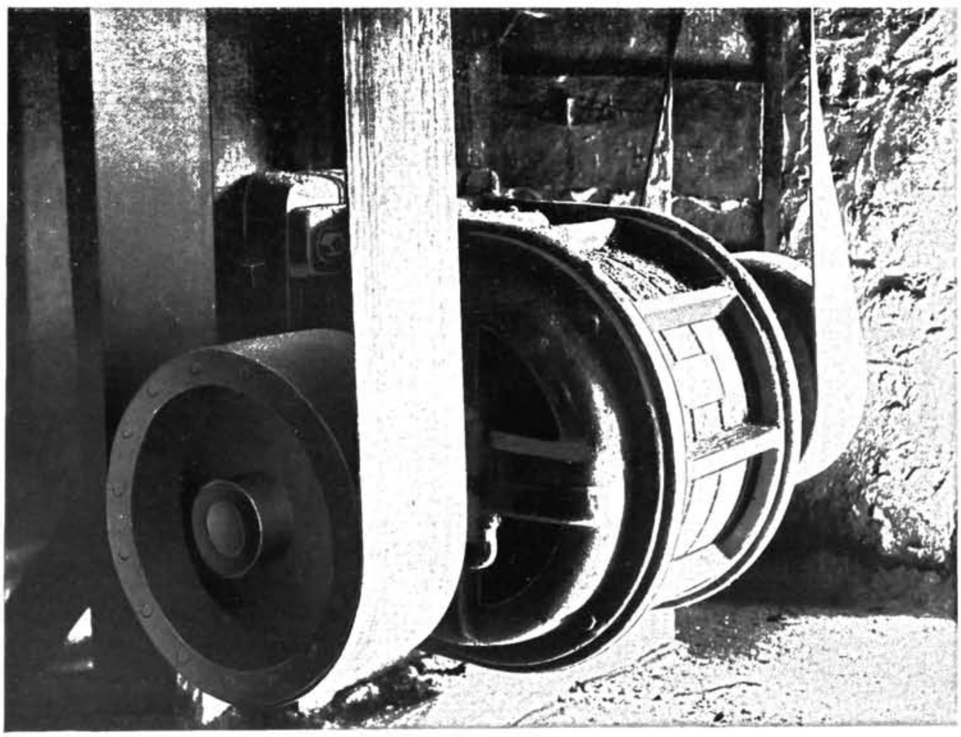
This is essentially a country elevator which handles lumber and coal as well as grain, and is typical of numerous small plants serving limited areas in rural districts. The principal grain business consists of grinding corn for farmers. The building is of wooden construction throughout, and the machinery was formerly operated by a steam engine. The work is now performed by means of three-phase 60 cycle, 220 volt induction motors, with a total rated capacity of 72½ h.p. In abandoning steam for electric drive a considerable saving in insurance expense was achieved; the rate being reduced from $3.40 to $2.20, while a yearly charge of $95 for boiler insurance was also eliminated.

Corn is received from the farmers either shelled or on the cob. Upon arrival at the elevator it is unloaded by hand into a hopper, whence it flows by gravity to a 40 ft. elevator which is driven by a 2 h.p., 1800 r.p.m. belted motor, and from this elevator it is run into the bins. It then flows by gravity to a hopper located directly over the corn crusher. Only the corn that is received on the cob is put through this crusher, where it is ground together with the cobs: The crusher is driven by a 10 h.p., 1800 r.p.m. belt connected motor. From the cob crusher the corn flows to an elevator boot and is raised by one of the 40 ft. elevators driven by a 5 h.p. motor. It is then deposited in bins from which it flows by gravity direct to the attrition mill where it is ground into feed. It is finally elevated by a 40 ft. leg to a bin from which it is spouted direct to the farmer's wagon. When the corn is to be ground into corn meal it is cleaned before reaching the attrition mill by a shaker screen operated by a ½ h.p. belted motor, and by a receiving separator which is driven

ELEVATOR AND MILL BUILDINGS



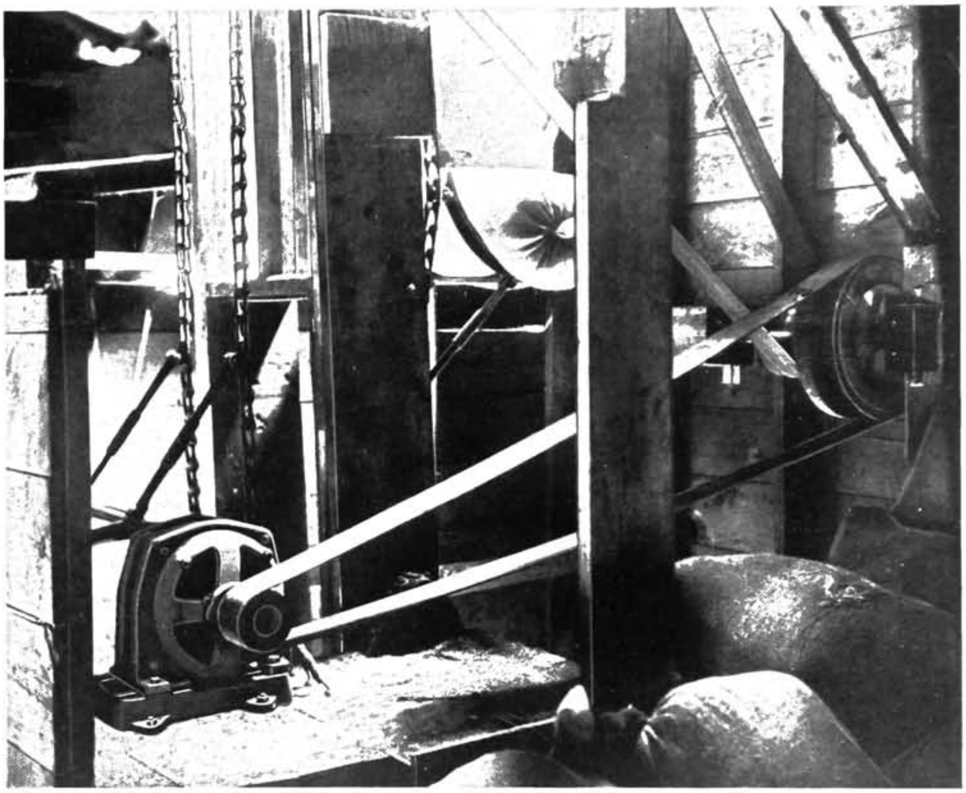
10 H.P., 1800 R.P.M. BACK GEARED INDUCTION MOTOR BELTED TO COUNTERSHAFT DRIVING COAL ELEVATOR AND AUTOMATIC SHOVEL



135 H.P., 1200 R.P.M. INDUCTION MOTOR WITH DOUBLE SHAFT EXTENSION DRIVING 24 INCH ATTRITION MILL

by the motor that operates the cob crusher. The capacity of the mill is about fifty bushels of ground corn per hour. When it is necessary to handle feed already sacked, it is unloaded from the cars and elevated to a storage floor by means of a 5 h.p. motor-driven sack elevator.

In order to obtain the low insurance rates already referred to, the wiring for the motors was installed in iron conduit and every precaution taken to avoid risk of fire. Inasmuch as current is purchased, the cost of power is directly proportional to the amount of work performed, and it is interesting to note the following record of operations extending from September 6 to September 13, 1911, during which time the total current consumption equalled 330 kw-hrs. During this time the elevator handled 19,180 lb. of rye, requiring fine grinding; 8580 lb. of oats, requiring light grinding; 3,000 lb. of corn on the cob, requiring both crushing and grinding: 56,000 lb. of corn were elevated 50 ft. and 30,000 lb. of gluten were elevated 30 ft. In addition to this grain handling work, the elevator utilizing a 1 h.p. motor was operated for three hours, one cord of wood was sawed, and 159,900 lb. of anthracite coal was unloaded and elevated 50 ft. At the rate of four cents the cost of current would be $13.20, or $1.89 cents per day. The power cost per cord for sawing four feet of wood into four pieces averages five cents. The current demand for elevating four hundred 100 lb. sacks of feed (approximately a carload) to a height of 30 ft. equals 6 kw-hours, or a cost of twenty-four cents. The elevator receives eight cents per hundred pounds for grinding grain, and the power costs vary with the amount handled from two to three cents per hundred pounds.



5 H.P. INDUCTION MOTOR DRIVING SACK ELEVATOR

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RAILWAY DEPARTMENT

August, 1912

Bulletin No. 4977

SPRAGUE-GENERAL ELECTRIC TYPE MK CONTROL

The well known Sprague-General Electric Type M control which has been in general use for many years was primarily designed to permit the operation of a train of several cars as a single unit from the master controller of the leading car. The success it achieved in this direction has lead to its more general application, and today it has almost entirely displaced the cylinder controller on locomotives and on interurban cars, and its use is now being rapidly extended to city service.

Where single car operation predominates, such as on interurban roads and in city service, and in cases where uniform acceleration is not of such importance as extreme simplicity, the hand-operated or Type MK control described in this publication is recommended.

The automatic control, or Type MA, which is described in another bulletin, is chiefly used in heavy service where uniformity of current input and rapid acceleration are important.

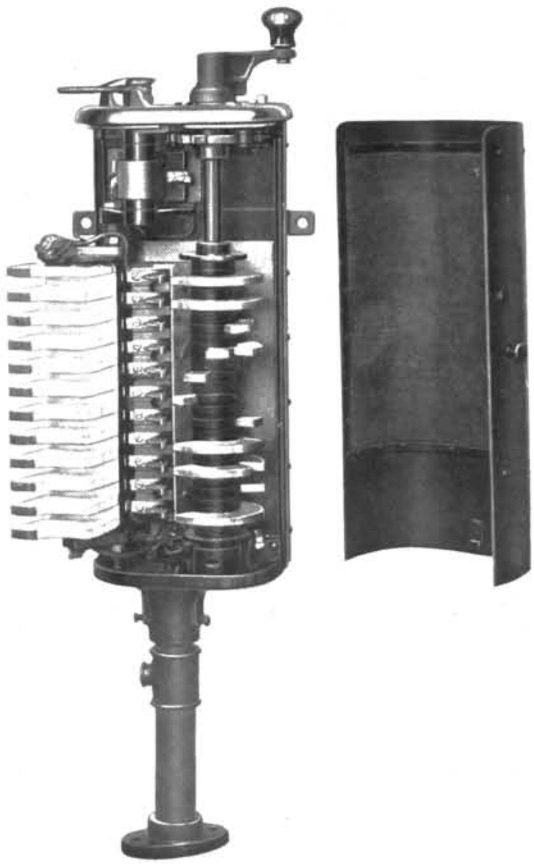

Fig. 1
TYPE C-94 CONTROLLER

The essential parts of an MK control equipment for double end operation are:

1. Two master controllers
2. A motor controller.

The master controller handles only the small current (about 2 amperes per car) required for the operation of the magnets in the motor controller, while the motor controller handles the heavy motor current. The control circuits and motor circuits are electrically independent of one another. A multiple conductor cable carries the small control current to the operating magnet coils of the motor controller. The contactors which close and vary the different motor and resistance circuits are provided with heavy contacts. It should be particularly noted that the magnet coils of the motor controller are actuated by line current and that the magnets operate the power circuit contacts directly with no intervening complications.

The diagram given in Fig. 2 shows the control circuits in light lines and the motor

* *Supersedes No. 4761 in part.*

circuits in heavy lines. This diagram emphasizes the point that no heavy current is ever handled by the master controller or control circuits, and that all parts carrying heavy current can be located under the car.

The simplicity of the Type MK control is shown by the fact that the following material constitutes the complete electrical equipment for a car:

Two master controllers
One motor controller
Three master control switches
One main switch
One main fuse box
One set of rheostats
Trolleys
Cable
Motors

Where train operation is desired a set of control couplers is also necessary.

Master Controller

The master controller, shown in Fig. 1, is very similar in appearance to an ordinary railway drum type controller, but very much smaller. The amount of current handled by the master controller is so small that the parts are subjected to very little burning, and consequently they are relatively small. Each contact finger which breaks a circuit is provided with an individual magnetic blowout. A separate reversing handle, mechanically interlocked with the operating handle, is provided so that reverse connections can be made only when the operating handle is in the "off" position.

When desired, the master controller is furnished with a "deadman's handle," which automatically interrupts the supply of current to the motors when the motorman's hand is removed from a button located in the top of the handle. The master controller may also be supplied with a small air valve, operated by the same button, which accomplishes the application of the air brakes simultaneously with the cutting off of power.

When a master controller is used for controlling two or more cars, the multiple conductor cable from the coupler socket is connected directly to the master controller instead of to a separate connection box, effecting a considerable reduction in weight and decrease in number of parts.

Motor Controller

The motor controller is designed for installing under the car—usually at the side where it may be readily inspected. Not only is the motor current broken by this controller under the car when shutting off power

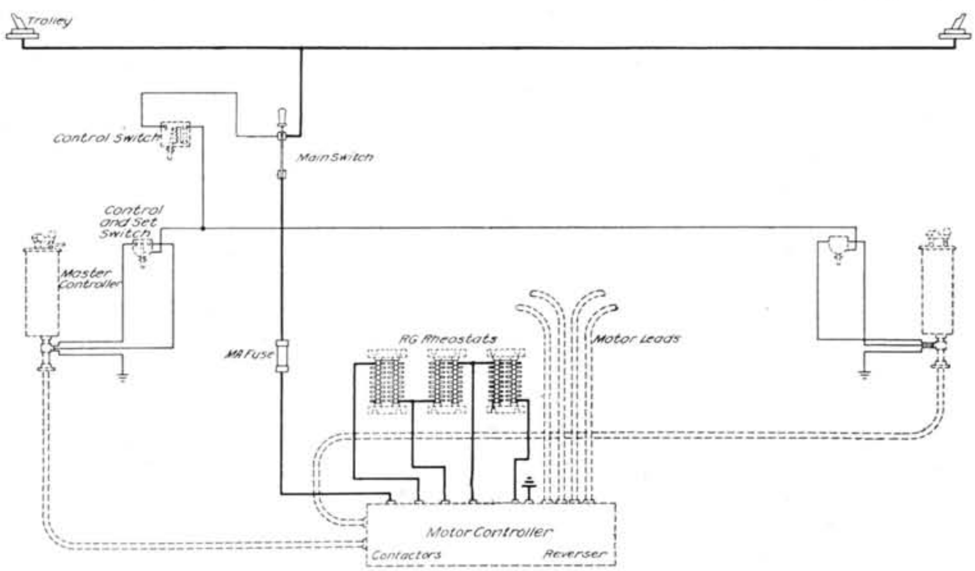

Fig. 2
SIMPLE DIAGRAM OF CONNECTIONS

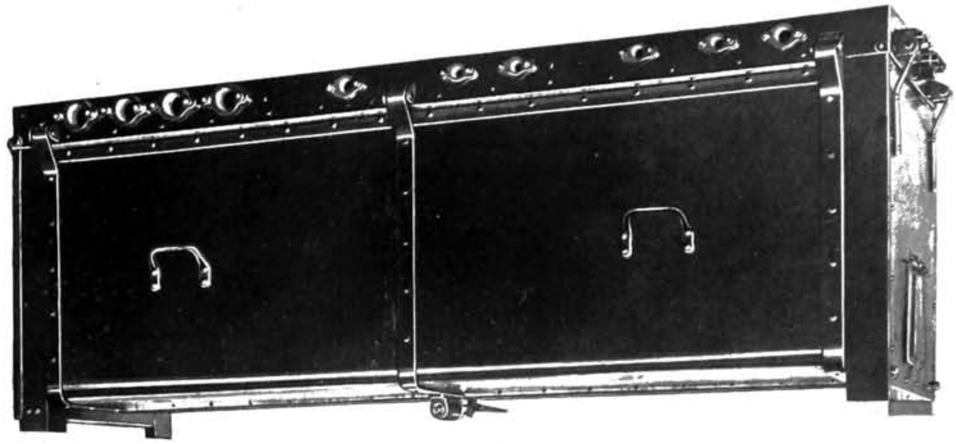

Fig. 3
MOTOR CONTROLLER

normally, but in case of overload, the circuit is opened by the contactors instead of by a separate circuit breaker.

This controller, shown in Fig. 3, consists of a box built of angle iron with sheet iron covers, and contains the contactors, overload relay, reverser, cutout switches, and resistance tubes, for the control circuit. The controller box is provided with conduit inlets to permit of running all wires in conduit. As all of the apparatus is thoroughly insulated from the casing and the latter is lined with insulating material, there is no necessity for insulating the box from ground. The resistance tubes used in series with the magnet coils are located at one end of the controller, protected with a removable cover. At the other end of the controller a removable cover gives access to the terminal board for the control circuit cables. Longitudinal covers are provided for the sides and bottom of the controller, which may be readily removed for inspecting the contactors, overload relay and reverser.

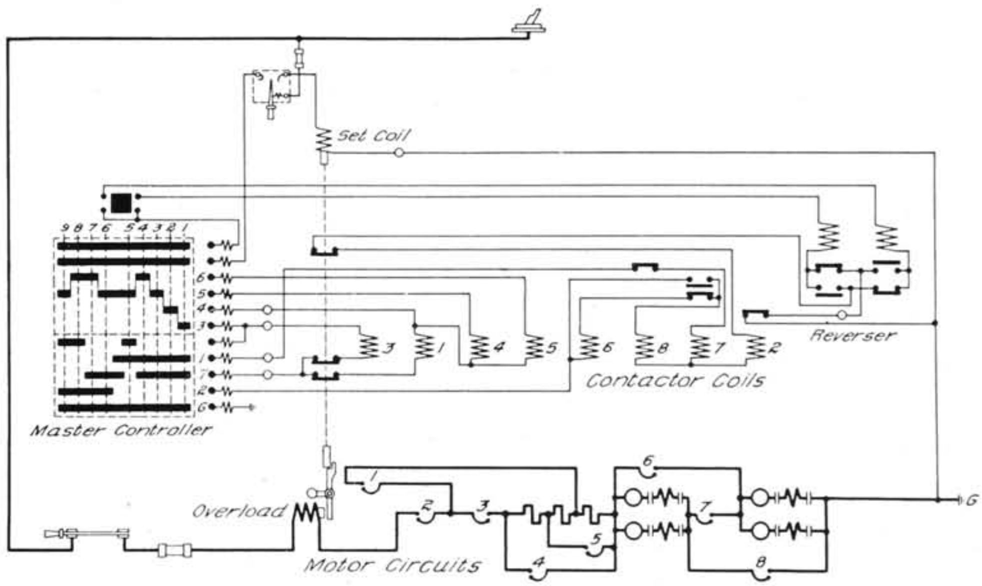

Fig. 4
CONTROL CONNECTIONS

The contactors are of the general form used for several years by the General Electric Company, but are greatly improved in detail. A powerful magnet operates an arm provided with a removable copper tip, which makes contact with a stationary tip. Surrounding the two tips is a box or chute of arc resisting, insulating material, and a powerful magnetic blowout is provided for disrupting the arc. One of the principal features contributing to the success of the contactor is the rolling motion imparted to the contact tips just after they touch each other. In the final position of these tips clean surfaces are brought together, due to this peculiar action. A heavy spring insures ample contact pressure for carrying the current, and also forces the contact arm to move rapidly in opening the circuit, when the operating magnet is de-energized. The contact pressure obtained is about four times that of the finger pressure in an ordinary cylinder controller. A cross section of the controller through one of the contactors is shown in Fig. 5. The simplicity of operation and small number of parts can be readily seen.

Owing to the large variation in capacity of motor equipments, several sizes of contactors are built, but they are very similar in appearance, aside from the difference in dimensions.

One of the principal improvements incorporated in these contactors is the form of magnetic blowout and its accompanying parts. The arc chute has a longer and deeper opening, and curved metal horns projecting from the contact tips, are provided to permit the arc to be greatly extended without

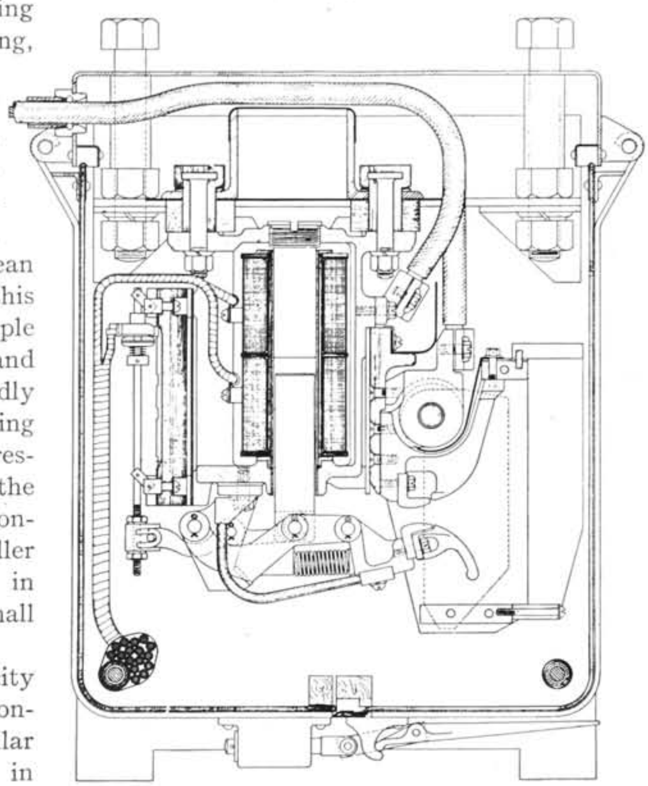

Fig. 5
CROSS SECTION OF CONTROLLER THROUGH ONE OF THE CONTACTORS

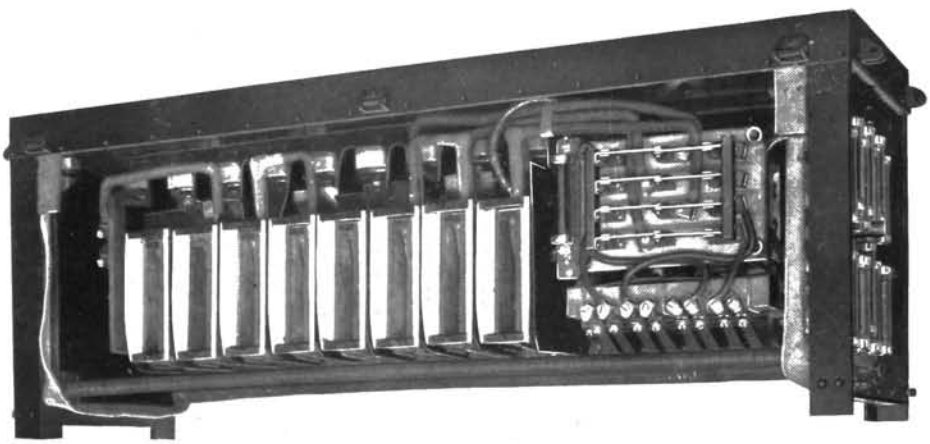

Fig. 6
MOTOR CONTROLLER WITH COVER REMOVED

coming in contact with the insulating material. This improvement enables a single contactor to break currents of several thousand amperes repeatedly without excessive burning. The design of the arc chutes is such that the arc is forced to the center of the chute, thus preventing excessive burning of the sides. This exclusive feature of the General Electric arc chutes gives them a very long life under the severest service conditions. Owing to their exceptional arc breaking capacity, but a small number of contactors are required, and a separate circuit breaker is unnecessary, as an overload relay performs its functions by opening the circuit of the contactor magnet coils.

All of the moving and wearing parts of the contactors may be readily replaced without removing the controller from the car. Owing to the use of magnets of ample size for the direct operation of the main controller contacts, no delicate parts or parts requiring careful adjustment are used, and therefore, skilled labor is unnecessary to make replacements. The bearing pins are ample in size, having bronze bushed seats which assure long

Fig. 8
CONTROL SWITCH AND FUSE

life and enable ready replacement. The copper shunt used to prevent current being taken through the bearing pins, is composed of a copper wire rope, which is extremely flexible and consequently free from breakage.

The overload relay consists of a series coil in the main power circuit, which trips an arm provided with contacts for opening the control circuit to the contactor operating magnets. After this relay has operated from

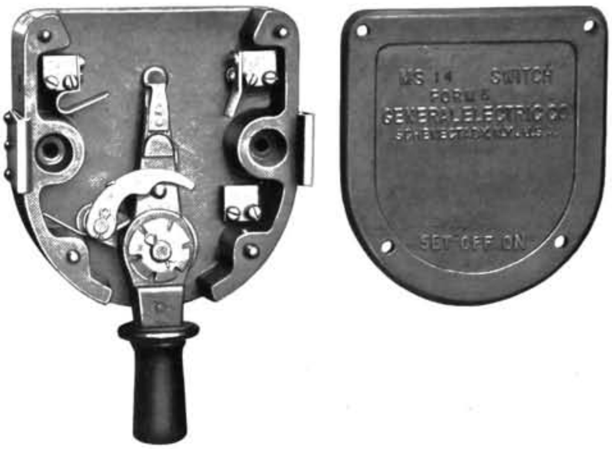

Fig. 7
CONTROL AND RESET SWITCH

overload, the control circuit contacts can only be closed by a small shunt coil energized by a movement of the combined control and reset switch in the motorman's cab.

The reverser, which is located in the controller box in equipments up to a capacity of four 75 h.p. motors, is comparable to the reverse switch in an ordinary cylinder controller, but is provided with two operating magnets, one for moving the switch to the forward and the other to the reverse position. Motor cutout switches are provided on the reverser to permit cutting out a disabled motor.

A small cylindrical cutout switch is provided at one end of the box for disconnecting the coils of the operating magnets from the control circuit cable leading to the master controller, in case of local trouble, when several cars are operated in a train.

The elimination of a separate circuit breaker, the location of the reverser in the same box as the contactors and the careful design of the box and all parts of the controller results in an equipment of minimum weight and size.

Control and Re-set Switch

A small double throw switch is located near the master controller, which in one position closes the supply circuit for the master controller, and in its opposite position closes the circuit to the resetting coil of the overload relay in the main controller. In the resetting position of the switch, the handle must be held against a spring pressure, as when the hand is removed the switch contacts automatically open the circuit. The switch is shown in Fig. 7. An additional control switch containing an enclosed fuse is used to protect the entire control circuit. See Fig. 8.

Fig. 10
CONTROL COUPLER SOCKET

Main Switch

The main switch is of the quick break knife blade type, located in the circuit between the trolley and the main fuse, and is used for disconnecting the motor circuit when it is desired to test the motor controller. This switch may be located either in the vestibule or under the car close to the motor controller.

Main Fuse Box

This fuse box, shown in Fig. 9, is of the magnetic blowout type, which has proven so reliable that its use is universal. The fuse consists of a thin copper ribbon held at the ends by heavy clamp terminals. The box is provided with a hinged lid held by an efficient catch, so that the fuse may be easily replaced.

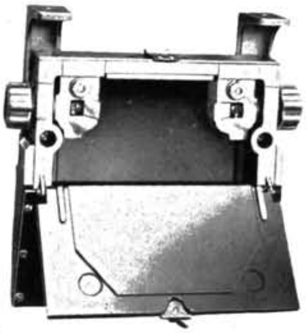

Fig. 9
MAIN FUSE BOX

Rheostat

The rheostats are of the standard cast grid type, shown in Fig. 11. They combine great strength and easy replacement of grids.

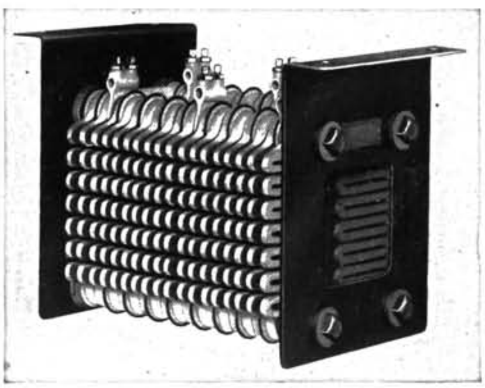

Fig. 11
TYPE RG RHEOSTAT

Control Couplers

The couplers consist of a socket attached to the end of the car and a jumper for connecting the sockets on adjacent cars. (See Fig. 10.) The socket frame is of malleable iron and is provided with a hinged lid for protecting the contacts when not in use. The cover also retains the jumper in position after it has been inserted. A block of moulded insulation within the socket carries the contacts which are connected to the wires of the multiple conductor cable leading to the master controller.

The jumper consists of two plugs connected by a multiple conductor cable. The plugs are of malleable iron, and contain blocks of insulation carrying contacts connected to the individual wires, so that a continuous connection of the various control circuit wires is secured the whole length of a train.

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POWER AND MINING DEPARTMENT

October, 1912

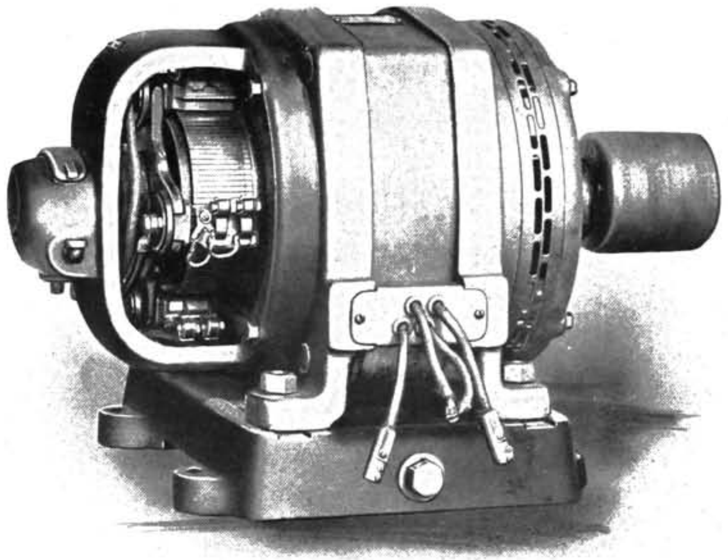
* Bulletin No. 4993

TYPE RI SINGLE-PHASE MOTORS

Many central stations and isolated plants find it both convenient and economical to combine in part their lighting and power loads on single-phase circuits. To cultivate successfully this dual field, a single-phase motor is required whose design and operation characteristics will allow favorable comparison with the starting torque, maximum overload capacity, efficiency, power-factor, mechanical simplicity and general service reliability of the polyphase induction type.

Pioneers in the design of the polyphase system of alternating current generation and distribution now employed with such universal and phenomenal success, the General Electric Company have, with equal success, supplied the requirements for a large proportion of the single-phase motors found in actual commercial operation.

The resistance reactance Type KS motor is already so well known as to need but a moment's comment. The KS motor will continue to fill those service requirements for which it was specifically designed, that is, constant speed duty and the acceleration of loads requiring light or moderate starting torque (i.e., not exceeding 150 per cent. of normal).



TYPE RI, SINGLE-PHASE REPULSION INDUCTION MOTOR

The Type RI motor fully meets the requirements for loads whose static friction, inertia or accelerating characteristics demand a reserve of torque exceeding the inherent limitations of the split phase or resistance reactance motor. The RI furthermore possesses a wider field of usefulness than the KS, due to availability of the former type for both varying and adjustable speed service.

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

* *Supersedes Bulletin No. 4858.*

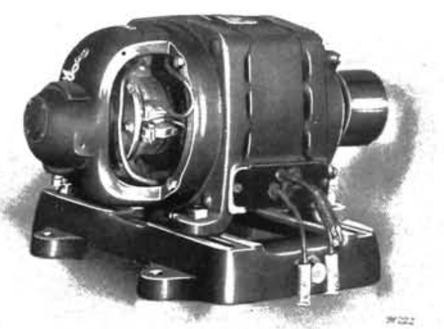
The succeeding paragraphs will be devoted to a consideration of the theory of design, electrical characteristics, mechanical construction, field for exploitation, and general details pertinent to the Type RI single-phase product.

THEORY OF DESIGN

The leading characteristics of the direct current series wound motor are well known; operating through a wide range of speed and torque, this type has, however, no inherent speed regulation and its use is consequently confined either to fixed loads like fans or pressure blowers, or to varying loads where the motor controlling device is constantly under the operator's guidance. The speed, torque, load characteristics of the series commutator type alternating current motor being distinctly analogous to that of its direct current prototype, the design fails to meet the requirements of constant speed power service, this service demanding a motor which maintains good regulation after having once been brought up to speed, with torque values increasing at satisfactory efficiency as speed decreases; in other words, characteristics approaching those of the direct current compound motor having the usual proportion of series field winding.

TYPE RI 4 POLE ¼ H.P. FORM G 1800 R.P.M. REPULSION INDUCTION MOTOR

The RI, or repulsion induction motor, however, gives this combination of series and shunt characteristics; that is, a limited speed with increase of torque with decrease in speed. In the straight repulsion motor, to secure the necessary starting torque, a direct current armature is placed in a magnetic field excited by an alternating current and short circuited through brushes set with a predetermined angular relation to the stator. To further improve the operating characteristics of the plain repulsion motor a second set of brushes (i.e., the compensating brushes) is placed at 90 electrical degrees from the main short circuiting brushes (i.e., the energy brushes). The compensating field is auxiliary to the main field and impresses upon the armature an electromotive force in angular and time phase with the electromotive force generated by the main field. In addition to correcting phase relation between current and voltage, thus giving approximately unity power-factor at full load and power-factors closely approaching unity over a wide range of load, the compensating field serves to restrict the maximum no-load speed and also permits, where varying speed service is involved, slight increase over synchronous values. The compensated repulsion induction

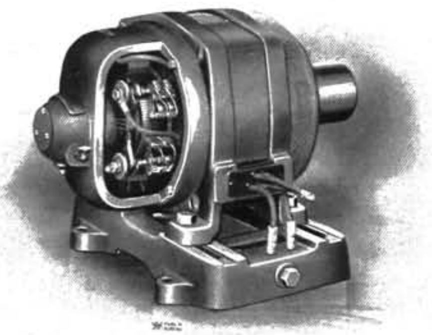


TYPE RI 4 POLE 1 H.P. FORM G 1800 R.P.M. REPULSION INDUCTION MOTOR

or RI motor is practically an induction motor capable of operation either above or below synchronous speed, possessing heavy starting torque and high power-factor at all loads as well as excellent efficiency constants. The RI motor has no tendency to spark or flash over since the armature coils successively short circuited by the energy brushes are not inductively placed in the magnetic field and have consequently only to commutate a low generated voltage. Four years of commercial exploitation with essentially no complaints due to poor commutation is proof of the Type RI's immunity from sparking difficulties.

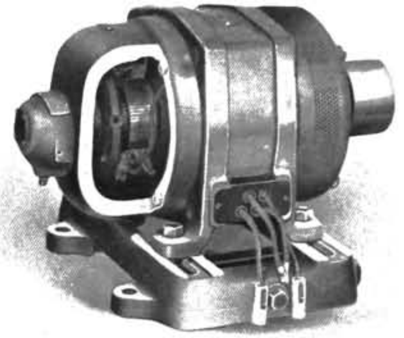
POWER-FACTOR

The importance of power-factor (i.e., the relation of true to apparent power in an alternating current circuit) and its effect upon both generator capacity and voltage regulation is deserving of the most careful consideration with all electrical apparatus in which an inherent phase difference exists between electromotive force and current, for example, arc lamps, static transformers and induction motors. While the belief is current that any decrease in power-factor from unity value does not demand any increase of mechanical input, this is not strictly true, since all internal generator and line losses manifest themselves as heat; the wasted energy to produce this heat being supplied by the prime mover. Apart from the poor voltage regulation of alternating current generators requiring abnormal field excitation to compensate for low power-factor, a part of the station's rated output is rendered unavailable and consequently produces no revenue. The poor steam economy of underloaded engines is also a serious source of fuel wastage.



TYPE RI 4 POLE 2 H.P. FORM G 1800 R.P.M. REPULSION INDUCTION MOTOR

Careful investigations have shown that the power-factor of industrial plants using induction motor drive with units of various sizes will average between 60 and 80 per cent. With plants supplying current to underloaded motors having inherently high lagging current values, a combined factor as low as 50 per cent. might be expected. Since standard generators are seldom designed to carry their rated kilowatt load at less than 80 per cent. power-factor the net available generator output is, therefore, considerably reduced.



TYPE RI 4 POLE 5 H.P. FORM G 1800 R.P.M. REPULSION INDUCTION MOTOR

With RI motors of mixed sizes and within the horse power range as manufactured by the General Electric Company, operating between three-quarter and full load, the combined plant power-factor should equal or exceed 90 per cent. At half load, this combined value should not be less than 85 per cent.

STARTING TORQUE AND CURRENT

Single-phase motors to render efficient service must be able, where requisite, to develop sufficient turning moment or torque to accelerate from standstill loads possessing large inertia or excessive static friction; for example, meat choppers and grinders; sugar or laundry centrifugals; heavy punch presses; group driven machines running from counter shafts with possibly over-taut belting, poor condition of alignment, lubrication, etc.

The starting torque demanded for the average industrial drive will be found to vary approximately between 100 and 200 per cent. The RI motor, if started by directly closing the line switch, will develop 250 per cent. torque. The starting current corresponding to full load starting torque is from two to two and a quarter times full load running current.

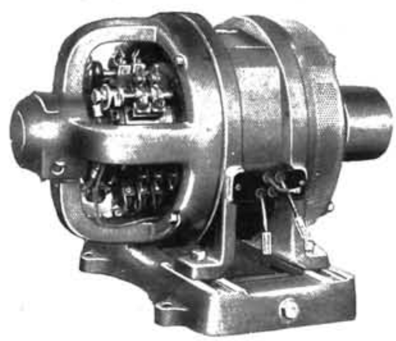
The additional current required by the Type RI for starting possesses only momen-

TYPE RI 6 POLE 7½ H.P. FORM G 1200 R.P.M.
REPULSION INDUCTION MOTOR

tary value (i.e., one to two seconds) and falls off very rapidly down to full load value as the motor accelerates. RI motors, assuming normal frequency and voltage, attain full speed under load from standstill in from two to five seconds. Due to this extremely rapid acceleration coupled with exceedingly high power-factor during the acceleration period, the voltage regulation of combined lighting and power circuits is but slightly affected and for a negligible period. RI motors are ordinarily fused for 200 per cent. of normal full load current, exception being made for special service conditions, where the percentage of starting to full load torque is excessive. As a general rule, starting boxes are not required up to and including the 2 h.p. rating; from 2 to 5 h.p. the use of a rheostat is optional, dependent upon the degree of care to be exercised in maintaining voltage regulation. Starting boxes should preferably be used on the 7.5, 10 and 15 h.p. sizes, especially where light and power circuits are combined.

If motors of 2 h.p. and larger are installed on the same secondaries, with arc or incandescent lamps or where it is otherwise deemed essential to minimize current rush at starting, the use of a rheostat will reduce current on first step to 150 per cent. of full load value. On special order rheostats may be furnished giving 100 per cent. current on the first step.

Due to the exceedingly high power-factor of RI motors, ampere values, both at starting and full load, are markedly below those of other single-phase induction motors. Example: Two single-phase motors are compared, each rated 3 h.p., 220 volts, and having a full load efficiency of 77 per cent.; the first motor (Type RI), which we will designate as "A" motor, has a tested full load power-factor of 98 per cent. The second motor, which we will call the "B" motor, has a tested full load power-factor of 80 per cent. Both motors are guaranteed to develop "full load torque with 2¼ times full load current."



TYPE RI 6 POLE 15 H.P. FORM G 1200 R.P.M.
REPULSION INDUCTION MOTOR

Motor "A" (with 98 per cent. power-factor) will require on this basis 31.5 amps. Motor "B" (with 80 per cent. power-factor) will require 36.5 amps. The example should clearly indicate that the proper method to determine the preferable motor should always consider true ampere values rather than percentage of starting to full load current. In the case at hand, motor "A" will develop the same torque with 87 per cent. of the current required by motor "B."

APPLICATIONS

Type RI motors are entirely automatic and may be thrown on the line without the use of rheostat, or other internal or external starting device. RI motors are particularly suitable for operating refrigerating machines,

TYPE RI ½ H.P. MOTOR OPERATING PEERLESS JOBBER

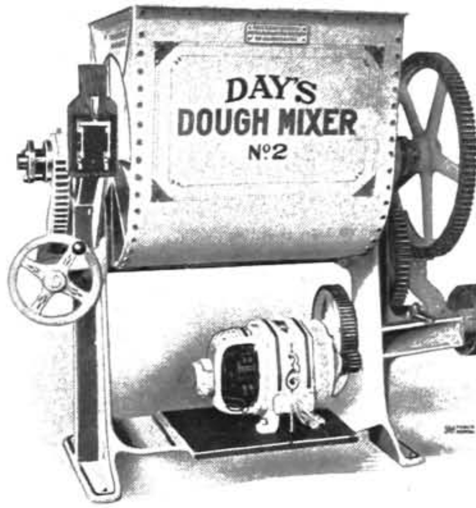
air compressors, house pumps or similar apparatus where a float switch or pressure regulator is used to close or open the supply circuit.

RI motors will not be injured in the slightest should the power service fail and the motor switch remain closed when the power on the line is resumed. Furthermore, no damage can result by opening or closing the line switch when the motor is at any point in its cycle of acceleration or deceleration.

The RI motor will safely carry very heavy overloads without sparking, down to or near standstill. This invaluable feature is not attainable with single-phase motors operating at full speed as induction motors, since upon excessive overload the motor will decelerate to the point where the automatic switch opens. A critical point may therefore exist where such a motor will "hunt" and become unstable, burning its switch contacts and otherwise causing trouble.

GENERAL DESCRIPTION

RI motors in all sizes are built in the unique and universally known "riveted frame" form. Riveted frame design combines rigid and compact mechanical construction with the most effective natural heat radiation, since the outer as well as the inner edges of all the stator laminæ are directly exposed to the air. The riveted frame design in addition to affording ready accessibility for cleaning or repairing, reduces both weight and bulk for a given output and speed. The advan-

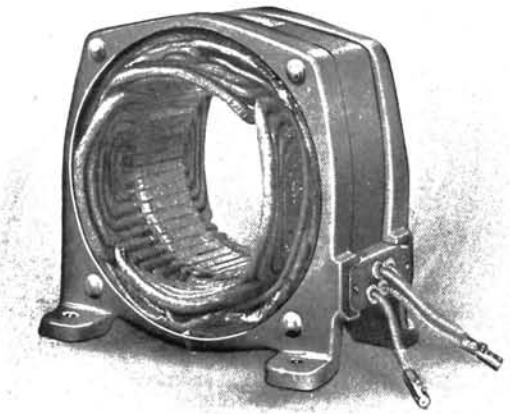


TYPE RI MOTOR DRIVING NO. 2 DAY DOUGH MIXER

tages just enumerated have been secured without in the least sacrificing strength, efficiency or quality.

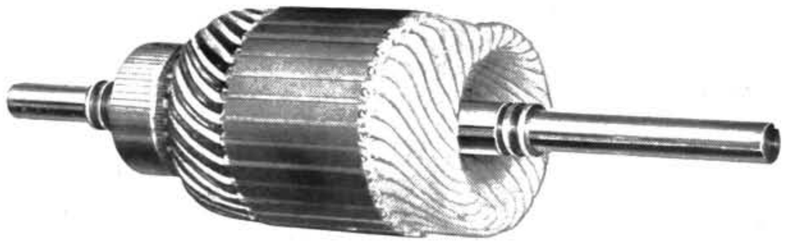
RI FIELD WINDINGS

The field of the RI motor consists of slotted laminations assembled between end flanges and wound with two windings, a main winding of the distributed concentric type, each coil being separately insulated and carefully taped up to each core slot. The second or compensating winding (depending usually on the size of frame used), forms either the center portion of the main winding or a



WOUND FIELD OF TYPE RI 3 H.P.
RIVETED FRAME MOTOR

cuits. By connecting adjacent pairs of these terminals in multiple, RI motors are made adaptable for 110 volt service; for double this pressure the four leading in wires are connected in series. RI motors will operate satisfactorily where the arithmetical sum of voltage and frequency variation does not exceed 10 per cent., e.g., the voltage may be 10 per cent. high if the frequency remains at normal or the frequency may be 10 per cent. high assuming no variation in voltage. A decrease of 5 per cent. in frequency accompanied by a similar increase in voltage is permissible or, as above stated, any similar combination whose arithmetical sum is within 10 per cent. of normal.

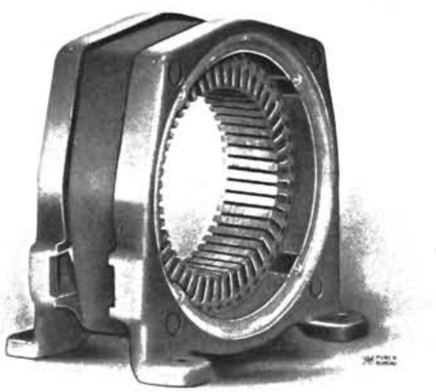


ASSEMBLED ARMATURE OF TYPE RI RIVETED FRAME MOTOR
READY FOR DIP AND BANDING

separate winding concentric therewith. When completed, the stator coils receive a dipping and baking treatment rendering the insulation impervious to ordinary dampness or moisture. When the motor is to be subjected to acid fumes, vapor from steam, or to excessive humidity, such duty should be specified, so that the field may be given an extra dipping.

FREQUENCY AND VOLTAGE

Standard RI motors have polar groupings arranged for 25 and 60 cycle operation; 40 cycle windings being furnished on special order. All constant and variable speed motors except reversible type, have four terminal leads permitting interchangeability of operation on 110 or 220 volt cir-



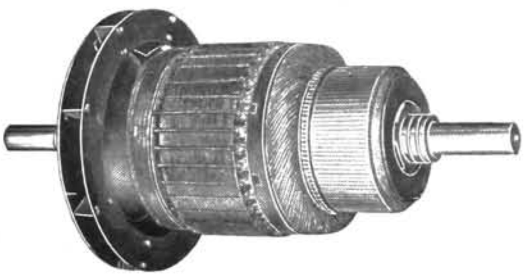
UNWOUND FIELD OF TYPE RI 3 H.P.
RIVETED FRAME MOTOR

RI ARMATURES

Type RI armatures are built up of selected sheet steel laminations in which the coil slots are punched before being assembled on the shaft. By the use of sharp and accurate dies, close fitting keys and general excellence of workmanship, the coil slots are made free from irregularities or projecting points which might injure the coil insulation. The laminations of RI motors up to and including 5 h.p. are built up on the shaft, the remaining sizes employing cast iron spiders held in place by retaining rings and cast iron core heads.

RI armature winding is of the series type.

The smaller RI armatures are form wound, the larger sizes employing bar windings, both windings being carefully insulated and interchangeable on armatures of the same rating and voltages. The coils after assembly are carefully taped up into the insulated core

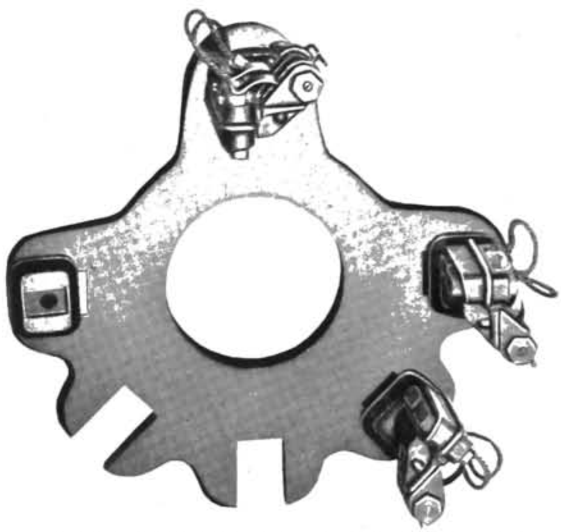


COMPLETED ARMATURE TYPE RI 3 H.P. RIVETED FRAME MOTOR

slots on the pulley end, "stocking" separators being used on all leads running to the commutator segments. The coils are finally retained by two heavy binding bands, one at each opposite extremity of the central laminated armature core body. All coils are tested as assembled on the core, the completed armature being finally subjected to a dielectric strain test to eliminate possibility of grounds or short circuits after the motor has been put into commercial service. Treatment with a special compound materially improves the insulation and mechanical rigidity of the rotating member in addition to rendering it proof against ordinary dampness or moisture.

ARMATURE SHAFTS

The high grade machine steel shafts of RI motors provide sufficient cross section to allow ample safety factor against all rotative or torsional strains. Fillets of liberal radius are provided to distribute strains at all diameter changings. Accurate grooves are



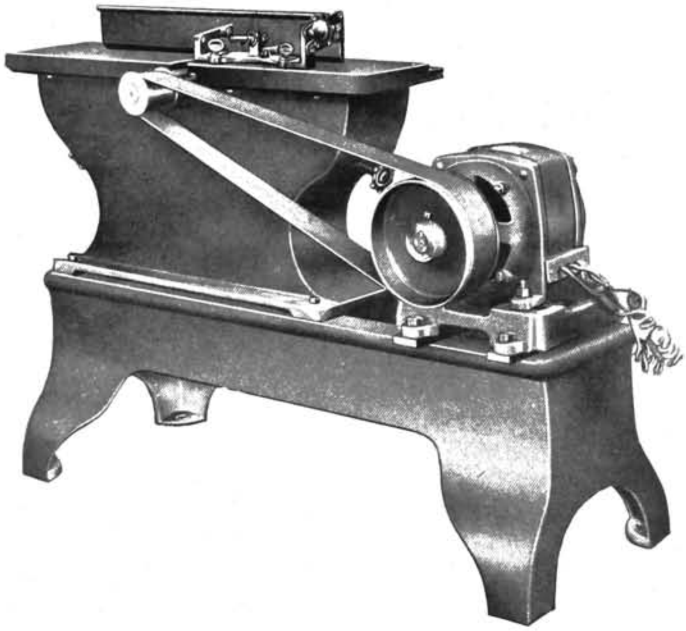
CAST BRUSH-HOLDER YOKE AND PARTS FOR 3 AND 5 H.P. RI MOTORS

machined outside of the pulley end bearing linings and inside of the bearing housing to prevent oil creepage.

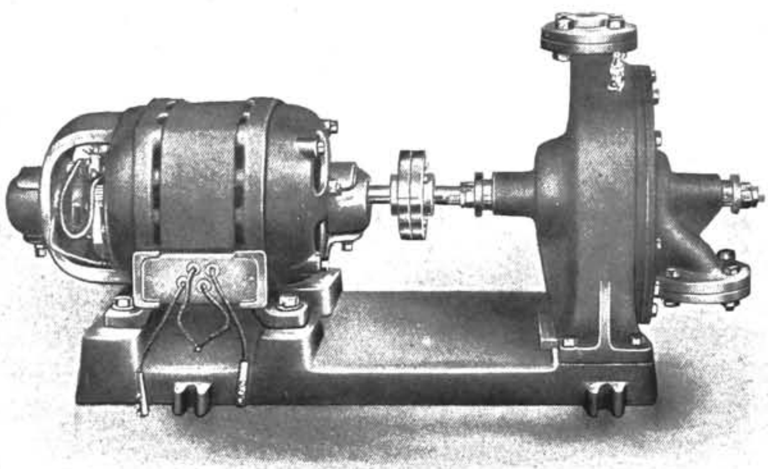
BEARINGS

RI bearing linings are made from a special metal having a low coefficient of friction and ample cross section. Generous bearing surfaces, carefully cut channeling to distribute the lubricant, heavy oil rings and deep oil wells, all insure immunity from bearing troubles. The reservoirs of all RI motors are equipped with gauges to indicate the amount of oil, and with taps for drawing off the lubricant when required.

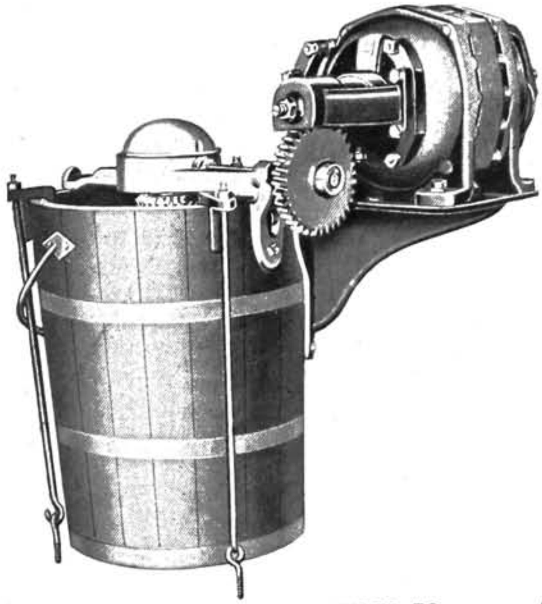
The construction of the bearing heads permits ready access to all parts of the commutator and brush gearing. The standard



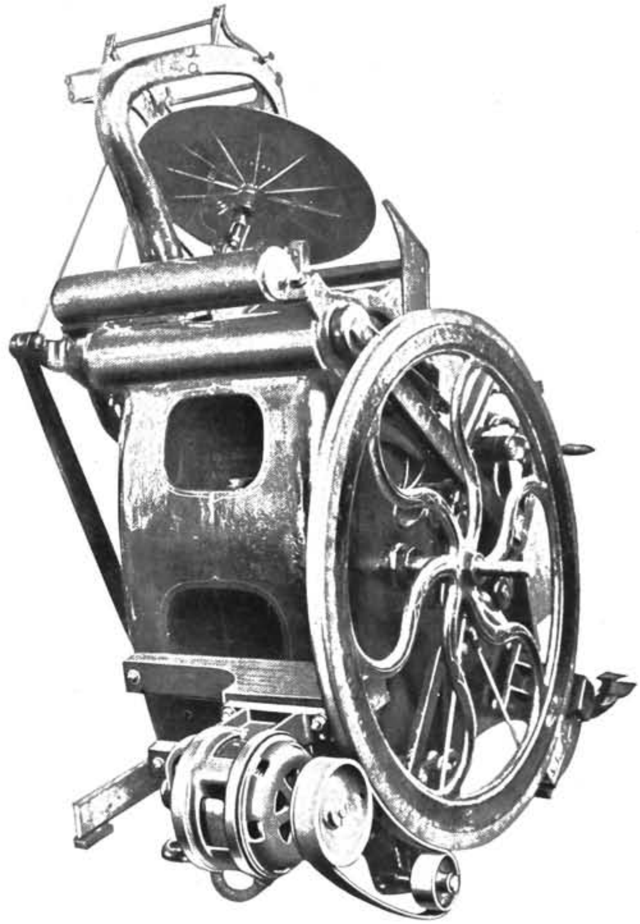
HAND JOINTER DRIVEN BY TYPE RI MOTOR



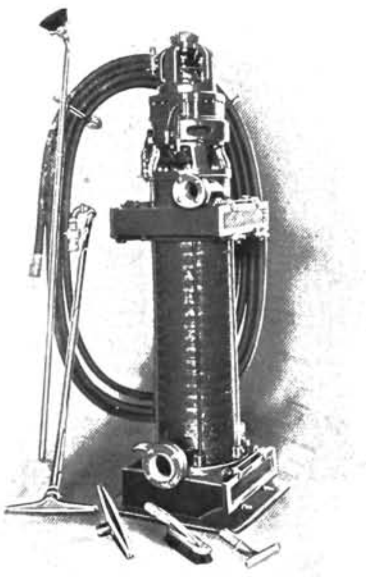
CENTRIFUGAL PUMP DIRECT DRIVEN BY TYPE RI MOTOR



TYPE RI ¼ H.P. MOTOR, GEARED TO WHITNEY ONE-GALLON FREEZER



TYPE RI ½ H.P. MOTOR OPERATING GOLDING JOBBER



TYPE RI MOTOR DRIVING SPENCER TURBINE CLEANER method of interchangeably spacing the end head retaining bolts allows the motor frame to be shifted 90 or 180 degrees for wall or ceiling suspension, as desired. The standard sliding base frame is slotted and provided with float bolts to properly secure and allow adjustment of the motor feet for either floor, wall or ceiling installation.

RI COMMUTATOR AND BRUSH RIGGING

Type RI commutators are in every respect equal in design to those used in the latest types of General Electric direct current

MOULDED BRUSH-HOLDER YOKE FOR 1 H.P. RI MOTOR

motors. The segments are made from the best grade hard drawn high conductivity copper, liberal in wearing surface and depth. The commutator bars are insulated with selected mica slotted in order to obtain the lowest coefficient of friction and electrical resistance between brushes and commutator surface. Brushes are used employing a special treatment which furnishes ample natural lubrication under normal conditions of service. Two types of brush-holder yoke are used. RI motors from ¼ to 2 h.p. employ a moulded yoke of special insulating composition, subjected to hydraulic pressure, and reinforced by a cast iron "L" section ring, imbedded in the moulded structure. Cast iron yokes are used on all RI motors from 3 to 15 h.p.

The brush-holder studs of both the moulded and cast yokes embody special features ensuring freedom from possible loosening of the studs due to shrinkage or vibratory strains.

DIRECTION OF ROTATION

Standard RI motors are so connected as to run counter-clockwise facing the commutator end. For clockwise rotation, it is simply necessary to interchange the leads to the compensating brushes and slightly shift the brush-holder yoke. (See instruction book.)

REVERSIBLE RI MOTORS

At a slight additional cost, reversible motors can be furnished by the addition of an auxiliary reversing winding spaced 90 degrees from the main field winding and connected in series with it. Leads from this auxiliary winding are brought out through the terminal board and connected, together with the main field winding, to a reversing switch. By reversing the relative polarity of the two windings, the direction of rotation is changed in a simpler manner than if the reversal were secured by mechanically shifting the radial position of the brush-holder yoke.

Reversible RI motors possess a unique and valuable feature, that is, instant reversal may be effected from full speed in one direction to full speed in the reverse direction; 200 per cent. of normal running torque being developed at moment of speed reversal in either direction. The motors are connected for one voltage only.

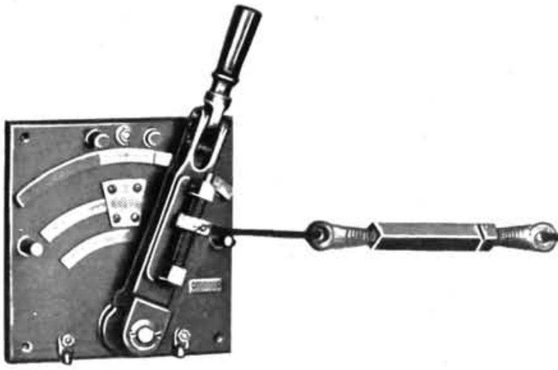
COMMUTATOR OF TYPE RI 3 H.P. MOTOR

RI MOTORS FOR VARYING AND ADJUSTABLE SPEED

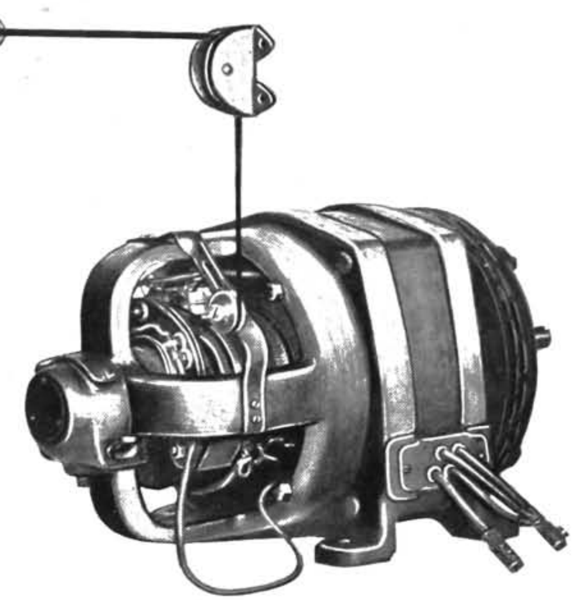
In addition to the constant speed RI line, two additional types of motors and controllers are available, one for constant torque, varying speed, the other for adjustable speed independent of torque.

Varying speed RI motors have a limited speed at no load so that they possess a distinct advantage over other "brush shift" motors having no speed limiting device, and which, therefore, may reach excessive velocities or "run away" at light loads.

NOTE.—Horse power is proportional to the *product of torque times speed.* Torque alone is a function of horse power, being defined as the pull or drag at the surface of the armature multiplied by the radius of the armature. Example: A motor develops 10 h.p. running at 1000 r.p.m. with a torque value of "A." Should the speed now be reduced to 500 r.p.m., or one half normal, the torque remaining at "A" value as before, it is obvious (since horse power equals torque times speed) that the horse power has also been reduced one half. If, on the other hand, the speed is reduced one half, but the same horse power is desired at such reduced speed, it is evident that the torque must be *doubled* if the original 10 horse power output is to be maintained.



BRUSH SHIFTING CONTROLLER



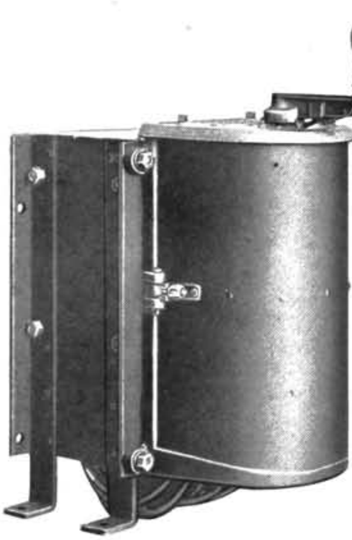
VARIABLE SPEED REVERSIBLE RI MOTOR

The speed and load characteristics of the varying speed RI motor are similar to those of the three-phase wound rotor type, or the direct current motor with armature control. In both these types, the speed inherently varies with the load, decreasing when the load increases, and vice versa. To secure satisfactory close speed regulation, at a given controller setting, the RI motor, like its varying speed prototypes above described, must work approximately against full load torque over the permissible range of speed variation, the horse power being reduced in direct proportion to the decrease in speed.

Assuming that the torque at any controller point is not less than 50 per cent. of normal full speed value, RI variable speed "brush shift" motors will allow a speed variation of 2 to 1 on a continuous service basis.

The power-factor of varying speed RI motors is well sustained throughout the entire speed range (see curve Fig. 2, page 13).

The lower set of characteristic curves Fig. 2, page 13, shows graphically that at full and 50 per cent. torque the efficiency of varying speed motors is well sustained over the entire range of speed, the drop at one-half speed



DRUM TYPE CONTROLLER FOR ADJUSTABLE SPEED TYPE RI MOTOR

at full load torque amounting to approximately 10 per cent. The curve also indicates the sustained economy of these motors at low speeds, the efficiency and power-factor at full torque, half speed, closely approximating the same values at half torque, full speed.

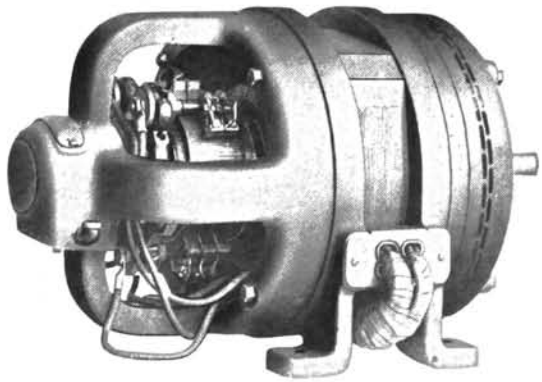
In applications demanding varying speed, care should be taken to "motor closely;" i.e., the horse power rating of the driving unit should compare as nearly as possible with the power at full speed of the driven machine. For example: If a 5 h.p. motor is applied to service having a maximum demand of only 3 h.p., the torque load will not be sufficient to decelerate the driving unit when the controller is thrown to the lower speed points.

In general, varying speed RI motors are not applicable to lathes, boring mills or similar machines where the service requires *adjustable* speed and *constant horse-power* at all speeds below or above normal.

As already stated, when a certain amount of variable speed is required at approximately constant torque, such as the driving of fans, or blowers, printing presses, binding machines, etc., the RI motor successfully meets a wide field of application.

The starting characteristics of the RI varying speed motors are unsurpassed, reference to the curves showing that full load torque is secured with very slight excess over full load current. If brushes are shifted up towards maximum speed, 275 per cent. starting torque may be secured with current in proportion to torque. Due to the high torque per ampere, varying speed RI motors will start, accelerate and reverse their loads with a smaller current demand on the line than any other existing commercial type of "brush shift" motor. As the accelerating torque exceeds the starting torque, these motors will bring up to speed any load which they will start.

The varying speed, "brush shift" motor is built from standard RI parts with the excep-



TYPE RI 6 POLE 5 H.P. ADJUSTABLE SPEED MOTOR

tion of slight modification in windings and brush rigging. The illustration (page 11) shows the ingenious mechanical arrangement through which the "energy" brushes are shifted with relation to the field windings, the "compensating" brushes remaining stationary.

To a grooved ring on the movable brush yoke is attached a flexible steel cable which is supported and guided in any desired direction by a small grooved pulley. The terminals of this cable are fastened by short eye bolts respectively to the controller handle and the movable brushes. A movable nut on the controller handle supplemented by a

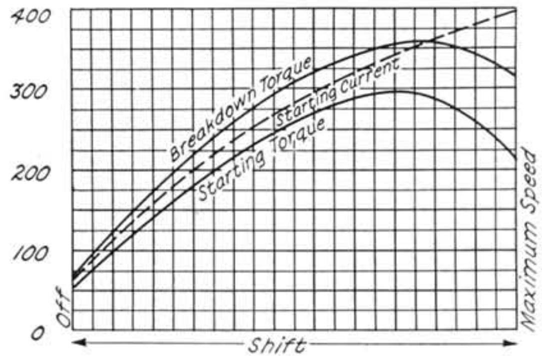


Fig. 1
TORQUE CURVE

turn buckle permits of readily adjusting the length of cable. The cable is kept taut through a clock spring, fastened to the movable brush-holder yoke. Since both the movable and fixed brush yokes are designed as a unit part, the entire brush rigging may be removed and replaced with a minimum of labor and fitting. The controller provides for a positive stop in the central or "off" position, the knurled lever handle giving fine speed increments through a closely graded notching rack.

To reverse direction of motor rotation, the operator simply pushes a spring-actuated double stop post on the face of the controller, a set position of this stop post holding the main lever handle from a possible inadvertent throw-over to reverse position.

The extremes of controller throw give the high speed points forward and reverse, the line being opened at the middle or neutral position. Depending upon the direction in which the arm is thrown, the line circuit is closed for starting on the first right- or left-hand controller position. The total throw of the controlling cable varies, depending upon the size of the motor involved, between 3⅞ in. and 6¼ in. Varying speed motors are furnished in ¼, ½, 1, 2, 3, 5 and 7½ h.p. 1800 r.p.m. maximum speed.

ADJUSTABLE SPEED RI MOTORS

Adjustable speed RI motor and controller equipments are recommended where service requirements demand the use of a motor whose speed can be adjusted over a considerable range, this speed at a fixed controller setting remaining practically unaffected by any load within the motor's rated capacity, (e.g., machine tools and similar apparatus).

With the controller on the high speed points, these motors possess an inherent speed regulation between no load and full load of approximately 6 per cent.; at the low speed points, under similar load conditions, the speed variation will be approximately 14 per cent.

To secure RI adjustable speed control, the armature circuits employ transformers, whose primaries are excited by the line circuit. The secondaries of these transformers are divided into two sections; the first or "regulating" circuit is placed across the "energy" brushes, the other section, since it is connected in series with the compensating winding, maintains the high power-factor and good speed regulation obtained in the constant speed type.

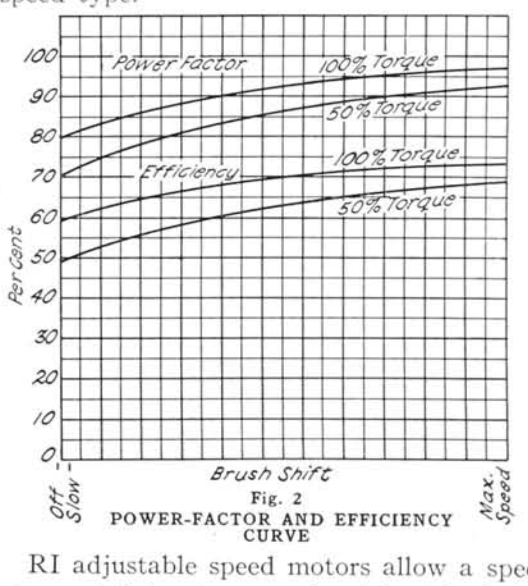
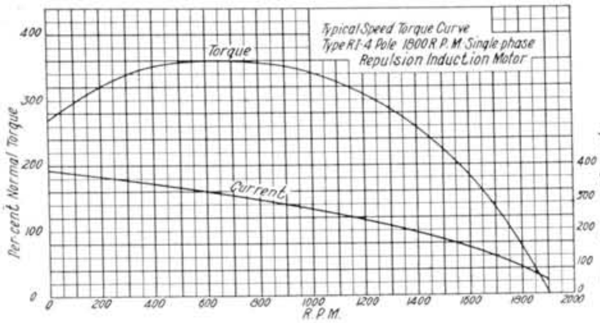


Fig. 2
POWER-FACTOR AND EFFICIENCY CURVE

RI adjustable speed motors allow a speed range of 2 to 1, approximately ½ of this range being below ½ and above synchronous speed. With the exception of the windings standard RI parts are used for the line of adjustable speed motors.

Adjustable speed motors are furnished for 60 cycles, the windings being interchangeable



SPEED TORQUE CURVE

on 110 or 220 volts. Motors of odd voltages and frequencies are supplied on order. With motors of ¼ to 2 h.p. inclusive (standard ratings), a dial controller is furnished, the larger sizes employing the drum type. These controllers are all arranged so that "jogging" reversal may be secured on one point and give from 150 to 200 per cent. starting torque in the reversing direction. This reversing point is only intended, however, for "jogging" operation. By supplying a four-pole double-throw switch, and making use of a reversible winding in the motor, an outfit may be furnished giving equal speed regulation in both directions of rotation. With this arrangement, full speed reversal may be obtained.

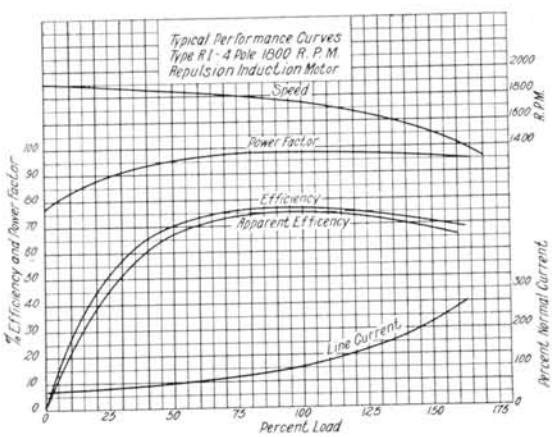
The tabulation on page 15 gives the horse power and speed ratings of RI adjustable speed motors on the two-hour, intermittent basis. For machine tool or similar service, a motor should be selected whose horse power at the minimum speed corresponds with the rating of the driven machine at *normal speed* and load.

TEMPERATURE AND OVERLOAD GUARANTEES

All Type RI motors are conservatively rated and guaranteed to carry full load continuously with a temperature rise above the surrounding air not to exceed 40 deg. C., on the commutator 45 deg. C., a 25 per cent. overload for two hours with rise not to exceed 55 deg. on the windings or 60 deg. on the commutator. A momentary overload of 50 per cent. may be carried without excessive heating or otherwise causing damage or unsatisfactory operation.

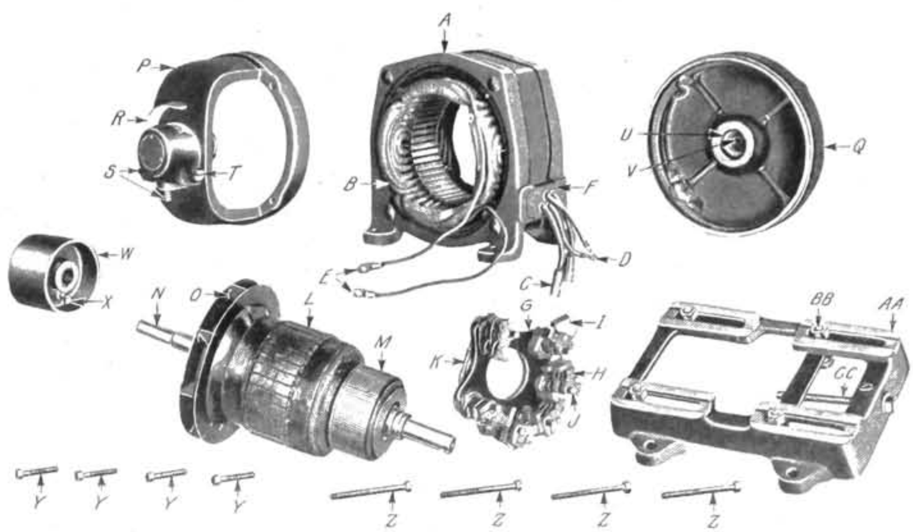
In line with the most modern methods for securing proper internal ventilation, RI motors of 1 h.p. 1200 r.p.m. and 2 h.p. 1800 r.p.m. and above, are fitted with a rigid and efficient fan mounted on the armature shaft. This fan supplies a constant flow of cool air over and about the windings, at once reducing temperature rise, improving operation and adding to the life of the insulation and the motor windings.

To aid in the dissipation of entrained heat in the stator laminæ, each disk is blanked out at regular intervals (as shown in cut of



PERFORMANCE CURVES

unwound field structure). These numerous ventilating ducts extending the entire length of the stationary member assist materially in reducing operating temperatures.



PARTS OF RI MOTORS

A Field
B Field winding
C Line terminal
D Tube terminal
E Compensating terminal
F Terminal board
G Brush yoke
H Brush-holder
I Carbon brush
J Brush stud
K Short circuit connection
L Armature
M Commutator
N Shaft
O Fan
P Commutator end shield
Q Pulley end shield
R Oil well cover
S Oil plugs
T Oil gauge
U Bearing lining
V Oil ring
W Pulley
X Pulley set screw
Y Commutator end shield holding bolts
Z Pulley end shield holding bolts
AA Base
BB Float bolts
CC Belt tightener screw

RATING AND SPEED

ADJUSTABLE SPEED RI MOTORS

*(For Intermittent Operation)

MINIMUM		NORMAL		MAXIMUM	
H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.
1/5	700	1/3	1050	2/5	1500
2/5	700	2/3	1050	3/4	1500
3/4	700	1¼	1050	1½	1500
1½	700	2½	1050	3	1500
2¼	700	3¾	1050	4½	1500
3½	700	6¼	1050	7¼	1500

* Heating guarantees on two-hour intermittent basis. Commutator 60 deg. all other parts 55 deg. C.

GENERAL ELECTRIC COMPANY

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Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
Jacksonville, Fla.	Florida Life Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Schwind Building
Toledo, Ohio	Spitzer Building
Chattanooga, Tenn.	James Building
Knoxville, Tenn.	Bank & Trust Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Davenport, Iowa	Security Building
Keokuk, Iowa	Monarch Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
Joplin, Mo.	Miners' Bank Building
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	1911 No. Lamar St.
El Paso, Tex.	Chamber of Commerce Building
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For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

General Electric Company
Schenectady, N.Y.

SUPPLY DEPARTMENT

November, 1912 — Bulletin No. 4994

TYPE H FORM K SUBWAY TRANSFORMERS

The General Electric Company manufactures a line of transformers, essentially similar in design to the well known Type H Form K pole transformer, with constructional modification which particularly adapt them for subway service.

Transformers for underground installation must possess certain features in order successfully to meet all service conditions. The following may be mentioned as the most essential:

They must be watertight, as subways are not always dry. They must be properly proportioned for the limited space available in the manholes.

They must have high efficiency because they are continuously connected to the mains. The radiating surface must be large and the temperature rise small, since the manholes are practically air tight and the heat radiation low.

Type H Form K subway transformers are absolutely watertight and are built to fulfill these requirements in every respect. They are equal to the standard Type H Form K pole transformers in safety, durability, and economy, since they are similar in design and, with the exception of the tank and cover, similar in construction.

30 KV-A. TYPE H FORM K SUBWAY TRANSFORMER

The Type H subway transformers are made for 60 cycles at standard voltages and in capacities of from 5 kv-a. to 100 kv-a. inclusive. For the principal dimensions, voltages and capacities of standard subway transformers see pages 5 and 6.

GENERAL CONSTRUCTION

Throughout the construction, the best materials are used, with the highest quality of workmanship. The insulation in all parts of the transformer must withstand certain severe tests and is therefore selected with reference to the respective duties for which it is required; i.e., whether to insulate turns, layers, coils, or between primary and secondary windings. This is a matter of great importance, since too great an economy in insulation or unsuitable material may mean the breakdown of the transformer, while too great an amount of insulation will mean an increased loss and temperature rise. The coils of all the smaller transformers are subjected to the vacuum drying and compound filling process developed by the Company. This process not only effectively drives out moisture from the interstices of the windings and prevents its re-absorption; but also cements the coils together into one solid block which considerably increases the dissipation of heat, thereby causing a low temperature rise. The transformers are constructed with numerous oil ducts and channels of ample size, and, as each individual coil is relatively thin, the oil comes in contact with all heated parts, resulting in a uniformly low temperature throughout the transformer.

For additional and more detailed information, in reference to the design and construc-

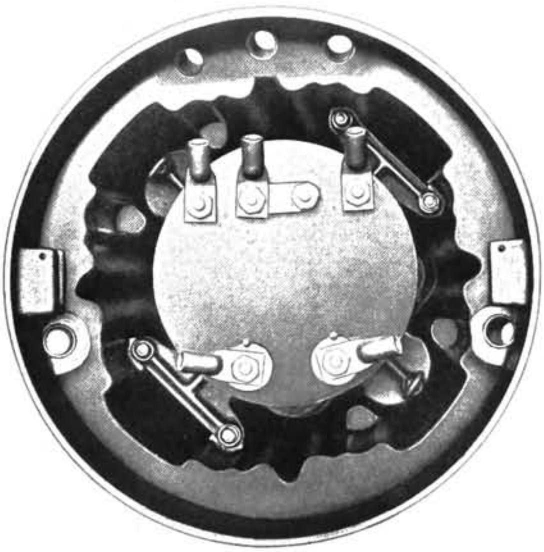
NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.

* *Supersedes Bulletin No. 4608.*

tion of subway transformers, reference should be made to the Bulletin on Type H Form K transformers. The following points have special reference to the subway type:

Bushings

A new style bushing has lately been developed for the leads going into the tank. These bushings are not only compact and watertight but are so arranged that the transformers can be readily connected to or disconnected from the mains without disturbing the wiped joint.



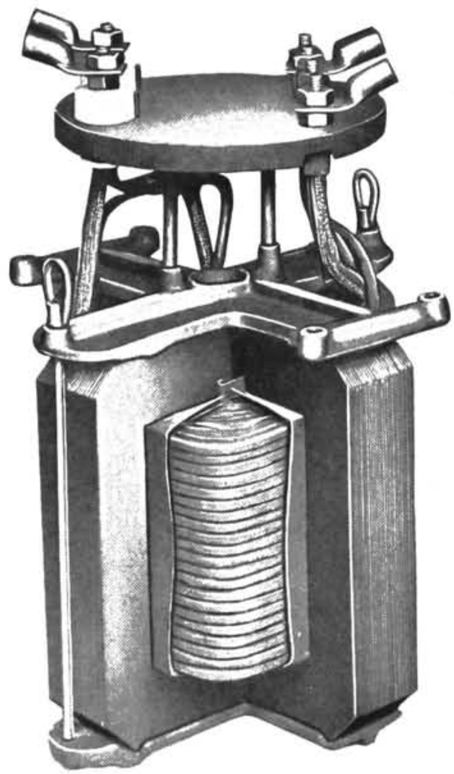
15 KV-A. TRANSFORMER WITH COVER REMOVED SHOWING TERMINALS ON CONNECTION BOARD

Before leaving the factory, all subway transformers are completely set up ready for operation and subjected to an air pressure of 6 pounds per square inch. The transformer should be given this pressure test just before being put into service.

The bushings on several sizes of transformers are made interchangeable, so that, in case of changed load, a transformer of different capacity can be readily substituted without disturbing soldered connections. The construction of primary and secondary bushings is similar, the details being clearly shown in the illustration on page 3.

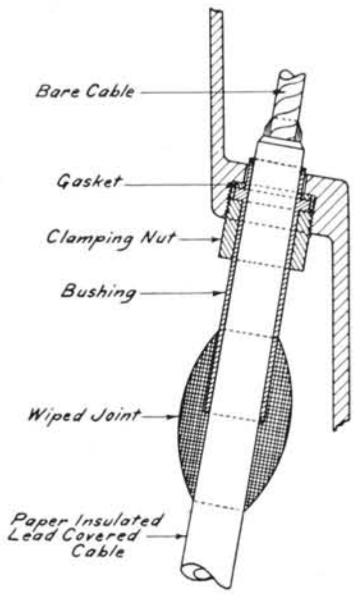
Tanks

The tank construction used in subway service has to meet with most severe operating conditions. The tanks are made of heavy cast iron or of sheet steel with a cast iron top and base. The sides of the tank are corrugated in order to provide the necessary radiating surface. On all sizes the cast iron top is circu-



CORE AND COILS OF 15 KV-A. TRANSFORMER

lar in shape, and in sizes above 50 kv-a. the corrugations are omitted on two sides in order to reduce the overall dimensions, as shown in the diagram on page 5. To allow a further reduction in size of the tanks the lifting lugs are cast on the cover. The domed covers are sufficiently strong to support the transformer when filled with oil, and provide a ready means for lowering it into the subway chamber.



BUSHING FOR SUBWAY TRANSFORMER

The joint surfaces of the cover and tank are carefully machined, and a specially constructed gasket is inserted in order to insure an air tight joint. The cover for sizes 50 kv-a. and smaller is clamped down by one bolt or stud tapped into a cross bar inside of the tank. On the larger sizes the cover is secured by a number of external bolts.

COVER AND CLAMPING CROSS BAR USED WITH 5 KV-A. TO 50 KV-A. TRANSFORMERS

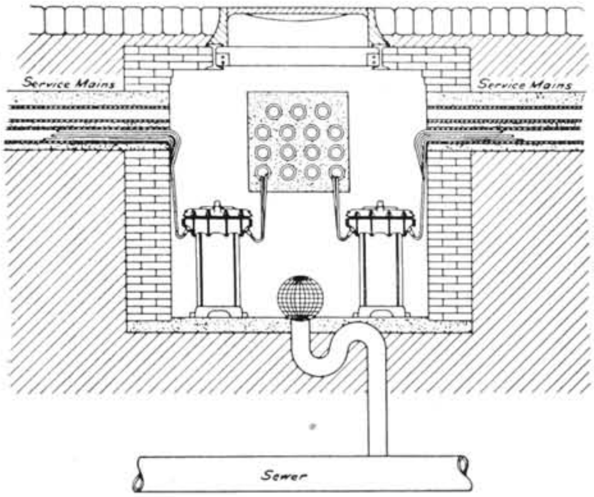
Connections of Primary and Secondary Coils

Standard subway transformers of 50 kv-a. and smaller have two primary and four secondary leads brought up to a terminal board inside of the tank, as shown on page 2. The primary coils are permanently connected in series for one voltage and the secondary coils can be readily connected for multiple, series or three-wire operation by means of the links on the connection board. The connection board is also provided with terminals to which

100 KV-A. TYPE H SUBWAY TRANSFORMER

the line cables should be soldered. Provision is made for bringing out two leads on the primary side and three on the secondary. When the secondary coils are connected for multiple or series operation, the middle lead is not used. In this case the middle bushing should be plugged with cork and sealed up with compound or some similar substance to make it air tight.

Sizes 75 and 100 kv-a. are of two-legged core type construction, with external appearance as shown above. On these sizes provision is made for the same number of leads to be brought out of the tank as in the smaller sizes. No connection board, however, is used, the leads being permanently connected to the coils and equipped with terminals to which the line cables should be soldered. The secondary leads are arranged, however, so that both series and three-wire connections are available. In case the series connection is required, the middle bushing should be plugged in the manner already described.



SECTION THROUGH SUBWAY TRANSFORMER CHAMBER

ADVANTAGES

The Form K subway transformer, besides possessing the many advantages inherent in the Type H transformer, has the following additional features:

1. An improved type of bushing allowing the transformer to be connected to the line without disturbing the wiped joint.

2. A tank construction which gives large radiating surface while yet allowing for ready installation in the subway chamber.

3. A cover provided with lifting lugs for readily handling the entire weight of the transformer filled with oil.

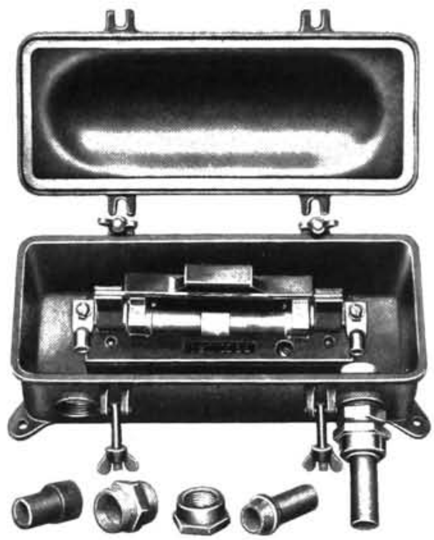
4. An improved gasket between the cover and tank which makes the transformer absolutely moisture-proof.

5. An oil plug is provided in the cover so that the transformer can be filled with oil without disturbing the joint between the cover and tank.

PRIMARY CUTOUTS

Fuse boxes and cutouts can be furnished for each subway transformer, as shown below. The fuse is enclosed in a cast iron box which is provided with feet, so that it can be conveniently attached to the walls of the subway chamber in any position desired. Since the cover is provided with a moulded rubber gasket, and the bushings are designed so that a plumber's wiped joint can be made with the lead cable entering the box, it is watertight if properly installed.

The fuse is of the enclosed type and is held by two punched clips fastened to a porcelain block. A handle is moulded in the top of the



FUSE BOX AND CUTOUT, COVER OPEN

block which is fitted with copper knife blades on each end.

The fuse block can thus be readily pulled out either for the insertion of a new fuse or for the opening of the primary circuit.

The following table gives the catalogue numbers of the fuse boxes and fuses for standard transformers of 100 kv-a. and under.

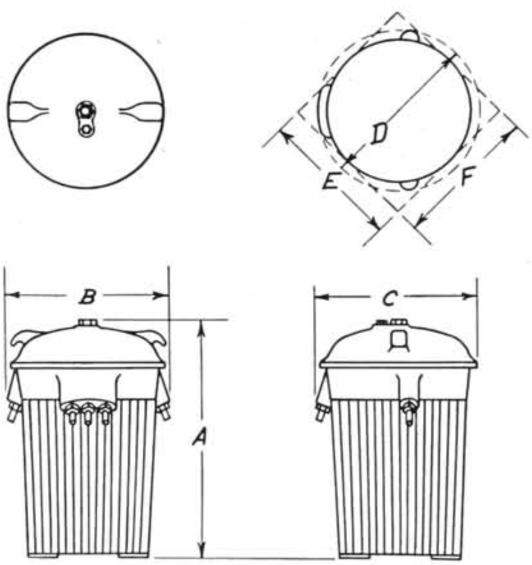
CATALOGUE NUMBERS AND DATA FOR SUBWAY TRANSFORMERS 5 TO 100 KV-A.

Primary Volts 2200			2400	Quarts of Oil Required	Net Wt. in Lb. Inc. Oil
Sec. Volts 110/220		122/244	120/240		
Kv-a.	Cat. No.	Cat. No.	Cat. No.		
5.0	79551	79560	79569	20	365
7.5	79552	79561	79570	25	445
10.0	79553	79562	79571	30	510
15.0	79554	79563	79572	48	835
20.0	79555	79564	79573	55	985
25.0	79556	79565	79574	77	1135
30.0	79557	79566	79575	105	1300
40.0	79558	79567	79576	190	1845
50.0	79559	79568	79577	190	1945
75.0	78978	78980	78982	180	1925
100.0	78979	78981	78983	220	2400

CATALOGUE NUMBERS

Kv-a. Capacity	Fuse Box	Fuses 2200/2400 Volts
5.0	27459	27460
7.5	27459	27461
10.0	27459	27461
15.0	27459	27462
20.0	27459	27463
25.0	27459	27464
30.0	27459	27465
40.0	27459	27466
50.0	27459	27467
75.0	58001	58003
100.0	58001	58006

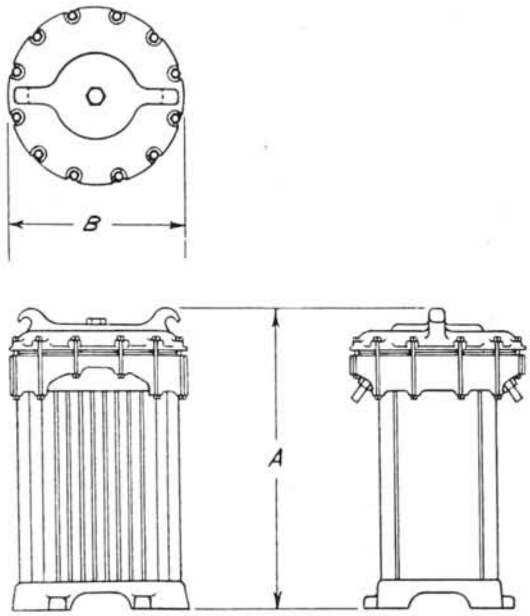
DIMENSIONS OF TYPE H FORM K SUBWAY TRANSFORMERS 60 CYCLES, PRIMARY VOLTS 2200 OR 2400



Tank C.P. No.	Kv-a.	A	B	C	Min. Dia. D	Minimum Rectangle E	Minimum Rectangle F	Bore of Bushings Primary	Bore of Bushings Secondary
115	5.0	27¾	17½	18	18¼	17	16¾	1	1
117	7.5	29¾	18¼	18½	19	17½	17½	1	1
119	10.	32	19½	20	20	18¾	18¾	1	1
121	15.	35¾	22¼	23½	23½	21¾	21¾	1⅛	1⅛
123	20.	39¾	25¼	25¾	25¾	25¼	25¼	1⅛	1⅛
125	25.	41	26¼	26½	26½	26¼	26¼	1⅛	1⅛
127	30.	45	27½	27¾	27¾	27½	27½	1⅛	1⅛
131	40.	56	30¼	30¼	30¼	30¼	30¼	1⅛	1⅜
131	50.	56	30¼	30¼	30¼	30¼	30¼	1⅛	1⅜

In selecting manholes at least ½ in. should be added to the dimensions on all sizes to allow for variations in castings and also for clearance in passing through the manhole.

DIMENSIONS OF TYPE H SUBWAY TRANSFORMERS, 75 AND 100 KV-A. 60 CYCLES 2200 OR 2400 VOLTS PRIMARY



Tank Symbol	Kv-a.	A	B	BORE OF BUSHINGS	
				Primary	Secondary
S-11	75	56½	27	1⅛	1⅜
S-23	100	59¾	30½	1⅛	1⅜

GENERAL ELECTRIC COMPANY

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DIRECT CURRENT SWITCHBOARDS

DOUBLE POLARITY, 125, 250 AND 600 VOLTS

90 INCHES HIGH

THE MOST RELIABLE SWITCHBOARDS

GE

August, 1912

General Electric Company
Schenectady, N. Y.

Bulletin No. 4995
Supersedes No. 4918

General Electric Company
Schenectady, N.Y.

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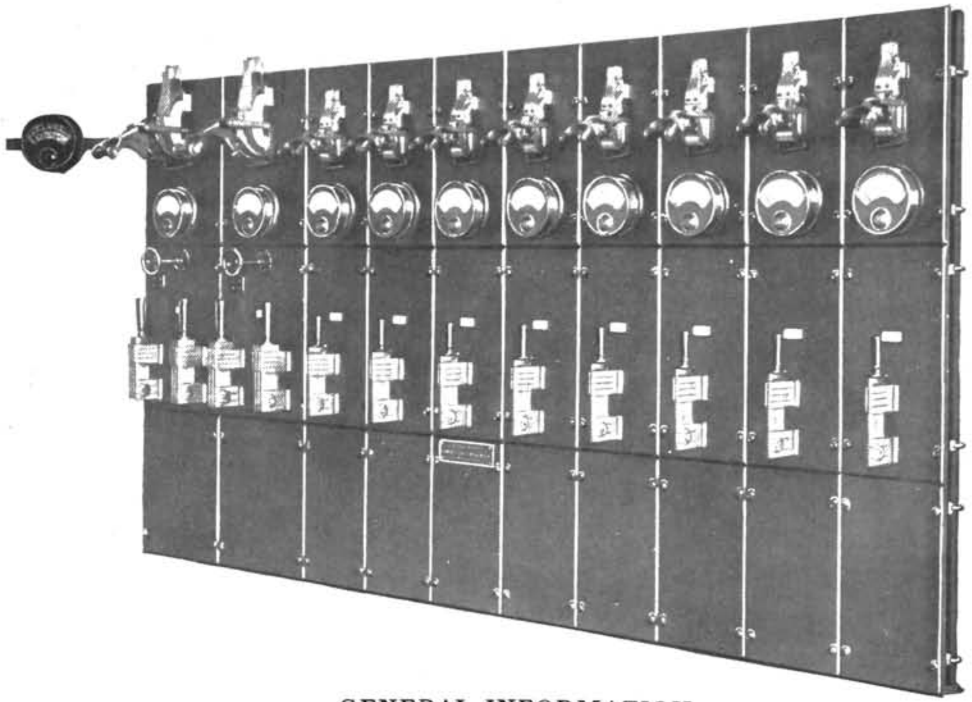
DIRECT CURRENT SWITCHBOARDS
DOUBLE POLARITY—90 INCHES HIGH—125, 250 AND 600 VOLTS



GENERAL INFORMATION

These panels are designed for general use in central stations. They are for use with one (1) set of busbars to which all generators and feeders are connected by means of single-throw lever switches with circuit breakers or fuses. Equalizer switches on pedestals are catalogued for the parallel operation of generators.

Generator panels are all provided with automatic circuit breakers. Feeder panels are listed with circuit breakers and with one or two lever switches per circuit. For 125 and 250 volts only, feeder panels are listed with lever switches and enclosed fuses to meet the conditions where a number of small capacity circuits are to be controlled.

MATERIAL OF PANELS

All panels are oiled Natural Black Slate 1½ inches thick up to and including 3000 amperes. 4000 ampere panels are 2 inches thick; 5000 and 6000 ampere panels are 2 inches thick when made of slate and 2½ inches thick when made of marble. All panels have ⅜ inch bevel.

Blue Vermont Marble, Black Enameled Slate, Dull Black Marine Finished Slate or panels 2 inches thick instead of 1½ inches may be substituted at increased prices which may be obtained from any office of the General Electric Company.

FRAMEWORK AND FINISH

A complete supporting framework of 1¼ inch pipe with necessary fittings is included for each panel, except the pipe for tie rods.

Instruments furnished with the panels have a dull black finish and all current carrying parts on the front of panels are polished and lacquered.

SILL

A wooden sill for supporting the switchboard 2 inches above the floor is recommended in all installations of more than one panel.

This sill is not furnished by the General Electric Company.

* *Supersedes Bulletin No. 4918.*

BUS

Owing to the varying amounts of busbar copper which may be required for a given panel, it is impossible to include a fixed amount which would not be too great for some cases and too small for others. *All panels are therefore listed without copper for buses*, and the latter must be ordered by Catalogue numbers, from the busbar tables on another page.

As it is impossible to predetermine the location of equalizer pedestals, copper for the equalizer bus is not listed.

CONNECTIONS

Each panel is furnished complete with necessary small wiring on back of panel, and with bare copper connections between the buses, switches and circuit breakers comprising the equipment of the panel.

RHEOSTAT MECHANISM

Panels up to and including 150 kw. 125 volts, 300 kw. 250 volts, and 480 kw. 600 volts are provided with adjustable supports for mounting the field rheostat directly behind the panel. These supports are adjustable both vertically and horizontally, thus allowing considerable range in the dimensions of the rheostat. Above these limits, chain operating mechanisms are included. Panels cannot be modified to meet special dimensions of rheostats without an additional charge being made.

EQUALIZER SWITCHES

Equalizer switches mounted on pedestals, which are suitable for mounting on the floor near the machine, are catalogued separately as these are not needed with first machine installed. With two machines only one equalizer pedestal is necessary. For three machines or over, one should be ordered for each generator panel.

FIELD SWITCHES

Field switches are not included with 125 and 250 volt generator panels listed on page 4. Field switches are listed separately, so that panels without or with field switches may be ordered as desired.

Although not included with these panels field switches are recommended for 125 volt generator panels above 2000 amperes and for 250 volt generator panels above 1000 amperes. Above these limits the rheostats furnished by the General Electric Company are provided with discharge resistances for use in connection with field switches.

Field switches, although not absolutely necessary are a great convenience when it is desired to open the field circuit while working on a machine which is running. On small machines the same result may be obtained by raising the brushes, which process would be very slow and laborious on a large machine.

Field switches are included on all 600 volt panels listed.

RATINGS OF GENERATOR PANELS

The ampere ratings of all generator panels are maximum currents which they are designed to carry for one or two hours, the corresponding kilowatt ratings being the normal capacities of the largest machines with which the panels can be used. Kilowatt ratings are based on overload of 25 per cent. for one or two hours and 65 per cent. momentarily.

For overloads of 50 per cent. for one or two hours and 100 per cent. momentarily, multiply the normal kilowatt rating of the generator by 1.2 and select a panel having a rating at least equal to the product thus obtained.

RATINGS OF FEEDER PANELS

The ampere ratings given for feeder panels are the maximum currents (normal or overload other than momentarily) which they are designed to carry.

FUSES

Unless otherwise ordered, fuses for feeder panels will be furnished of the same capacity as the switches.

Other capacities may be substituted within certain limits as given in the following table, when fuses differing in capacity from those catalogued are required, the capacity desired must be specified in the order.

Feeder Switch	Ampere Capacity Standard Fuses
30	3-5-8-10-12-15-20-25-30
60	35-40-45-50-55-60
100	65-70-75-80-90-100
200	110-120-130-140-150-160-170-180-190-200
400	225-250-275-300-325-350-375-400

INFORMATION WHICH SHOULD ACCOMPANY ORDERS

Delay in shipment and dissatisfaction on the part of the purchaser will often be avoided if the order is accompanied by as much of the following information as pertains to the panel or panels ordered.

GENERAL

1. **Order of Panels**—Preferably in the form of a rough sketch including *existing blank* and *new panels* and also showing any open spaces. See Fig. 1 page 13 for recommended arrangement.
2. **If Existing Panels are to be matched** give serial numbers of same if of General Electric manufacture, otherwise give brief description preferably in form of sketch showing location of apparatus and bolts on front of panels, location and size of busbars, location of switches, etc.
3. **Available Space** behind and above switchboard, also height of basement, if any.

INFORMATION WHICH SHOULD ACCOMPANY ORDERS (Cont'd)

GENERATOR PANELS

1. **Rating of Generators** including voltage, normal load, and one or two hour overload.
2. **Location of Rheostats**—These panels above 1200 amp. are designed for chain operated generator field rheostats. When chain operated, which of the rheostat locations shown on pages in rear of this section is desired?
3. **Main Cables**—Are they to be brought to switches from above or from below? Give size and number of cables in multiple in each lead.

FEEDER PANELS

1. **Main Cables**—Are they to be brought to switches from above or from below? Give size and number of cables in multiple in each lead.
2. **Normal Ampere Load of Circuits** to be controlled.

DIAGRAMS OF CONNECTIONS

KEY TO SYMBOLS

A = Ammeter.

C.B. = Circuit breaker.

F = Fuse.

F.S. = Field switch.

O.C. = Overload coil.

P.P. = Potential plug.

P.R. = Potential receptacle.

Rheo. = Rheostat.

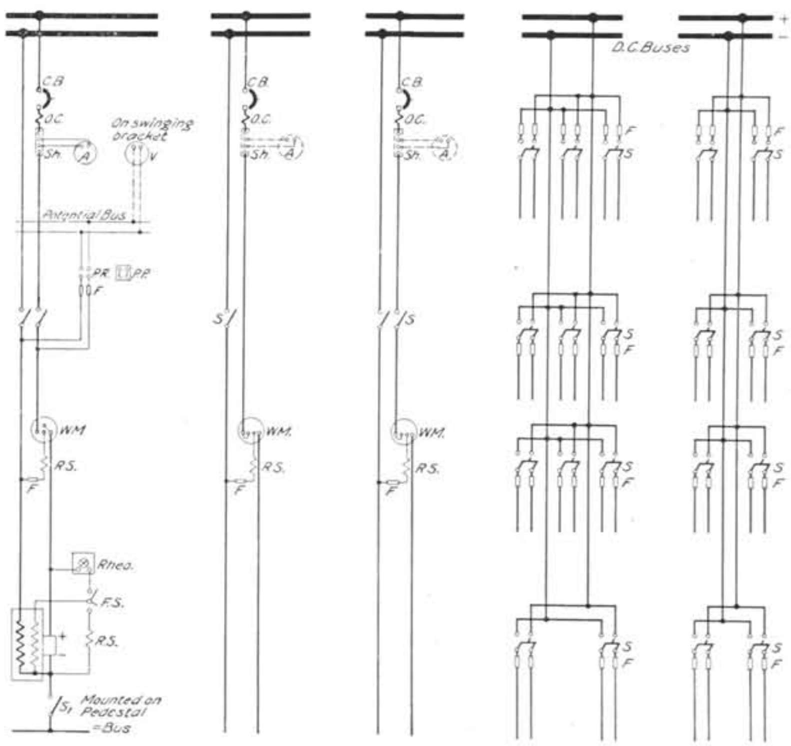
R.S. = Resistance.

S = Switch.

Sh. = Shunt.

V = Voltmeter.

W.M. = Watthour meter.



125 AND 250 VOLT GENERATOR PANELS

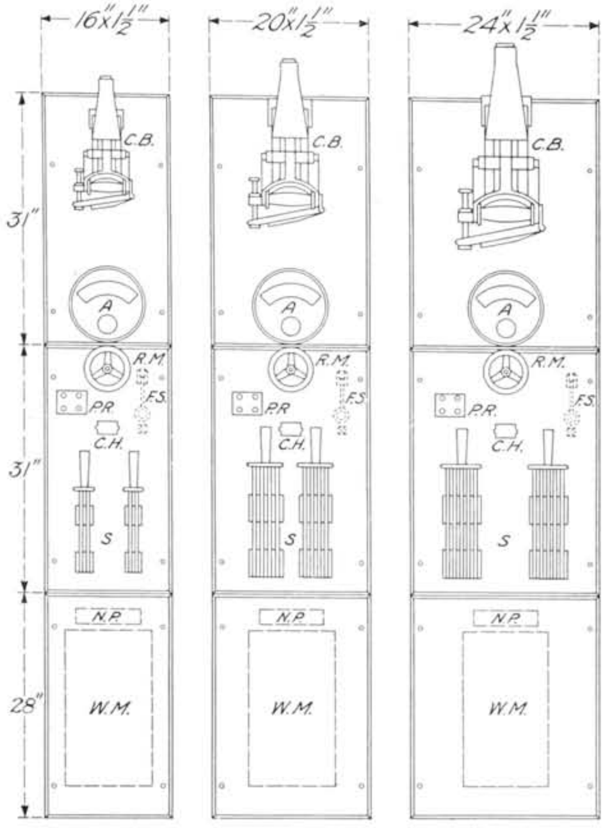


Fig. 1 Fig. 2 Fig. 3

EQUIPMENT

C.B. = S.P.......amp. 250 volt Type.....carbon break overload circuit breaker with spade handle (above 500 amp.).

A = ...amp. Type D7 ammeter with shunt.

R.M. = Handwheel and mounting (up to 1200 amp.) or handwheel and chain mechanism (above 1200 amp.), for field rheostat.

P.R. = 4 point potential receptacle.

F.S. (optional) = S.P.S.T. 200 amp. 250 volt field switch, with discharge resistance clips. **When required see below.**

C.H. = Card holder.

N.P. = Name plate (on only one panel in a complete switchboard).

S = ***Two*** S.P.S.T.......amp. 250 volt lever switches.

W.M. = ...amp. 125 (or 250) volt Type.....watthour meter with glass cover. (Type CS to 1500 amp. Type G3 above 1500 amp.)

Equalizer switches must be ordered separately, see page 14.

Busbars must be ordered separately; see "Busbar Copper."

Each complete switchboard must include a voltmeter on swinging bracket.

△ Panels without Field Switches. (For Recommendations see Page 2.)

KW. Capacity of Generator		Ampere Capacity						Type of Circuit Breaker	Fig. No.	Cat. No.		
										Panel with Watthour Meter		Panel without Watthour Meter
125 Volts	250 Volts	Panel	Circuit Breaker	Ammeter	Main Switches	Equalizer Switches	Watt-hour Meter			125 Volts	250 Volts	125 or 250 Volts
25	50	250	300	300	300	200	200	CP	1	122868	122883	122898
30	60	300	300	400	300	200	300	CP	1	122869	122884	122899
40	80	400	500	500	400	200	300	CP	1	122870	122885	122900
50	100	500	500	600	600	200	400	CP	1	122871	122886	122901
60	120	600	800	800	600	300	600	CP	1	122872	122887	122902
80	160	800	800	1000	800	300	600	CP	1	122873	122888	122903
100	200	1000	1000	1200	1000	400	800	CP	1	122874	122889	122904
120	240	1200	1200	1500	1200	400	1200	CP	1	122875	134834	122905
150	300	1500	1500	2000	1500	600	1200	CK	1	122876	134835	122906
200	400	2000	2000	2500	2000	800	1500	CK	1	122877	134836	122907
250	500	2500	3000	3000	3000	1000	2000	CK	2	134829	134837	134842
300	600	3000	3000	4000	3000	1000	3000	CK	2	134830	134838	134843
400	800	4000	4000	5000	4000	1500	3000	CK	2	†134831	†134839	†134844
500	1000	5000	6000	6000	5000	1500	4000	CK	3	*134832	*134840	*134845
600	1200	6000	6000	8000	6000	2000	6000	CK	3	*134833	*134841	*134846

* If Blue Vermont Marble is used, these panels must be 2½ in. thick.

† These panels are 2 in. thick.

△ **EXTRAS.** The following must be ordered separately when needed: Cat. No. 65012 *one* S.P.S.T. 200 amp. 250 volt field switch with discharge resistance clips. (Discharge resistance is not included.)

125 AND 250 VOLT FEEDER PANELS WITH CIRCUIT BREAKERS ONE SWITCH PER CIRCUIT

EQUIPMENT

C.B. =S.P.. . . . . .amp. 250 volt Type. . . . . .overload carbon break circuit breaker, with spade handle (above 500 amp.)
(Type CP up to 1200 amp., Type CK above 1200 amp.)

A =. . . . . .amp. Type D7 ammeter with shunt.

C.H. =Card holder.

S =S.P.S.T.. . . . . .amp. 250 volt lever switches.

N.P. =Name plate (on only one panel in a complete switchboard).

W.M. =. . . . . .amp. 125 (or 250) volt Type. . . . . .watthour meter with glass cover.
(Type CS up to 1500 amp., Type G3 above 1500 amp.)

Busbars must be ordered separately; see "Busbar Copper."

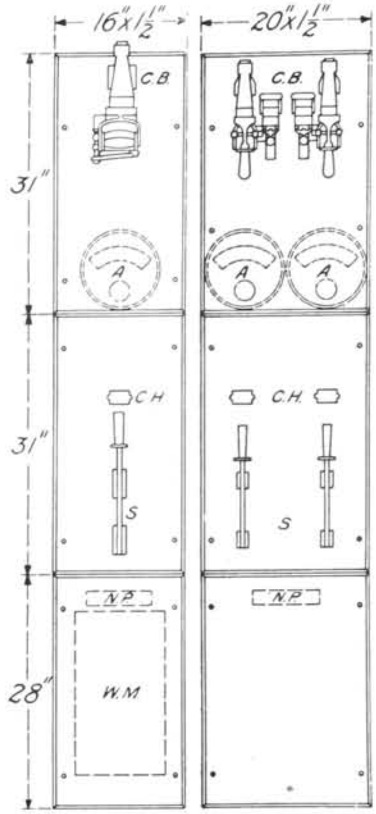


Fig. 1 Fig. 2

AMPERE CAPACITY						CAT. NO.					
						Panel with Watthour Meter				Panel without Watt-hour Meter	
						With Ammeter		Without Ammeter		With Ammeter	Without Ammeter
Panel	Circuit Breaker	Ammeter	Switches	Watthour Meter	Fig. No.	125 Volts	250 Volts	125 Volts	250 Volts	125 or 250 Volts	
SINGLE CIRCUIT PANELS											
100	100	150	100	100	1	122913	122924	122935	122946	122957	122968
160	200	200	200	150	1	122914	122925	122936	122947	122958	122969
200	200	300	200	150	1	122915	122926	122937	122948	122959	122970
250	300	300	300	200	1	122916	122927	122938	122949	122960	122971
300	300	400	300	300	1	122917	122928	122939	122950	122961	122972
400	500	500	400	300	1	122918	122929	122940	122951	122962	122973
500	500	600	600	400	1	122919	122930	122941	122952	122963	122974
600	800	800	600	600	1	122920	122931	122942	122953	122964	122975
800	800	1000	800	600	1	122921	122932	122943	122954	122965	122976
1000	1000	1200	1000	800	1	122922	122933	122944	122955	122966	122977
1200	1200	1500	1200	1200	1	122923	122934	122945	122956	122967	122978
1500	1500	2000	1500	1200	1	133986	133991	133996	134001	134006	134011
2000	2000	2500	2000	1500	1	133987	133992	133997	134002	134007	134012
2500	3000	3000	3000	2000	1	133988	133993	133998	134003	134008	134013
3000	3000	4000	3000	3000	1	133989	133994	133999	134004	134009	134014
*4000	4000	5000	4000	3000	1	133990	133995	134000	134005	134010	134015
DOUBLE CIRCUIT PANELS											
200	100	150	100	....	2	......	......	......	......	122979	122986
320	200	200	200	....	2	......	......	......	......	122980	122987
400	200	300	200	....	2	......	......	......	......	122981	122988
500	300	300	300	....	2	......	......	......	......	122982	122989
600	300	400	300	....	2	......	......	......	......	122983	122990
800	500	500	400	....	2	......	......	......	......	122984	122991
1000	500	600	600	....	2	......	......	......	......	122985	122992

* These panels are 2 inches thick.

125 AND 250 VOLT FEEDER PANELS WITH CIRCUIT BREAKERS TWO SWITCHES PER CIRCUIT

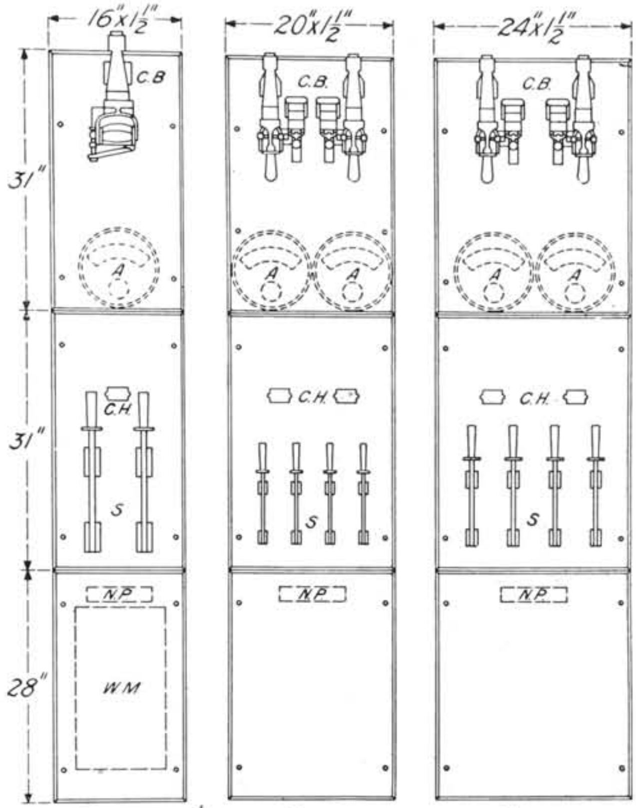


Fig. 1 Fig. 2 Fig. 3

EQUIPMENT

C.B. =S.P. . . . . . .amp. 250 volt Type . . . . . .overload carbon break circuit breaker, with spade handle (above 500 amp.) (Type CP up to 1200 amp., Type CK above 1200 amp.)

A =. . . . . .amp. Type D7 ammeter with shunt.

C.H. =Card holder.

S =S.P.S.T.. . . . . .amp. 250 volt lever switches.

N.P. =Name plate (on only one panel in a complete switchboard).

W.M. =. . . . . .amp. 125 (or 250) volt Type. . . . . .watthour meter with glass cover. (Type CS up to 1500 amp., Type G3 above 1500 amp.)

Busbars must be ordered separately; see "Busbar Copper."

AMPERE CAPACITY					Fig. No.	CAT. NO.					
						Panel with Watthour Meter				Panel without Watt-hour Meter	
						With Ammeter		Without Ammeter		With Ammeter	Without Ammeter
Panel	Circuit Breaker	Ammeter	Switches	Watthour Meter		125 Volts	250 Volts	125 Volts	250 Volts	125 or 250 Volts	
SINGLE CIRCUIT PANELS											
100	100	150	100	100	1	122993	123004	123015	123026	123037	123048
160	200	200	200	150	1	122994	123005	123016	123027	123038	123049
200	200	300	200	150	1	122995	123006	123017	123028	123039	123050
250	300	300	300	200	1	122996	123007	123018	123029	123040	123051
300	300	400	300	300	1	122997	123008	123019	123030	123041	123052
400	500	500	400	300	1	122998	123009	123020	123031	123042	123053
500	500	600	600	400	1	122999	123010	123021	123032	123043	123054
600	800	800	600	600	1	123000	123011	123022	123033	123044	123055
800	800	1000	800	600	1	123001	123012	123023	123034	123045	123056
1000	1000	1200	1000	800	1	123002	123013	123024	123035	123046	123057
1200	1200	1500	1200	1200	1	123003	123014	123025	123036	123047	123058
1500	1500	2000	1500	1200	1	134016	134021	134026	134031	134036	134041
2000	2000	2500	2000	1500	1	134017	134022	134027	134032	134037	134042
*2500	3000	3000	3000	2000	1	134018	134023	134028	134033	134038	134043
*3000	3000	4000	3000	3000	1	134019	134024	134029	134034	134039	134044
†4000	4000	5000	4000	3000	1	134020	134025	134030	134035	134040	134045
DOUBLE CIRCUIT PANELS											
200	100	150	100	....	2	......	......	......	......	123059	123066
320	200	200	200	....	2	......	......	......	......	123060	123067
400	200	300	200	....	2	......	......	......	......	123061	123068
500	300	300	300	....	2	......	......	......	......	123062	123069
600	300	400	300	....	2	......	......	......	......	123063	123070
800	500	500	400	....	3	......	......	......	......	123064	123071
1000	500	600	600	....	3	......	......	......	......	123065	123072

* These panels are 20 inches wide.
† These panels are 20 inches wide and 2 inches thick.

125 AND 250 VOLT FEEDER PANELS WITH FUSES—TWO TO FOUR CIRCUITS

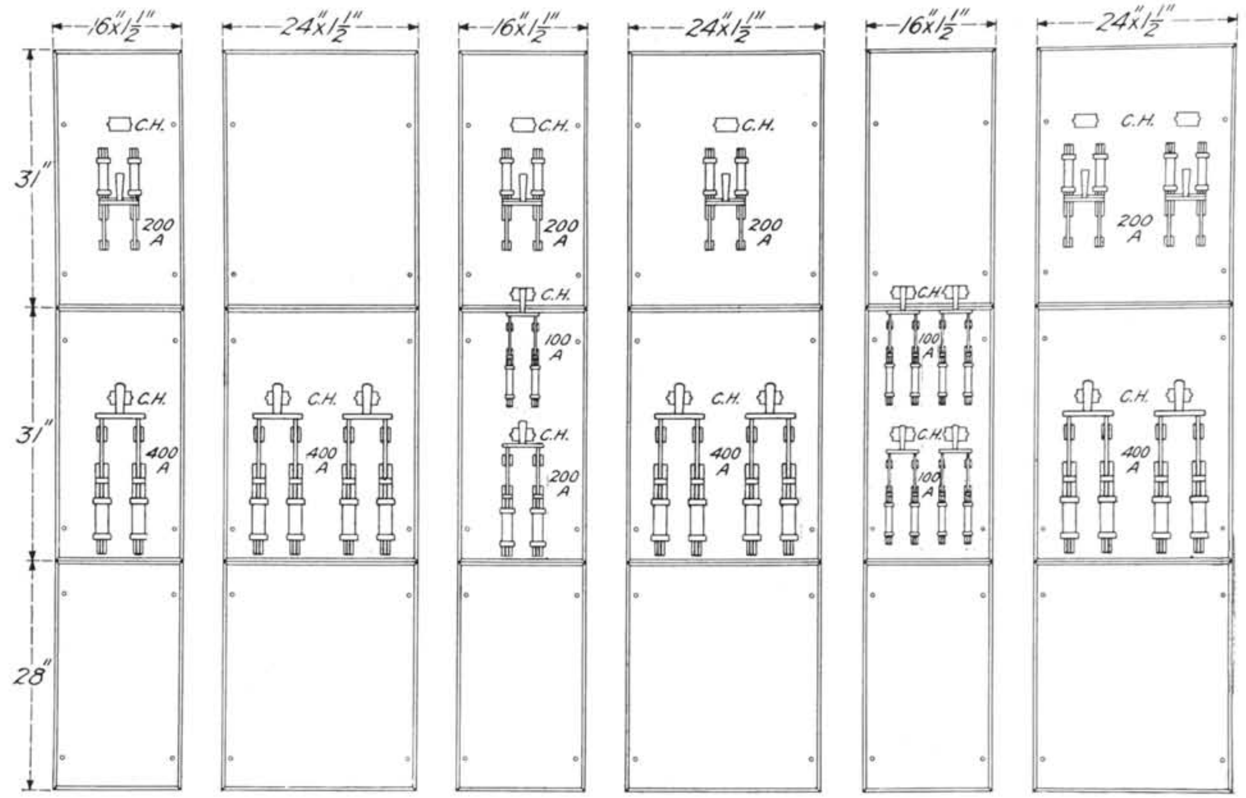


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6

EQUIPMENT

The number of switches covered by a Cat. No. is shown on Fig. to which the Cat. No. applies.

All switches are D.P.S.T. 250 volt lever switches with fuse blocks and one set of N.E.C.S. fuses on front of panel. Unless otherwise ordered fuses of same capacity as the switches will be furnished. When smaller fuses are desired see page 2.

One card holder is furnished for each switch.

A name plate is furnished for only one panel in a complete switchboard.

Busbars must be ordered separately; see "Busbar Copper."

INSTRUCTIONS FOR ORDERING

All switches in the illustrations are marked with the maximum allowable ampere capacity so that the Fig. No. for the panel required can be readily determined.

Order *one* top, *one* middle and *one* bottom section. All sections must be ordered from columns headed by the Fig. No. chosen.

MIDDLE SECTIONS

AMPERE CAPACITY OF SWITCHES		CAT. NO.			
Lower Row	Upper Row	Fig. 1	Figs. 2, 4, 6	Fig. 3	Fig. 5
60	30	......	......	123077	123085
60	60	......	......	123078	123086
100	30	......	......	123079	123087
100	60	......	......	123080	123088
100	100	......	......	123081	123089
200	30	......	......	123082	......
200	60	......	......	123083	......
200	100	......	......	123084	......
200	none	123073	123075	......	......
400	none	123074	123076	......	......

TOP SECTIONS

Ampere Capacity of Switches	CAT. NO.				
	Fig. 2	Fig. 5	Figs. 1, 3	Fig. 4	Fig. 6
blank	123090	123091	......	......	......
30	......	......	123092	123096	123100
60	......	......	123093	123097	123101
100	......	......	123094	123098	123102
200	......	......	123095	123099	123103

BOTTOM SECTIONS

Ampere Capacity of Switches	CAT. NO.	
	Figs. 1, 3, 5	Figs. 2, 4, 6
blank	123104	123105

125 AND 250 VOLT FEEDER PANELS—SIX TO EIGHT CIRCUITS

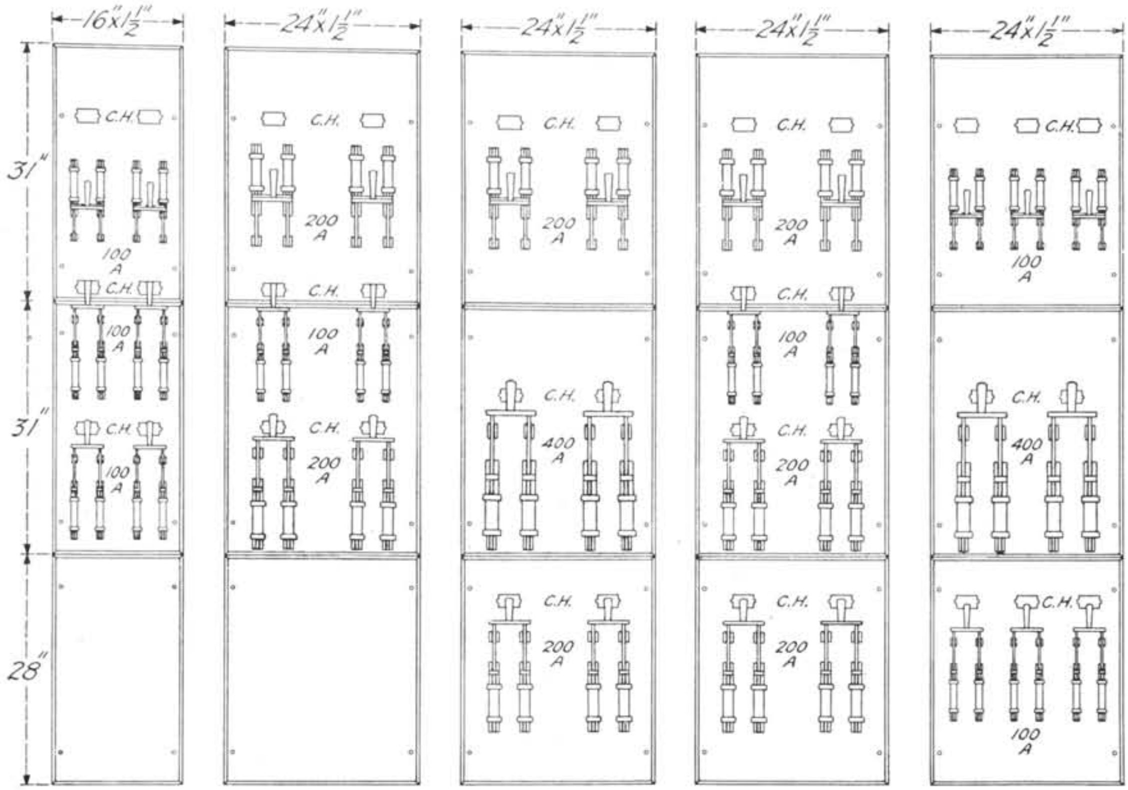


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5

EQUIPMENT

The number of switches covered by a Cat. No. is shown on Fig. to which the Cat. No. applies.

All switches are D.P.S.T. 250 volt lever switches with fuse blocks and one set of N.E.C.S. fuses on front of panel. Unless otherwise ordered fuses of same capacity as the switches will be furnished. When smaller fuses are desired see page 2.

One card holder is furnished for each switch.

A name plate is furnished for only one panel in a complete switchboard.

Busbars must be ordered separately; see "Busbar Copper."

INSTRUCTIONS FOR ORDERING

All switches in the illustrations are marked with the maximum allowable ampere capacity so that the Fig. No. for the panel required can be readily determined.

Order *one* top, *one* middle and *one* bottom section. All sections must be ordered from columns headed by the Fig. No. chosen.

MIDDLE SECTIONS

AMPERE CAPACITY OF SWITCHES		CAT. NO.		
Lower Row	Upper Row	Fig. 1	Figs. 2, 4	Figs. 3, 5
60	30	123085	123106	......
60	60	123086	123107	......
100	30	123087	123108	......
100	60	123088	123109	......
100	100	123089	123110	......
200	30	......	123111	......
200	60	......	123112	......
200	100	......	123113	......
200	none	......	......	123075
400	none	......	......	123076

TOP SECTIONS

Ampere Capacity of Switches	CAT. NO.		
	Fig. 1	Figs. 2, 3, 4	Fig. 5
30	123114	123100	123117
60	123115	123101	123118
100	123116	123102	123119
200	......	123103	......

BOTTOM SECTIONS

Ampere Capacity of Switches	CAT. NO.			
	Fig. 1	Fig. 2	Figs. 3, 4	Fig. 5
blank	123104	123105	......	......
30	......	......	123120	123124
60	......	......	123121	123125
100	......	......	123122	123126
200	......	......	123123	......

125 AND 250 VOLT FEEDER PANELS—WITH FUSES—NINE TO TWELVE CIRCUITS

EQUIPMENT

The number of switches covered by a Cat. No. is shown on Fig. to which the Cat. No. applies.

All switches are D.P.S.T. 250 volt lever switches with fuse blocks and one set of N.E.C.S. fuses on front of panel. Unless otherwise ordered fuses of same capacity as the switches will be furnished. When smaller fuses are desired see page 2.

One card holder is furnished for each switch.

A name plate is furnished for only one panel in a complete switchboard.

Busbars must be ordered separately; see "Busbar Copper."

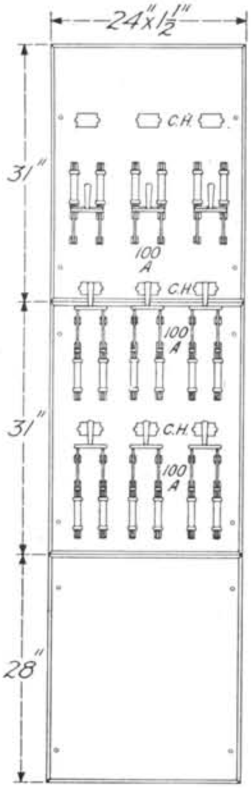


Fig. 1

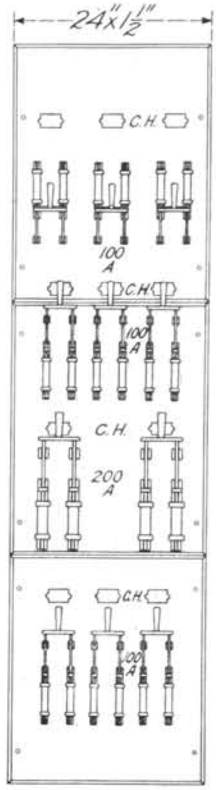


Fig. 2

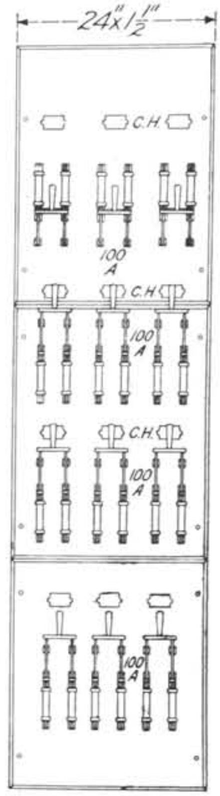


Fig. 3

INSTRUCTIONS FOR ORDERING

All switches in the illustrations are marked with the maximum allowable ampere capacity so that the Fig. No. for the panel required can be readily determined.

Order *one* top, *one* middle and *one* bottom section. All sections must be ordered from columns headed by the Fig. No. chosen.

MIDDLE SECTIONS

AMPERE CAPACITY OF SWITCHES		CAT. NO.	
Lower Row	Upper Row	Figs. 1, 3	Fig. 2
60	30	123127	123132
60	60	123128	123133
100	30	123129	123134
100	60	123130	123135
100	100	123131	123136
200	30	......	123137
200	60	......	123138
200	100	......	123139

TOP SECTIONS

Ampere Capacity of Switches	CAT. NO.
	Figs. 1, 2, 3
30	123140
60	123141
100	123142

BOTTOM SECTIONS

Ampere Capacity of Switches	CAT. NO.	
	Fig. 1	Figs. 2, 3
blank	123105	......
30	......	123124
60	......	123125
100	......	132126

600 VOLT GENERATOR PANELS

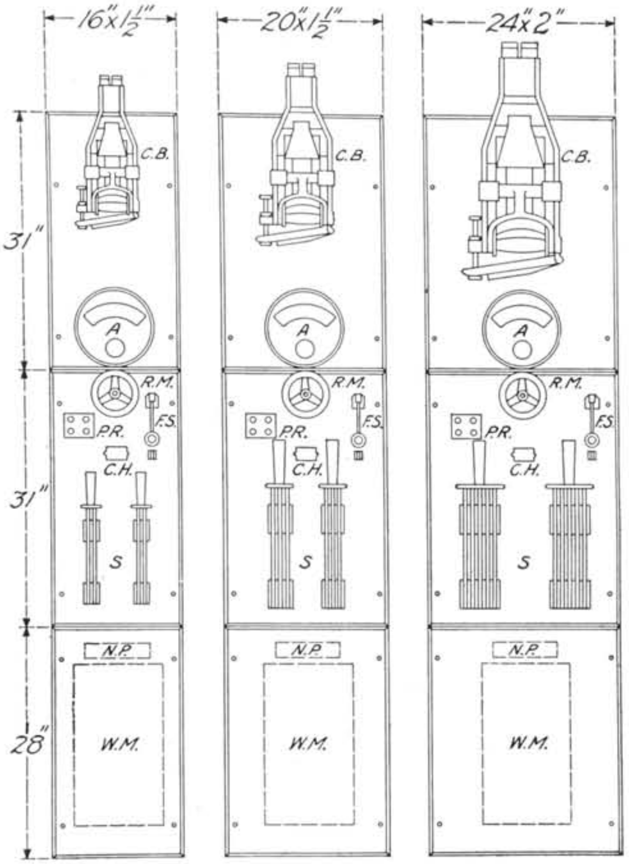


Fig. 1 Fig. 2 Fig. 3

EQUIPMENT

C.B. = S.P. . . . . . amp. 650 volt Type . . . . . . carbon break overload circuit breaker with reversed spade handle (above 500 amp.)

A = ... amp. Type D7 ammeter with shunt.

R.M. = Handwheel and mounting (up to 1200 amp.) or handwheel and chain mechanism (above 1200 amp.) for field rheostat.

P.R. = 4 point potential receptacle.

F.S. = S.P.S.T. 200 amp. 600 volt field switch with discharge resistance clip. (Discharge resistance is not included.)

C.H. = Card holder.

N.P. = Name plate (on only one panel in a complete switchboard).

S = *Two* S.P.S.T. . . . . . . amp. 600 volt lever switches.

W.M. = ... amp. 600 volt Type . . . . . . watthour meter with glass cover.

(Type CS to 1500 amp.; Type G3 above 1500 amp.)

Equalizer switches must be ordered separately; see page 14.

Busbars must be ordered separately; see "Busbar Copper."

Each complete switchboard must include a voltmeter on swinging bracket.

Kw. Capacity of Generator	AMPERE CAPACITY						Type of Circuit Breaker	Fig. No.	CAT. NO.	
	Panel	Circuit Breaker	Ammeter	Main Switches	Equalizer Switches	Watthour Meter			Panel with Watthour Meter	Panel without Watthour Meter
120	250	300	300	300	200	200	CP	1	123143	123158
145	300	300	400	300	200	300	CP	1	123144	123159
190	400	500	500	400	200	300	CP	1	123145	123160
240	500	500	600	600	200	400	CP	1	123146	123161
290	600	800	800	600	300	600	CP	1	123147	123162
380	800	800	1000	800	300	600	CP	1	123148	123163
480	1000	1000	1200	1000	400	800	CP	1	123149	123164
580	1200	1200	1500	1200	400	1200	CP	1	123150	123165
725	1500	1500	2000	1500	600	1200	CK2	1	123151	123166
965	2000	2000	2500	2000	800	1500	CK2	2	123152	123167
1200	2500	3000	3000	3000	1000	2000	CK2	2	123153	123168
1450	3000	3000	4000	3000	1000	3000	CK2	2	123154	123169
1925	4000	4000	5000	3000	1500	3000	CK2	3	† 123155	† 123170
2400	5000	6000	6000	5000	1500	4000	CK2	3	* 123156	* 123171
2900	6000	6000	8000	6000	2000	6000	CK2	3	* 123157	* 123172

* If Blue Vermont Marble is used these panels must be 2½ in. thick.

† These panels are 2 in. thick.

600 VOLT FEEDER PANELS—WITH ONE SWITCH PER CIRCUIT

EQUIPMENT

C.B. =S.P.......amp. 650 volt Type CP overload carbon break circuit breaker, with spade handle (above 500 amp.)

A =.......amp. Type D7 ammeter with shunt.

C.H. =Card holder.

S =S.P.S.T.......amp. 600 volt lever switches.

N.P. =Name plate (on only one panel in a complete switchboard).

W.M. =.......amp. 600 volt Type CS watthour meter with glass cover.

Busbars must be ordered separately; see "Busbar Copper."

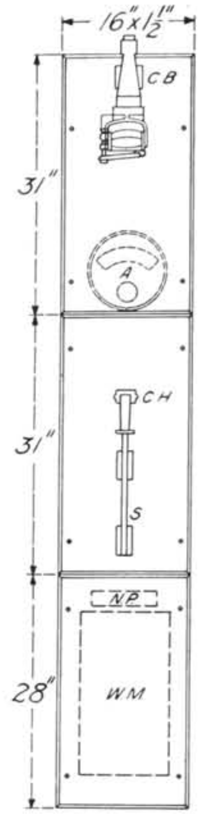


Fig. 1

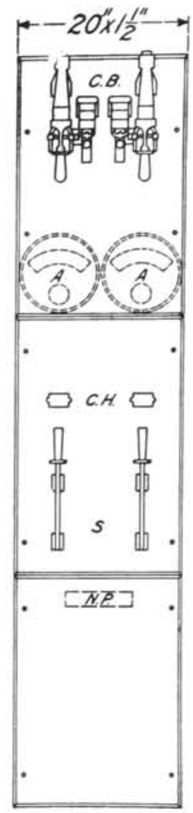


Fig. 2

AMPERE CAPACITY					Fig. No.	CAT. NO.			
						Panel with Watthour Meter		Panel without Watthour Meter	
Panel	Circuit Breaker	Ammeter	Switches	Watthour Meter		With Ammeter	Without Ammeter	With Ammeter	Without Ammeter
SINGLE CIRCUIT PANELS									
100	100	150	200	100	1	123173	123184	123195	123206
160	200	200	200	150	1	123174	123185	123196	123207
200	200	300	200	150	1	123175	123186	123197	123208
250	300	300	300	200	1	123176	123187	123198	123209
300	300	400	300	300	1	123177	123188	123199	123210
400	500	500	400	300	1	123178	123189	123200	123211
500	500	600	600	400	1	123179	123190	123201	123212
600	800	800	600	600	1	123180	123191	123202	123213
800	800	1000	800	600	1	123181	123192	123203	123214
1000	1000	1200	1000	800	1	123182	123193	123204	123215
1200	1200	1500	1200	1200	1	123183	123194	123205	123216
DOUBLE CIRCUIT PANELS									
200	100	150	200	....	2	......	......	123217	123224
320	200	200	200	....	2	......	......	123218	123225
400	200	300	200	....	2	......	......	123219	123226
500	300	300	300	....	2	......	......	123220	123227
600	300	400	300	....	2	......	......	123221	123228
800	500	500	400	....	2	......	......	123222	123229
1000	500	600	600	....	2	......	......	123223	123230

600 VOLT FEEDER PANELS—WITH TWO SWITCHES PER CIRCUIT

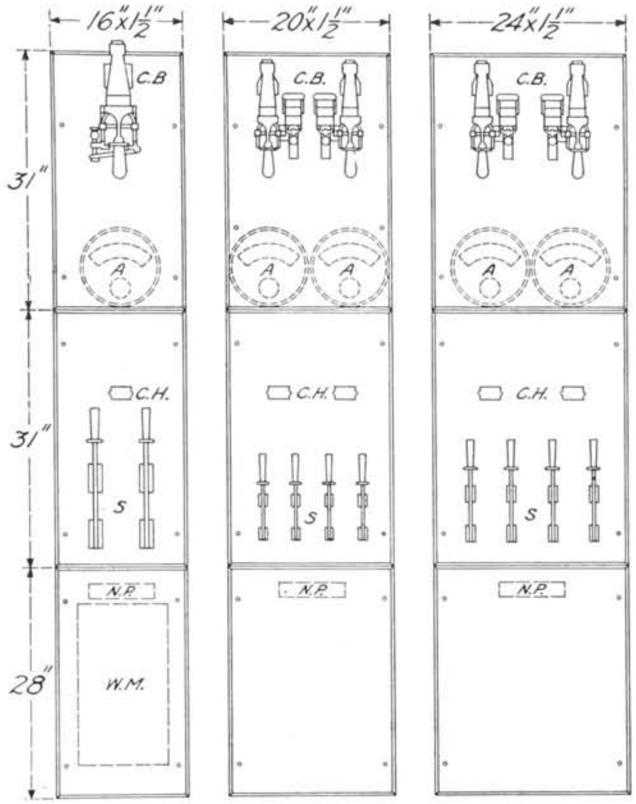


Fig. 1 Fig. 2 Fig. 3

EQUIPMENT

C.B. = S.P. . . . . . amp. 650 volt Type CP overload carbon break circuit breaker, with spade handle (above 500 amp.)

A = ... amp. Type D7 ammeter with shunt.

C.H. = Card holder.

S = S.P.S.T. . . . . . . amp. 600 volt lever switches.

N.P. = Name plate (on only one panel in a complete switchboard).

W.M. = ... amp. 600 volt Type CS watthour meter with glass cover.

Busbars must be ordered separately; see "Busbar Copper."

AMPERE CAPACITY						CAT. NO.			
						Panel with Watthour Meter		Panel without Watthour Meter	
Panel	Circuit Breaker	Ammeter	Switches	Watthour Meter	Fig. No.	With Ammeter	Without Ammeter	With Ammeter	Without Ammeter
SINGLE CIRCUIT PANELS									
100	100	150	200	100	1	123231	123242	123253	123264
160	200	200	200	150	1	123232	123243	123254	123265
200	200	300	200	150	1	123233	123244	123255	123266
250	300	300	300	200	1	123234	123245	123256	123267
300	300	400	300	300	1	123235	123246	123257	123268
400	500	500	400	300	1	123236	123247	123258	123269
500	500	600	600	400	1	123237	123248	123259	123270
600	800	800	600	600	1	123238	123249	123260	123271
800	800	1000	800	600	1	123239	123250	123261	123272
1000	1000	1200	1000	800	1	123240	123251	123262	123273
1200	1200	1500	1200	1200	1	123241	123252	123263	123274
DOUBLE CIRCUIT PANELS									
200	100	150	200	. . . .	2	. . . . . .	. . . . . .	123275	123282
320	200	200	200	. . . .	2	. . . . . .	. . . . . .	123276	123283
400	200	300	200	. . . .	2	. . . . . .	. . . . . .	123277	123284
500	300	300	300	. . . .	2	. . . . . .	. . . . . .	123278	123285
600	300	400	300	. . . .	2	. . . . . .	. . . . . .	123279	123286
800	500	500	400	. . . .	3	. . . . . .	. . . . . .	123280	123287
1000	500	600	600	. . . .	3	. . . . . .	. . . . . .	123281	123288

BUSBAR COPPER

Busbars must be ordered separately for each panel as per the following sample order:

Item No. 1—*One* direct current generator panel Cat. No......., buses........, Cat. No........

If the total current supplied to a bus by all the panels connected to it *does not exceed the minimum limits catalogued* for the different station kilowatt capacities, busbars may at once be chosen from the following tables, since the ampere capacity of bus required for any panel will be within these limits.

For all other cases the method described below is recommended as a simple means of determining the ampere capacity of bus required.

Catalogue numbers of buses cover one positive and one negative bus of bare copper bar of one or more laminations. The ultimate kilowatt capacity of the station must be taken into consideration in order that future additions may be made to the busbars without changing the bars already installed. Equalizer bus is not included, as it is impossible to predetermine the location of equalizer pedestals and bus.

Kilowatt Capacity of Station			Ampere Capacity of Bus Required	Cat. No.		
125 Volt	250 Volt	600 Volt		For Panel 16 In. Wide	For Panel 20 In. Wide	For Panel 24 In. Wide
225	450	1000	1 to 750	123289	123299	123309
225	450	1000	751 to 1500	123290	123300	123310
225	450	1000	1501 to 2250	123291	123301	123311
375	750	1800	1 to 1250	123292	123302	123312
375	750	1800	1251 to 2500	123293	123303	123313
375	750	1800	2501 to 3750	123294	123304	123314
1000	2000	4800	1 to 2500	123295	123305	123315
1000	2000	4800	2501 to 5000	123296	123306	123316
1000	2000	4800	5001 to 7500	123297	123307	123317
1000	2000	4800	7501 to 10000	123298	123308	123318

METHOD OF DETERMINING AMPERE CAPACITY OF BUS REQUIRED FOR A PANEL

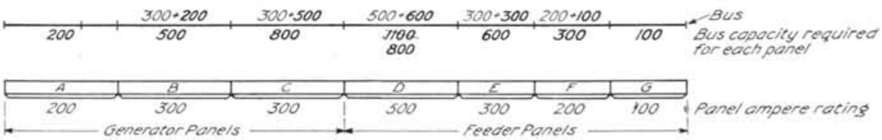


Fig. 1

The arrangement of panels shown in Fig. 1 is the one almost universally used, and the following is a simple method of determining bus capacity for such an arrangement:

1. Make a rough sketch of the **entire board,** regardless of the number of panels to be ordered, and with a single line represent the bus.
2. Below each panel mark its ampere rating.
3. The ampere capacity of the bus may then be determined by applying the following rules consecutively.

The application of these rules is illustrated in Fig. 1, ampere ratings being light face type and bus capacities in **bold face type.**

(a) Begin at generator end of bus for generator panels, and at feeder end for feeder panels.

(b) Bus capacity for first panel = ampere rating of panel.

(c) Bus capacity for each succeeding panel = ampere rating of panel **plus** bus capacity for preceding panels. (See sums marked above buses in Fig. 1.)

(d) The bus capacity of any feeder panel need not exceed the maximum for the generator panels (see bus for panel "D") and vice versa. Sometimes reductions may, therefore, be made for certain panels after applying rules (b) and (c).

VOLTMETERS ON SWINGING BRACKETS

Cat. No. 122063
One swinging bracket containing:
One 150 volt Type D7 voltmeter.
Two ground detector lamp receptacles (no lamps included).
One 4 point potential plug.

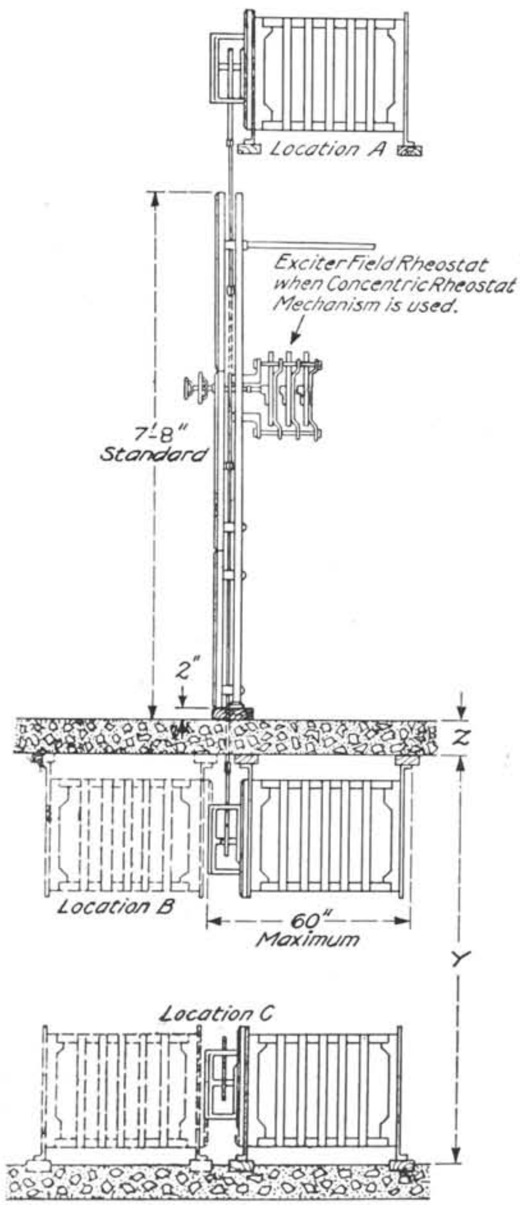
Cat. No. 122064
One swinging bracket containing:
One 300 volt Type D7 voltmeter.
Two ground detector lamp receptacles (no lamps included).
One 4 point potential plug.

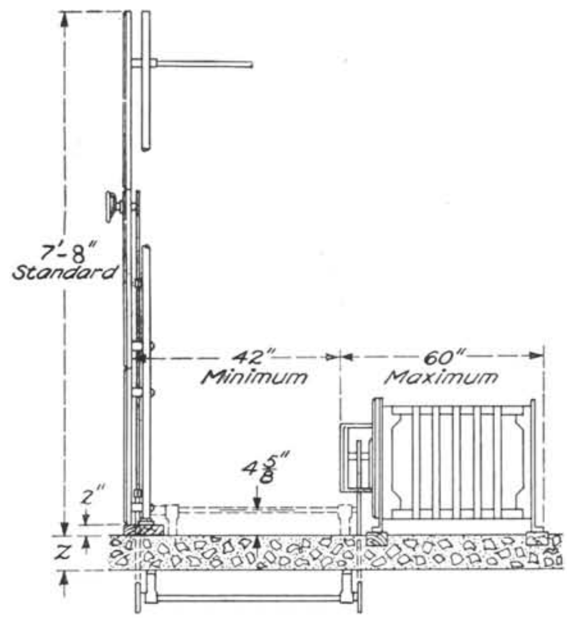
Cat. No. 122062
One swinging bracket containing:
One 750 volt Type D7 voltmeter.
One 4 point potential plug.

EQUALIZER SWITCHES ON PEDESTALS

Ampere Capacity of Panel	Ampere Capacity of Equalizer Switch	CAT. NO.	
		125 and 250 Volts	600 Volts
250, 300, 400, 500	200	123447	123456
600, 800	300	123448	123457
1000, 1200	400	123449	123458
1500	600	123450	123459
2000	800	123451	123460
2500–3000	1000	123452	123461
4000–5000	1500	123454	123463
6000	2000	123455	123464

125, 250 AND 600 VOLT D.C. SWITCHBOARD ARRANGEMENTS
ALTERNATE LOCATIONS OF CHAIN OPERATED GENERATOR FIELD RHEOSTATS





Dimensions Y and Z should be given with the order.

Ample provision should be made for dissipating heat radiated from the rheostats.

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES

(Address nearest office)

BOSTON, MASS.	84 State Street
Springfield, Mass.	Massachusetts Mutual Building
Providence, R. I.	Union Trust Building
NEW YORK, N. Y.	30 Church Street
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Post-Standard Building
Buffalo, N. Y.	Ellicott Square Building
New Haven, Conn.	Malley Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charlotte, N. C.	Trust Building
Charleston, W. Va.	Charleston National Bank Building
Erie, Pa.	Marine National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
New Orleans, La.	Maison-Blanche Building
CINCINNATI, OHIO	Provident Bank Building
Columbus, Ohio	Columbus Savings & Trust Building
Cleveland, Ohio	Citizens Building
Dayton, Ohio	Reibold Building
Youngstown, Ohio	Wick Building
Chattanooga, Tenn.	James Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Indianapolis, Ind.	Traction Terminal Building
Louisville, Ky.	Paul Jones Building
CHICAGO, ILL.	Monadnock Building
Detroit, Mich.	Majestic Building (Office of Soliciting Agent)
St. Louis, Mo.	Wainwright Building
Kansas City, Mo.	Dwight Building
Butte, Montana	Electric Building
Minneapolis, Minn.	410 Third Ave., North
Milwaukee, Wis.	Public Service Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building

For TEXAS and OKLAHOMA Business refer to
General Electric Company of Texas,

Dallas, Tex.	Lamar & Caruth Sts.
El Paso, Tex.	Chamber of Commerce Building
Houston, Tex.	Chronicle Building
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES

Schenectady, N. Y., Foreign Dept.
New York, N. Y., 30 Church St.
London, E.C., England, 83 Cannon St.

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.

ALTERNATING CURRENT SWITCHBOARD PANELS

With Oil Switches on Pipe Framework Back of Panel

THREE-PHASE THREE-WIRE

240, 480 AND 600 VOLTS, 25 TO 60 CYCLES

90 INCHES HIGH

THE MOST RELIABLE SWITCHBOARDS

General Electric Company
Schenectady, N. Y.

August, 1912

Bulletin No. 4996

General Electric Company
Schenectady, N.Y.

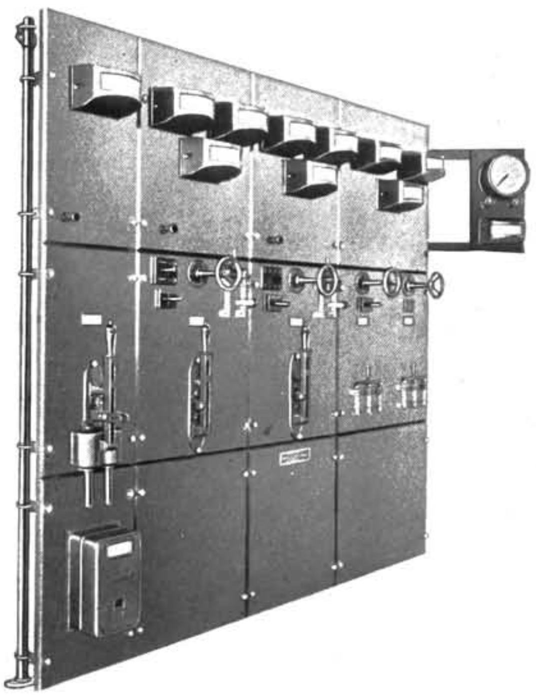
August, 1912

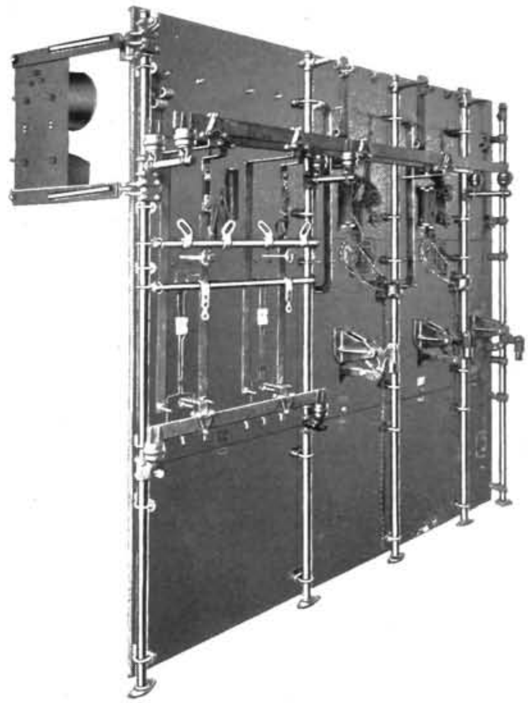
Bulletin No. 4996

ALTERNATING CURRENT SWITCHBOARD PANELS
With Oil Switches on Pipe Framework Back of Panel

THREE-PHASE THREE-WIRE
240, 480 AND 600 VOLTS—25 TO 60 CYCLES

90 INCHES HIGH





This bulletin contains a number of references to other publications. Information regarding the matters thus referred to may be obtained from any local office of the General Electric Company.

GENERAL INFORMATION

These panels are designed for general use in central stations and isolated plants, and are extensively used in mills and factories. They are for use with one set of busbars to which all generators and feeders are connected by means of single-throw oil switches, suitable provision being made for the parallel operation of generators.

Instruments, meters and oil switch trip coils have secondary current windings operated from current transformers included with the panels. All apparatus, excepting TA regulators, has primary potential windings.

The instruments, meters, oil switches, etc., furnished with these panels are of the General Electric Company's highest grade, and sufficient information regarding them is given under the "Equipment" of the panels to enable the reader to refer to the various bulletins which contain detailed description.

VOLTAGE

All panels may be used for either 240, 480 or 600 volt circuits. Since instruments and meters having potential windings require different resistances for the three voltages, it is essential that the voltage of the circuit to be controlled be given with the order. Unless otherwise ordered panels will be furnished for 600 volts.

FREQUENCY

All panels may with slight modifications be used on any frequency from 25 to 60 cycles, but the frequency must be given with the order. Unless otherwise ordered panels will be furnished for 60 cycles.

MATERIAL OF PANELS

All sections are oiled natural black slate 1½ in. thick, with ⅜ in. bevel, when used with switches not over 800 amps., above 800 amps. panels are 2 in. thick. Panels of different thickness in a switchboard are arranged to line up on the front. When it is desired to line up the backs of panels, 2 in. panels should be ordered in place of 1½ in. Blue Vermont Marble, Black Enameled Slate, or panels 2 in. thick may be substituted at increased prices which may be obtained from any office of the General Electric Company.

FRAMEWORK

A complete supporting framework of 1¼ in. pipe with necessary fittings is included with each panel as shown in switchboard arrangements in rear of bulletin.

SILL

A wooden sill for supporting the switchboard 2 in. from the floor is recommended for all installations. (See Switchboard Arrangements.) This sill is not furnished by the General Electric Company.

BUSES

Suitable insulating supports for alternating current and exciter buses are furnished with these panels. Buses will be located as shown on the Switchboard Arrangements.

Owing to the varying amounts of busbar copper which may be required for a given panel, it is impossible to include with these panels a *fixed* amount which would not be too great for some cases and too small for others. *All panels are, therefore, listed without copper for buses* and the latter must be ordered by Cat. No. from the busbar tables on another page.

Busbars carrying more than 5200 amperes per leg require special consideration and are not listed; all such cases should be referred to the General Office for recommendations.

CONNECTIONS

Each panel is furnished complete with bare connections from oil switches to buses, necessary small wiring on back of panel, primary leads (not exceeding 15 ft. in length) for potential transformers, and multi-conductor cable (not exceeding 25 ft. in length) for secondary connections from both the current and potential transformers to the terminal blocks on the panel.

It will be noted from the diagrams of connections for the various panels that each panel is so wired on the back that secondary leads from current transformers may be brought to the panel either from above or from below, and that suitable terminal blocks are provided for attaching these leads to the panel. The terminal blocks have suitable terminals and links for the insertion of calibrating instruments while the panel is in service.

The Switchboard Arrangements on the pages in rear of this bulletin show the main connections and supports for same which are to be furnished by the purchaser. When generator panels with governor control switches are ordered, the purchaser must furnish the necessary control leads from the panel to the governor.

INSTRUMENT EQUIPMENTS

Alternative instrument equipments are provided for both generator and feeder panels in order that suitable combinations may be available for any of the usual load conditions.

INSTRUMENT EQUIPMENTS (Cont'd)

For **Generator Panels** the following are recommended:

(a) For ordinary balanced power loads	*One* A.C. Ammeter, *One* A.C. Voltmeter, *One* D.C. Field Ammeter, for units 500 kw. and above, *One* A.C. Indicating Wattmeter.
(b) For unbalanced loads	*One* A.C. Ammeter, *One* Ammeter Switch, *One* A.C. Voltmeter, *One* D.C. Field Ammeter, *One* A.C. Indicating Wattmeter.

With combination (b) an eight-point receptacle is furnished on the middle section to allow voltage readings on all three phases.

Indicating wattmeters are important as it is not possible to determine by any other means the division of load between two generators operating in parallel. The ammeters do not differentiate between the idle current and the line current from the machines.

Field ammeters are useful, but not absolutely necessary when the panel is equipped with an indicating wattmeter. They serve as a check on the generator in case of trouble and are invaluable at times of testing for trouble.

For **Feeder Panels** it is customary to use:

One ammeter and ammeter switch for three-phase lighting.

One ammeter for three-phase power. If indicating wattmeters are not used on the generator panels, it will generally be advisable to use them on three-phase power feeders instead of ammeters.

METER EQUIPMENTS

Watthour meters are listed for both generator and feeder panels. Except where it is necessary to meter certain feeders, *generator watthour meters are recommended* in preference to feeder watthour meters as the former operate at better load factors and are not subject to changes in capacity.

OIL SWITCH EQUIPMENT

All panels are equipped with single-throw oil switches mounted on pipe supports back of the panel. Panels with switches greater than 2000 amp. capacity are not listed; when the same are required the matter should be referred to the General Office of the Company for recommendations.

The illustrations in the body of this bulletin, show operating mechanisms for Type K5 oil switches only. The mechanisms furnished with Type K12 oil switches are illustrated on page 6.

RELAYS

Relays are not required on any of these panels excepting when an indicating wattmeter or a watthour meter and an automatic oil switch are operated from the same current transformers. However, *time limit relays* are listed for all panels having automatic switches, both for the purpose of securing *greater oil switch rupturing capacity* when required, and for use on circuits subject to heavy *momentary overloads.*

RATINGS OF GENERATOR PANELS

The ampere ratings given for generator panels are the maximum currents which they are designed to carry for one or two hours, the corresponding kilowatt ratings being the normal capacity of the largest machines with which the panels may be used. The kilowatt ratings given are based on *unity power-factor* and overloads of 25 per cent. for one or two hours and 65 per cent. momentarily. For overloads of 50 per cent. for one or two hours and 100 per cent. momentarily multiply the normal kilowatt rating of the generator by 1.2 and select a panel having a kilowatt rating at least equal to product thus obtained.

RATINGS OF INDUCTION MOTOR PANELS

The apparent efficiency of an induction motor of given horse power and voltage varies somewhat with the speed for which the motor is designed, so that panels having a given ampere rating cannot be given a corresponding horse power rating which will be correct for all speeds. Panels listed herein which are intended for controlling induction motors are, therefore, rated in amperes only, the ratings given being the maximum current (other than momentary) which they are designed to carry. The ampere capacity of the panel required for a given motor may be determined by the following formula:

For motors with 25 per cent. overload guarantee:

Ampere Capacity of Panel

$$= \frac{\text{H.P.} \times 0.746 \times 1000 \times 1.25}{1.73 \times \text{volts} \times \text{efficiency} \times \text{power-factor}}$$

$$= \frac{\text{H.P.} \times 539}{\text{volts} \times \text{efficiency} \times \text{power-factor}}$$

RATINGS OF FEEDER PANELS

The ampere ratings given for feeder panels are the maximum currents (normal or overload other than momentary) which they are designed to carry. *Panels of larger capacity than necessary* should not as a rule be chosen in order to provide for a possible future increase of load, since the consequent low

RATINGS OF FEEDER PANELS (Cont'd)

load factor of the current transformers has an injurious effect on the accuracy of the instruments and meters; furthermore the overload feature on the oil switches is rendered inoperative except on short circuits and extremely heavy overloads due to the very high ratio of the current transformers as compared with the normal load of the circuit to be controlled.

RUPTURING CAPACITY OF OIL SWITCHES

The following table defines safe limits for the *average* installation.

It is obviously impossible to absolutely define limits of capacity applicable for all conditions since the design of generators, line conditions, and operating requirements vary widely for different installations.

Conditions such as the following may, singly or in combination, make it necessary to use a switch of greater bus capacity than the table would indicate, especially when the bus capacity of the station is near the limit given for the switch, and the switch is connected directly to the bus.

(1) Where continuity of service is of prime importance.

(2) Where line or service conditions are unusually severe.

The term "maximum bus capacity" refers to the aggregate kv-a. capacity (including overloads of one hour or more duration) of all sources of power directly feeding into the buses to which the oil switch is connected.

The following table gives the maximum kv-a. capacity of the buses to which the oil switches included with these panels may be connected and at the same time, afford protection under short circuit conditions to the machine or circuit for which the switch is used:

Class A Systems. All systems excepting those in Class B.

Class B Systems. Systems in which one or more generating units are turbo driven, and where the reactance of each generator and its connections to the buses is less than 8 per cent.

Ampere Rating of Oil Switch	MAXIMUM KV-A. BUS CAPACITY, INCLUDING OVERLOADS OF ONE HOUR OR MORE			
	Non-Automatic or Automatic with Time Limit Set for not Less than 2 Seconds		Automatic (Instantaneous)	
	For Class A Systems	For Class B Systems	For Class A Systems	For Class B Systems
200, 300, 500	11000	9000	5600	3000
800	21000	17000	11000	5600
1200, 1500, 2000	17000	13500	8800	4600

RHEOSTAT MECHANISM

Generator panels with concentric rheostat mechanism are provided with adjustable supports for mounting the exciter field rheostat directly behind panel. These supports are adjustable both vertically and horizontally, thus allowing considerable range in the dimensions of the rheostat, but the panels cannot be modified to meet special dimensions for rheostats not manufactured by the General Electric Company without an additional charge being made.

INFORMATION WHICH SHOULD ACCOMPANY ORDERS

Delay in shipment and dissatisfaction on the part of the purchaser will often be avoided if the order is accompanied by as much of the following information as pertains to the panel or panels ordered.

GENERAL

1. **Order of Panels**—Preferably in the form of a rough sketch including *existing*, *blank* and *new panels*, and also showing any open spaces. See Fig. 1, Page 42 for recommended arrangement.
2. **If Existing Panels are to be Matched** give serial numbers of same if of General Electric manufacture, otherwise give brief description preferably in form of sketch showing location of apparatus and bolts on front of panels, location and size of busbars, location of oil switches, etc.
3. **Ultimate Total Capacity of Station**—If power is received from an outside source, do conditions exist such as outlined under "Rupturing Capacity of Oil Switches?"
4. **Available Space** behind and above switchboard, also height of basement, if any.

GENERATOR PANELS

1. **Rating of Generators** including voltage, normal load, one or two hour overload, frequency, power-factor and maximum excitation.
2. **Location of Rheostats**—All of these panels are designed for chain operated generator field rheostats. Which of the rheostat locations shown on pages in rear of this bulletin is desired?
3. **Main Cables**—Are they to be brought to oil switches from above or from below?

FEEDER PANELS

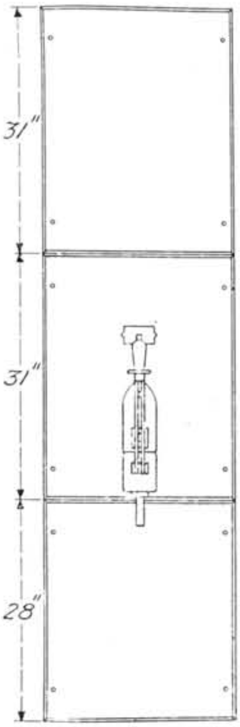
1. **Main Cables**—Are they to be brought to oil switches from above or from below?
2. **Voltage** of circuit to be controlled.
3. **Normal Ampere Load of Circuits** to be controlled. —See "Rating of Feeder Panels" on a preceding page.

INDUCTION MOTOR PANELS

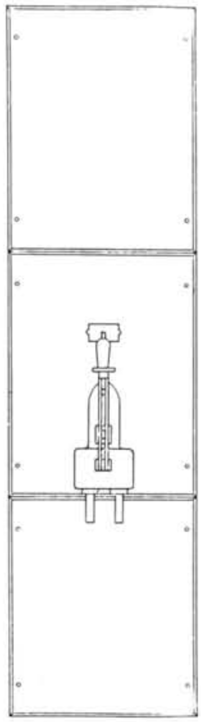
1. **Main Cables**—Are they to be brought to oil switches from above or from below?
2. **Rating of Motor** including voltage, normal and overload horse power rating, power-factor and efficiency.
3. **Method of Starting Motor.**

TA REGULATOR PANELS

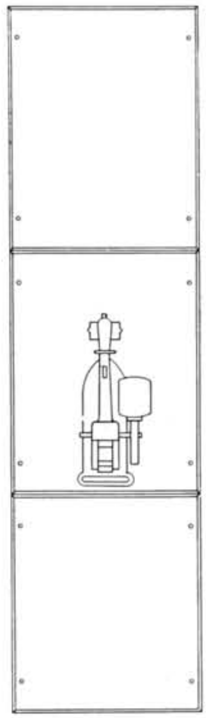
1. Fill out and attach special Regulator Information Blank.
2. If a current transformer is used for compensating for line drop specify where same is to be connected.



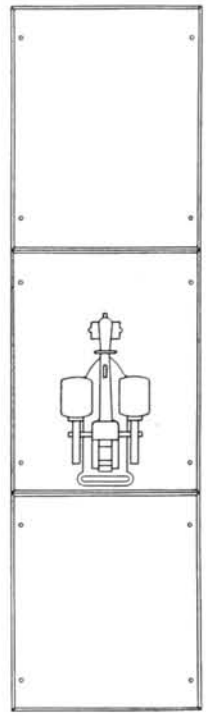
Operating Lever
for
800 Ampere Switch
with Single Trip Coil



Operating Lever
for
800 Ampere Switch
with Two Trip Coils



Operating Lever
for
1200, 1500 or 2000 Ampere
Switch with Single Trip Coil



Operating Lever
for
1200, 1500 or 2000 Ampere
Switch with Two Trip Coils

THREE-PHASE GENERATOR PANELS

240 VOLTS—22 TO 650 KILOWATTS
480 VOLTS—44 TO 1300 KILOWATTS
600 VOLTS—55 TO 1650 KILOWATTS

IMPORTANT—NOTE BEFORE ORDERING

1. Do not forget "Information which should accompany orders"—see page 5.
2. Always consider carefully the question of "Oil Switch Rupturing Capacity" in order to determine if panels are suitable for future as well as present requirements.
3. Note that kilowatt ratings are based on *unity* power-factor; also that unless otherwise ordered panels will be furnished for 600 volts and 60 cycles. See VOLTAGE, FREQUENCY and RATING OF GENERATOR PANELS in General Information.
4. The generator field rheostats used with these panels must be arranged for chain and sprocket control, and the exciter field rheostats must all be suitable for mounting directly behind the panel. See Switchboard Arrangements.
5. **Exciter Panels** are listed in S 413 and should be used whenever the exciters are to be connected to a bus for use with one or more generators.

   When TA regulators are used, all exciters must be paralleled and exciter panels are therefore necessary.
6. **Rheostat Mechanism**—Use *Concentric Rheostat Mechanism* (for operating both the generator and exciter field rheostats) when generators have individual exciters and exciter panels are not required.

   Use *Chain Rheostat Mechanism* (for operating generator field rheostat only) when generators are excited from an exciter bus or other common source.
7. One **D.P.D.T. Governor Control Switch** Cat. No. 108907 should be ordered in addition to the generator panel whenever the generator is equipped with a motor-operated governor.
8. **Synchronizing Equipment**—*One* of the following equipments should be ordered for the entire switchboard, if two or more generators are to be operated in parallel. Equipment B is necessary only when exciter panels are used and the same are not equipped with voltmeters.

Equipment A

240 Volts

One—Swinging bracket containing:
- *One*—240 volt....cycle synchronism indicator.
- *Two*—Synchronizing lamp receptacles and lamps.

Two—6 point synchronizing plugs.

480 or 600 Volts

One—Swinging bracket containing:
- *One*—110 volt....cycle synchronism indicator.
- *Two*—Synchronizing lamp receptacles.
- *Two*—440 (or 550)/110 volt 50 watt potential transformers with fuses.

Two—6 point synchronizing plugs.

Equipment B

240 Volts

One—Swinging bracket containing:
- *One*—240 volt....cycle synchronism indicator.
- *Two*—Synchronizing lamp receptacles and lamps.
- *One*—150 volt exciter voltmeter Type DH2.

Two—6 point synchronizing plugs.
One—4 point potential plug.

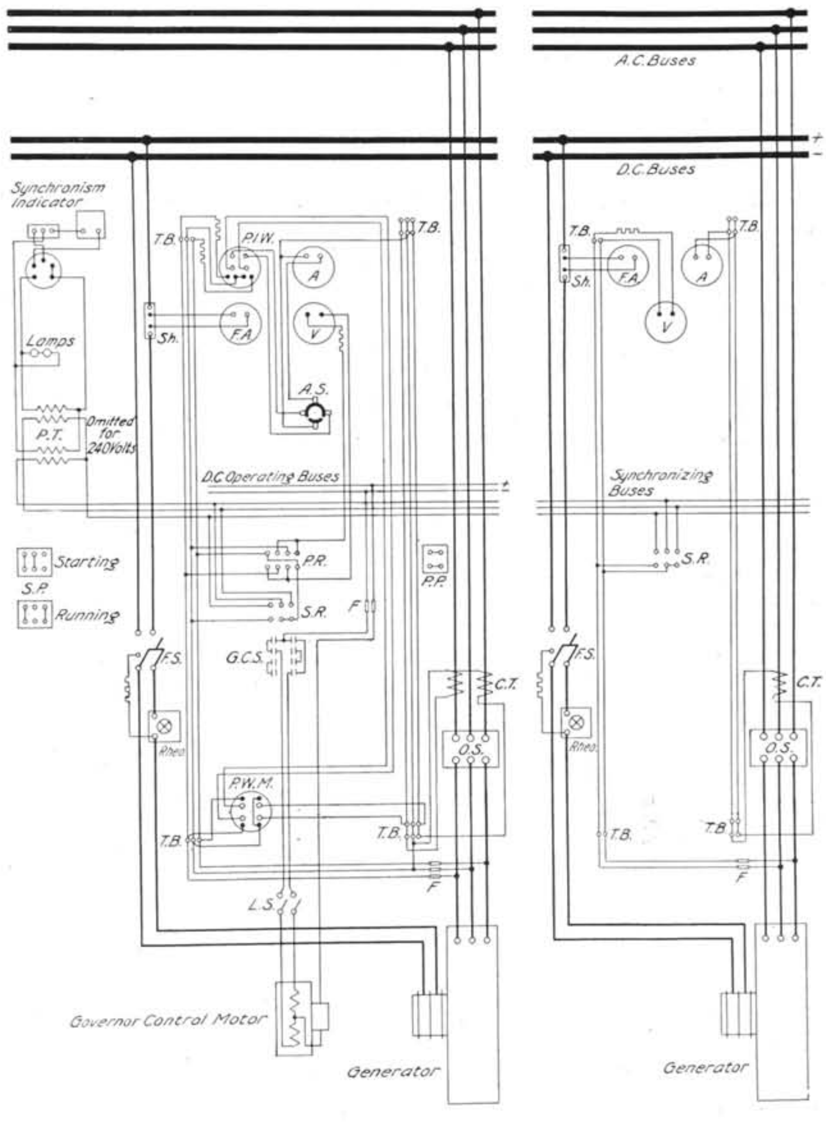
480 or 600 Volts

One—Swinging bracket containing:
- *One*—110 volt....cycle synchronism indicator.
- *Two*—Synchronizing lamp receptacles.
- *One*—150 volt exciter voltmeter Type DH2.

Two—440 (or 550)/110 volt 50 watt potential transformers with fuses.
Two—6 point synchronizing plugs.
One—4 point potential plug.

		25 Cycles	40 Cycles	60 Cycles
Equipment A	240 volts	Cat. No. 59718	Cat. No. 59719	Cat. No. 59720
	480 volts	Cat. No. 134907	Cat. No. 134908	Cat. No. 134909
	600 volts	Cat. No. 134910	Cat. No. 134911	Cat. No. 134912
Equipment B	240 volts	Cat. No. 104228	Cat. No. 104229	Cat. No. 104230
	480 volts	Cat. No. 134913	Cat. No. 134914	Cat. No. 134915
	600 volts	Cat. No. 134916	Cat. No. 134917	Cat. No. 134918

DIAGRAMS OF CONNECTIONS FOR GENERATOR PANELS

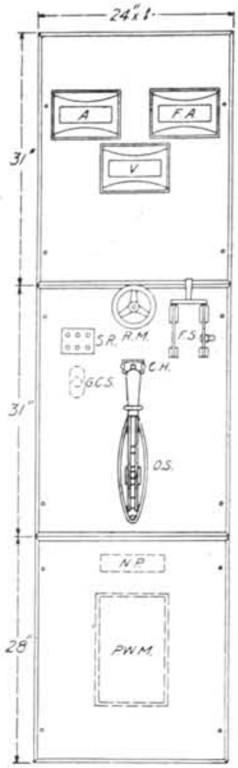


KEY TO SYMBOLS

A = Ammeter (A.C.).
A.S. = Three-way ammeter switch.
C.T. = Current transformer.
F = Fuse.
F.A. = Field ammeter (D.C.).
F.S. = Field switch.
G.C.S. = Governor control switch.
L.S. = Limit switch (included with governor motor).
O.S. = Oil switch.
P.I.W. = Polyphase indicating wattmeter.
P.W.M. = Polyphase watthour meter.
P.R. = Potential receptacle.
P.P. = Potential plug.
P.T. = Potential transformers.
Rheo. = Rheostat.
S = Shunt (only for 80 amp. and over).
S.R. = Synchronizing receptacle.
S.P. = Synchronizing plugs.
T.B. = Terminal board for instrument leads.
V = Voltmeter (A.C.).

GENERATOR PANELS

EQUIPMENT



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

(Current coils for A.C. instruments and meters are **secondary** for all panels.)

A = H.E. A.C. ammeter with ...... amp. scale.

F.A = DH-2 D.C. field ammeter with ...... amp. scale (scale to be given with order).

V = H.E. A.C. voltmeter with 750 volt scale.

R.M. = ... rheostat mechanism (chain or concentric). See page 7.

S.R. = 6 point synchronizing receptacle.

F.S. = D.P.S.T. 250 volt ...... amp. field switch with discharge clips. (Discharge resistance is not included.)

G.C.S. = Governor control switch—**not included** (when desired see page 7).

C.H. = Card holder.

O.S. = T.P.S.T. ...... amp. non-automatic Type ...... oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

...... current transformers ...... amp.

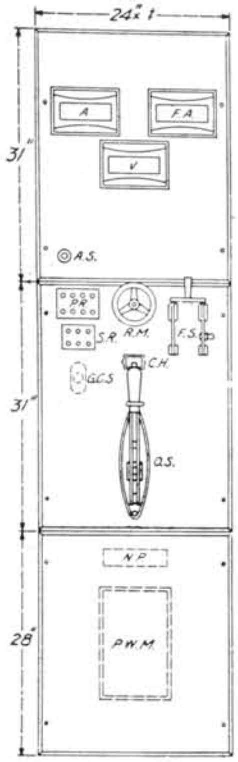
Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			AMPERE CAPACITY					No. of Current Trans-formers	CAT. NO.	
240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Trans-formers		With Chain Rheostat Mech.	With Concen-tric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER										
22	44	55	65	80	200	200	80	one	131200	131215
27.5	55	70	80	100	200	200	100	one	131201	131216
41.5	83	100	125	150	200	200	150	one	131202	131217
55	110	135	160	200	200	200	200	one	131203	131218
65	130	165	200	250	200	200	300	one	131204	131219
82.5	165	205	250	300	200	300	300	one	131205	131220
100	200	250	300	400	200	300	400	one	131206	131221
137.5	275	340	400	500	200	500	600	one	131207	131222
165	330	415	500	600	200	500	600	one	131208	131223
200	400	500	600	800	200	800	800	one	131209	131224
275	550	680	800	1000	200	800	1000	one	131210	131225
330	660	840	960	1200	300	1200	1500	one	131211	131226
415	830	1000	1200	1500	300	1200	1500	one	131212	131227
500	1000	1250	1500	2000	300	1500	2000	one	131213	131228
650	1300	1650	2000	2500	300	2000	3000	one	131214	131229
PANELS WITH WATTHOUR METER										
22	44	55	65	80	200	200	80	two	131230	131245
27.5	55	70	80	100	200	200	100	two	131231	131246
41.5	83	100	125	150	200	200	150	two	131232	131247
55	110	135	160	200	200	200	200	two	131233	131248
65	130	165	200	250	200	200	300	two	131234	131249
82.5	165	205	250	300	200	300	300	two	131235	131250
100	200	250	300	400	200	300	400	two	131236	131251
137.5	275	350	400	500	200	500	600	two	131237	131252
165	330	415	500	600	200	500	600	two	131238	131253
200	400	500	600	800	200	800	800	two	131239	131254
275	550	680	800	1000	200	800	1000	two	131240	131255
330	660	840	960	1200	300	1200	1500	two	131241	131256
415	830	1000	1200	1500	300	1200	1500	two	131242	131257
500	1000	1250	1500	2000	300	1500	2000	two	131243	131258
650	1300	1650	2000	2500	300	2000	3000	two	131244	131259

* See General Information, Page 2.

GENERATOR PANELS



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

EQUIPMENT

(Current coils for A.C. instruments and meters are **secondary** for all panels.)

A = H.E. A.C. ammeter with ...... amp. scale.

F.A. = DH-2 D.C. field ammeter with ...... amp. scale (scale to be given with order).

V = H.E. A.C. voltmeter with 750 volt scale.

A.S. = Three-way ammeter switch for connecting **A** in each phase.

R.M. = ... rheostat mechanism (chain or concentric). See page 7.

P.R. = 8 point potential receptacle with *one* 4 point plug.

S.R. = 6 point synchronizing receptacle.

F.S. = D.P.S.T. 250 volt ...... amp. field switch with discharge clips. (Discharge resistance is not included.)

G.C.S. = Governor control switch—**not included** (when desired see page 7).

C.H. = Card holder.

O.S. = T.P.S.T. ...... amp. non-automatic Type ...... oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers ...... amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			AMPERE CAPACITY					CAT. NO.	
240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Transformers	With Chain Rheostat Mech.	With Concentric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER									
22	44	55	65	80	200	200	80	131260	131275
27.5	55	70	80	100	200	200	100	131261	131276
41.5	83	100	125	150	200	200	150	131262	131277
55	110	135	160	200	200	200	200	131263	131278
65	130	165	200	250	200	200	300	131264	131279
82.5	165	205	250	300	200	300	300	131265	131280
100	200	250	300	400	200	300	400	131266	131281
137.5	275	340	400	500	200	500	600	131267	131282
165	330	415	500	600	200	500	600	131268	131283
200	400	500	600	800	200	800	800	131269	131284
275	550	680	800	1000	200	800	1000	131270	131285
330	660	840	960	1200	300	1200	1500	131271	131286
415	830	1000	1200	1500	300	1200	1500	131272	131287
500	1000	1250	1500	2000	300	1500	2000	131273	131288
650	1300	1650	2000	2500	300	2000	3000	131274	131289
PANELS WITH WATTHOUR METER									
22	44	55	65	80	200	200	80	131290	131305
27.5	55	70	80	100	200	200	100	131291	131306
41.5	83	100	125	150	200	200	150	131292	131307
55	110	135	160	200	200	200	200	131293	131308
65	130	165	200	250	200	200	300	131294	131309
82.5	165	205	250	300	200	300	300	131295	131310
100	200	250	300	400	200	300	400	131296	131311
137.5	275	340	400	500	200	500	600	131297	131312
165	330	415	500	600	200	500	600	131298	131313
200	400	500	600	800	200	800	800	131299	131314
275	550	680	800	1000	200	800	1000	131300	131315
330	660	840	960	1200	300	1200	1500	131301	131316
415	830	1000	1200	1500	300	1200	1500	131302	131317
500	1000	1250	1500	2000	300	1500	2000	131303	131318
650	1300	1650	2000	2500	300	2000	3000	131304	131319

* See General Information, Page 2.

GENERATOR PANELS

EQUIPMENT

(Current coils for A.C. instruments and meters are **secondary** for all panels.)

A =H.E. A.C. ammeter with......**amp. scale.**

P.I.W. =H.E. polyphase indicating **wattmeter** with......kw. scale.

V =H.E. A.C. voltmeter with 750 **volt** scale.

R.M. =......rheostat mechanism (chain or concentric). See page 7.

S.R. =6 point synchronizing receptacle.

F.S. =D.P.S.T. 250 volt......amp. field switch with discharge clips. **(Discharge resistance is not included.)**

G.C.S. =Governor control switch—**not included** (when desired see page **7**).

C.H. =Card holder.

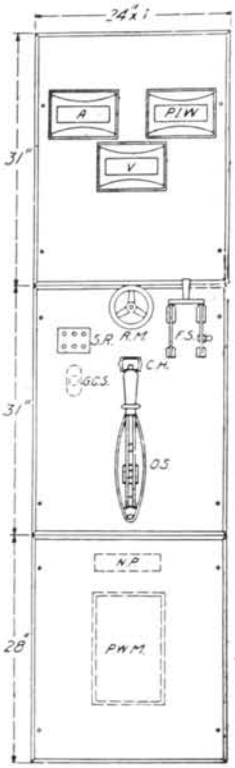
O.S. =T.P.S.T.......amp. non-automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. =Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) =Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

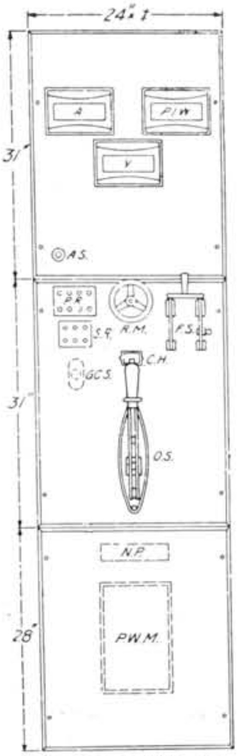
Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			P.I.W. SCALE IN KW.			AMPERE CAPACITY					CAT. NO.	
240 Volts	480 Volts	600 Volts	240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Transformers	With Chain Rheostat Mech.	With Concentric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131320	131335
27.5	55	70	40	80	100	80	100	200	200	100	131321	131336
41.5	83	100	70	125	150	125	150	200	200	150	131322	131337
55	110	135	100	175	200	160	200	200	200	200	131323	131338
65	130	165	100	200	250	200	250	200	200	300	131324	131339
82.5	165	205	150	250	300	250	300	200	300	300	131325	131340
100	200	250	175	350	400	300	400	200	300	400	131326	131341
137.5	275	340	200	400	500	400	500	200	500	600	131327	131342
165	330	415	250	500	600	500	600	200	500	600	131328	131343
200	400	500	350	700	800	600	800	200	800	800	131329	131344
275	550	680	400	800	1000	800	1000	200	800	1000	131330	131345
330	650	840	500	1000	1200	960	1200	300	1200	1500	131331	131346
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131332	131347
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131333	131348
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131334	131349
PANELS WITH WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131350	131365
27.5	55	70	40	80	100	80	100	200	200	100	131351	131366
41.5	83	100	70	125	150	125	150	200	200	150	131352	131367
55	110	135	100	175	200	160	200	200	200	200	131353	131368
65	130	165	100	200	250	200	250	200	200	300	131354	131369
82.5	165	205	150	250	300	250	300	200	300	300	131355	131370
100	200	250	175	350	400	300	400	200	300	400	131356	131371
137.5	275	340	200	400	500	400	500	200	500	600	131357	131372
165	330	415	250	500	600	500	600	200	500	600	131358	131373
200	400	500	350	700	800	600	800	200	800	800	131359	131374
275	550	680	400	800	1000	800	1000	200	800	1000	131360	131375
330	660	840	500	1000	1200	960	1200	300	1200	1500	131361	131376
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131362	131377
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131363	131378
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131364	131379

* See General Information, Page 2.

GENERATOR PANELS

EQUIPMENT



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

(Current coils for A.C. instruments and meters are **secondary** for all panels.)

A = H.E. A.C. ammeter with . . . . . . amp. scale.

P.I.W. = H.E. polyphase indicating wattmeter with . . . . . . kw. scale.

V = H.E. A.C. voltmeter with 750 volt scale.

A.S. = Three-way ammeter switch for connecting **A** in each phase.

R.M. = ... rheostat mechanism (chain or concentric). See page 7.

P.R. = 8 point potential receptacle with *one* 4 point plug.

S.R. = 6 point synchronizing receptacle.

F.S. = D.P.S.T. 250 volt . . . . . . amp. field switch with discharge clips. (Discharge resistance is not included.)

G.C.S. = Governor control switch—**not included** (when desired see page 7).

C.H. = Card holder.

O.S. = T.P.S.T. . . . . . . amp. non-automatic Type . . . . . . oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers . . . . . . amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			P.I.W. SCALE IN KW.			AMPERE CAPACITY					CAT. NO.	
240 Volts	480 Volts	600 Volts	240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Transformers	With Chain Rheostat Mech.	With Concentric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131380	131395
27.5	55	70	40	80	100	80	100	200	200	100	131381	131396
41.5	83	100	70	125	150	125	150	200	200	150	131382	131397
55	110	135	100	175	200	160	200	200	200	200	131383	131398
65	130	165	100	200	250	200	250	200	200	300	131384	131399
82.5	165	205	150	250	300	250	300	200	300	300	131385	131400
100	200	250	175	350	400	300	400	200	300	400	131386	131401
137.5	275	340	200	400	500	400	500	200	500	600	131387	131402
165	330	415	250	500	600	500	600	200	500	600	131388	131403
200	400	500	350	700	800	600	800	200	800	800	131389	131404
275	550	680	400	800	1000	800	1000	200	800	1000	131390	131405
330	660	840	500	1000	1200	960	1200	300	1200	1500	131391	131406
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131392	131407
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131393	131408
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131394	131409
PANELS WITH WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131410	131425
27.5	55	70	40	80	100	80	100	200	200	100	131411	131426
41.5	83	100	70	125	150	125	150	200	200	150	131412	131427
55	110	135	100	175	200	160	200	200	200	200	131413	131428
65	130	165	100	200	250	200	250	200	200	300	131414	131429
82.5	165	205	150	250	300	250	300	200	300	300	131415	131430
100	200	250	175	350	400	300	400	200	300	400	131416	131431
137.5	275	340	200	400	500	400	500	200	500	600	131417	131432
165	330	415	250	500	600	500	600	200	500	600	131418	131433
200	400	500	350	700	800	600	800	200	800	800	131419	131434
275	550	680	400	800	1000	800	1000	200	800	1000	131420	131435
330	660	840	500	1000	1200	960	1200	300	1200	1500	131421	131436
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131422	131437
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131423	131438
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131424	131439

* See General Information, Page 2.

GENERATOR PANELS

EQUIPMENT

Current coils for A.C. instruments and meters are **secondary** for all panels.)

A = H.E. A.C. ammeter with ...... amp. scale.

P.I.W. = H.E. polyphase indicating wattmeter with ...... kw scale.

V = H.E. A.C. voltmeter with 750 volt scale.

F.A. = DH-2 D.C. field ammeter with ...... amp. scale (scale to be given with order)

R.M. = ... rheostat mechanism (chain or concentric). See page 7.

S.R. = 6 point synchronizing receptacle.

F.S. = D.P.S.T. 250 volt ...... amp. field switch with discharge clips. (Discharge resistance is not included.)

G.C.S. = Governor control switch—**not included** (when desired see page 7).

C.H. = Card holder.

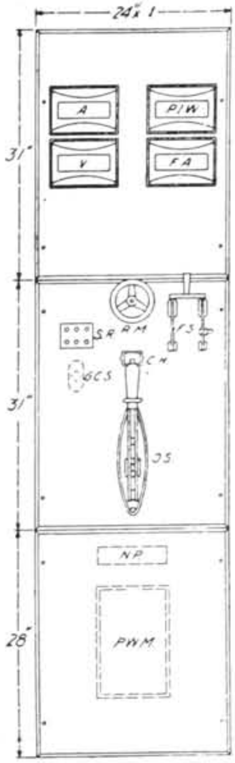
O.S. = T.P.S.T. ...... amp. non-automatic Type ...... oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers ...... amp.

Busbars must be ordered separately; see "Busbar Copper."



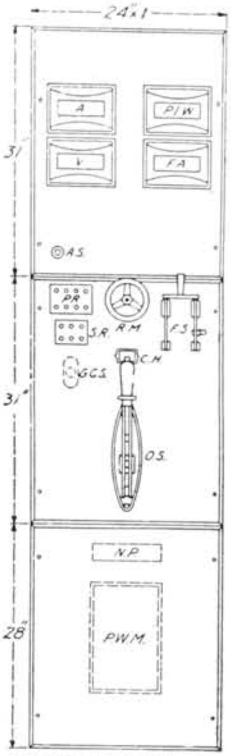
‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			P.I.W. SCALE IN KW.			AMPERE CAPACITY					CAT. NO.	
240 Volts	480 Volts	600 Volts	240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Transformers	With Chain Rheostat Mech.	With Concentric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131440	131455
27.5	55	70	40	80	100	80	100	200	200	100	131441	131456
41.5	83	100	70	150	150	125	150	200	200	150	131442	131457
55	110	135	100	175	200	160	200	200	200	200	131443	131458
65	130	165	100	200	250	200	250	200	200	300	131444	131459
82.5	165	205	150	250	300	250	300	200	300	300	131445	131460
100	200	250	175	350	400	300	400	200	300	400	131446	131461
137.5	275	340	200	400	500	400	500	200	500	600	131447	131462
165	330	415	250	500	600	500	600	200	500	600	131448	131463
200	400	500	350	700	800	600	800	200	800	800	131449	131464
275	550	680	400	800	1000	800	1000	200	800	1000	131450	131465
330	660	840	500	1000	1200	960	1200	300	1200	1500	131451	131466
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131452	131467
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131453	131468
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	31454	131469
PANELS WITH WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131470	131485
27.5	55	70	40	80	100	80	100	200	200	100	131471	131486
41.5	83	100	70	150	150	125	150	200	200	150	131472	131487
55	110	135	100	175	200	160	200	200	200	200	131473	131488
65	130	165	100	200	250	200	250	200	200	300	131474	131489
82.5	165	205	150	250	300	250	300	300	300	300	131475	131490
100	200	250	175	350	400	300	400	200	300	400	131476	131491
137.5	275	340	200	400	500	400	500	200	500	600	131477	131492
165	330	415	250	500	600	500	600	200	500	600	131478	131493
200	400	500	350	700	800	600	800	200	800	800	131479	131494
275	550	680	400	800	1000	800	1000	200	800	1000	131480	131495
330	660	840	500	1000	1200	960	1200	300	1200	1500	131481	131496
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131482	131497
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131483	131498
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131484	131499

* See General Information, Page 2.

GENERATOR PANELS



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

EQUIPMENT

(Current coils for A.C. instruments and meters are **secondary** for all panels.)

A = H.E. A.C. ammeter with...... amp. scale.

P.I.W. = H.E. polyphase indicating wattmeter with...... kw. scale.

V = H.E. A.C. voltmeter with 750 volt scale.

F.A. = DH-2 D.C. field ammeter with...... amp. scale (scale to be given with order).

A.S. = Three-way ammeter switch for connecting **A** in each phase.

R.M. = ... rheostat mechanism (chain or concentric). See page 7.

P.R. = 8 point potential receptacle with *one* 4 point plug.

S.R. = 6 point synchronizing receptacle.

F.S. = D.P.S.T. 250 volt...... amp. field switch with discharge clips. (Discharge resistance is not included.)

G.C.S. = Governor control switch—**not included** (when desired see page 7).

C.H. = Card holder.

O.S. = T.P.S.T....... amp. non-automatic Type ...... oil switch mounted on pipe framework back of panel, with operating mechanism. (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers...... amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

KW. OF GEN.			P.I.W. SCALE IN KW.			AMPERE CAPACITY					CAT. NO.	
240 Volts	480 Volts	600 Volts	240 Volts	480 Volts	600 Volts	Panel	Ammeter	Field Switch	Oil Switch	Current Transformers	With Chain Rheostat Mech.	With Concentric Rheostat Mech.
PANELS WITHOUT WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131500	131515
27.5	55	70	40	80	100	80	100	200	200	100	131501	131516
41.5	83	100	70	125	150	125	150	200	200	150	131502	131517
55	110	135	100	175	200	160	200	200	200	200	131503	131518
65	130	165	100	200	250	200	250	200	200	300	131504	131519
82.5	165	205	150	250	300	250	300	200	300	300	131505	131520
100	200	250	175	350	400	300	400	200	300	400	131506	131521
137.5	275	340	200	400	500	400	500	200	500	600	131507	131522
165	330	415	250	500	600	500	600	200	500	600	131508	131523
200	400	500	350	700	800	600	800	200	800	800	131509	131524
275	550	680	400	800	1000	800	1000	200	800	1000	131510	131525
330	660	840	500	1000	1200	960	1200	300	1200	1500	131511	131526
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131512	131527
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131513	131528
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131514	131529
PANELS WITH WATTHOUR METER												
22	44	55	35	70	80	65	80	200	200	80	131530	131545
27.5	55	70	40	80	100	80	100	200	200	100	131531	131546
41.5	83	100	70	125	150	125	150	200	200	150	131532	131547
55	110	135	100	175	200	160	200	200	200	200	131533	131548
65	130	165	100	200	250	200	250	200	200	300	131534	131549
82.5	165	205	150	250	300	250	300	200	300	300	131535	131550
100	200	250	175	350	400	300	400	200	300	400	131536	131551
137.5	275	340	200	400	500	400	500	200	500	600	131537	131552
165	330	415	250	500	600	500	600	200	500	600	131538	131553
200	400	500	350	700	800	600	800	200	800	800	131539	131554
275	550	680	400	800	1000	800	1000	200	800	1000	131540	131555
330	660	840	500	1000	1200	960	1200	300	1200	1500	131541	131556
415	830	1000	600	1500	1500	1200	1500	300	1200	1500	131542	131557
500	1000	1250	1000	1750	2000	1500	2000	300	1500	2000	131543	131558
650	1300	1650	1000	2000	2500	2000	2500	300	2000	3000	131544	131559

* See General Information, Page 2.

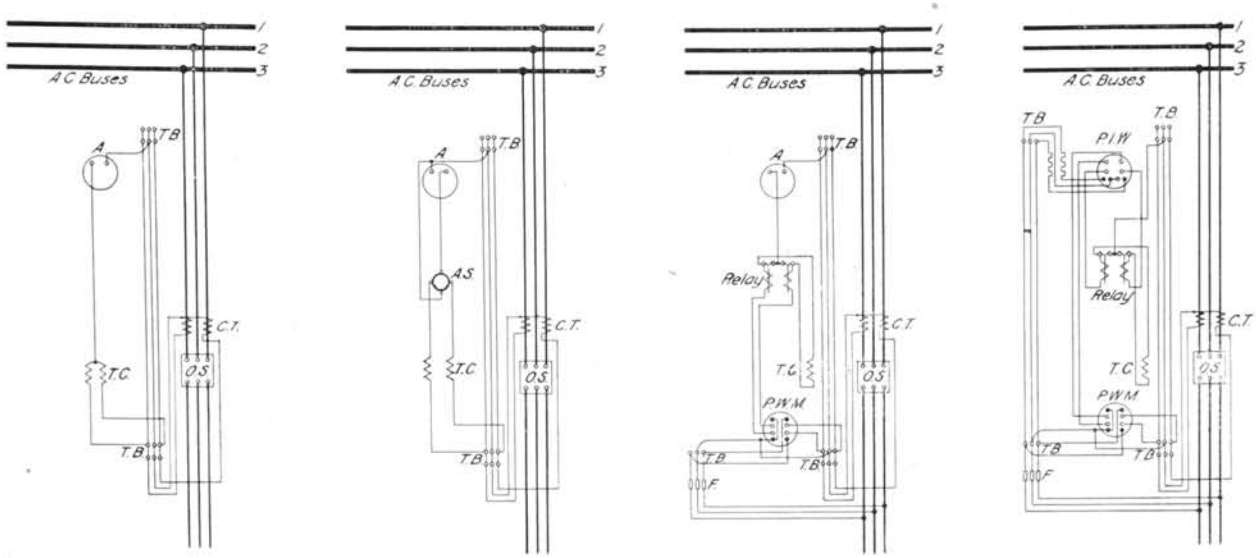
SINGLE-CIRCUIT
THREE-PHASE FEEDER PANELS

240, 480 AND 600 VOLTS
50 TO 2000 AMPERES

IMPORTANT—NOTE BEFORE ORDERING

1. Do not forget "Information which should accompany orders"—see page 5.
2. Avoid ordering *panels larger than necessary* for present requirements—See "Rating of Feeder Panels."
3. Always consider the question of "Oil Switch Rupturing Capacity" in order to determine if panels are suitable for future as well as present requirements.
4. Unless otherwise ordered panels will be furnished for 600 volts and 60 cycles. See *Voltage* and *Frequency* in General Information.
5. *Lightning Arresters* are not included with these panels.

DIAGRAMS OF CONNECTIONS FOR FEEDER PANELS



KEY TO SYMBOLS

A. = Ammeter.
A.S. = Three-way ammeter switch.
B.A.S. = Bell alarm switch.
C.T. = Current transformer.
F = Fuse.
O.S. = Oil switch.
P.I.W. = Polyphase indicating wattmeter.
P.W.M. = Polyphase watthour meter.
T.B. = Terminal board.
T.C. = Trip coils for oil switch.

SINGLE-CIRCUIT FEEDER PANELS WITH INSTANTANEOUS OIL SWITCH TRIP

EQUIPMENT

(Oil switch trip coils and current coils of watthour meter are **secondary** for all panels.)

I.R. = D.P. instantaneous overload relay (for Fig. 2 only).

C.H. = Card holder.

O.S. = T.P.S.T. . . . . . .amp. automatic Type. . . . . .oil switch mounted on pipe framework back of panel, with operating mechanism (double coil for Fig. 1 and single coil for Fig. 2). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt, Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers. . . . . .amp.

Busbars must be ordered separately; see "Busbar Copper."

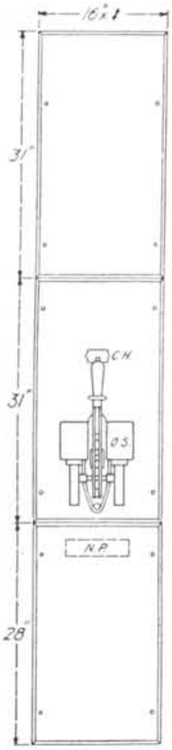


Fig. 1

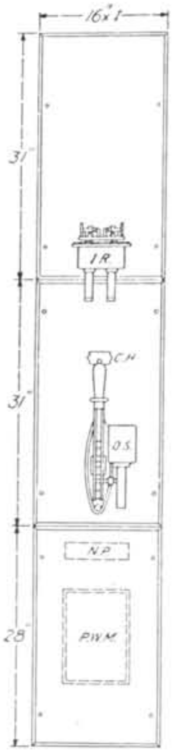


Fig. 2

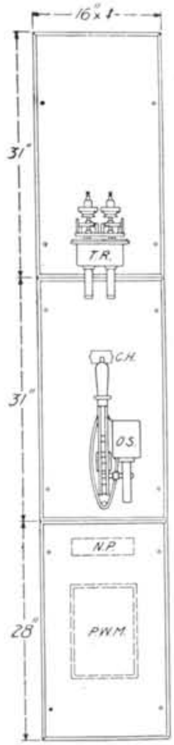
‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY			Fig. No.	Cat. No.
Panel	Oil Switch	Current Transformers		
PANELS WITHOUT WATTHOUR METER				
60	200	60	1	131560
80	200	80	1	131561
100	200	100	1	131562
150	200	150	1	131563
200	200	200	1	131564
300	300	300	1	131565
400	500	400	1	131566
500	500	600	1	131567
600	800	600	1	131568
800	800	800	1	131569
1200	1200	1500	1	131570
1500	1500	1500	1	131571
2000	2000	2000	1	131572
PANELS WITH WATTHOUR METER				
60	200	60	2	131573
80	200	80	2	131574
100	200	100	2	131575
150	200	150	2	131576
200	200	200	2	131577
250	300	300	2	131578
300	300	300	2	131579
400	500	400	2	131580
500	500	600	2	131581
600	800	600	2	131582
800	800	800	2	131583
1200	1200	1500	2	131584
1500	1500	1500	2	131585
2000	2000	2000	2	131586

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS WITH TIME LIMIT OIL SWITCH TRIP



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

EQUIPMENT

(Oil switch trip coil and current coils of watthour meter are **secondary** for all panels.)

T.R. = D.P. time limit overload relay.

C.H. = Card holder.

O.S. = T.P.S.T.......amp. automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism (one secondary coil). (200 amp. switches are 4500 volts; 300 and 500 amp. are 7500 volts Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY			CAT. NO.	
Panel	Oil Switch	Current Transformers	Without Watthour Meter	With Watthour Meter
60	200	60	131587	131601
80	200	80	131588	131602
100	200	100	131589	131603
150	200	150	131590	131604
200	200	200	131591	131605
250	300	300	131592	131606
300	300	300	131593	131607
400	500	400	131594	131608
500	500	600	131595	131609
600	800	600	131596	131610
800	800	800	131597	131611
1200	1200	1200	131598	131612
1500	1500	1500	131599	131613
2000	2000	2000	131600	131614

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS WITH INSTANTANEOUS OIL SWITCH TRIP

EQUIPMENT

Oil switch trip coils and current coils of ammeter and watthour meter are **secondary** for all panels.)

A =H.E. A.C. ammeter with......amp. scale.

I.R. =D.P. instantaneous overload relay (for Fig. 2 only .

C.H. =Card holder.

O.S. =T.P.S.T.......amp. automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism (double coil for Fig. 1 and single coil for Fig. 2). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. =Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) =Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

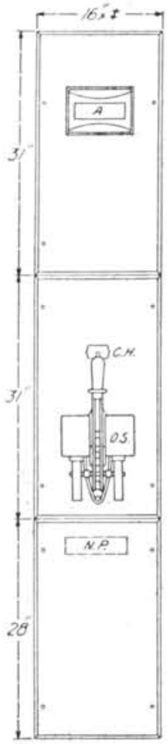


Fig. 1

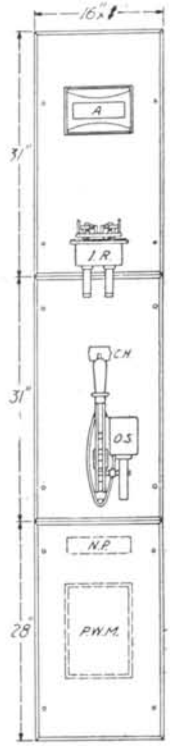


Fig. 2

‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

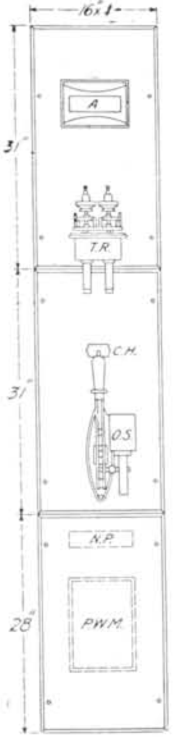
Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				Fig. No.	Cat. No.
Panel	Ammeter	Oil Switch	Current Transformers		
PANELS WITHOUT WATTHOUR METER					
80	100	200	100	1	131615
125	150	200	150	1	131616
160	200	200	200	1	131617
200	300	200	300	1	131618
250	300	300	300	1	131619
300	400	300	400	1	131620
400	500	500	600	1	131621
500	600	500	600	1	131622
600	800	800	800	1	131623
800	1000	800	1000	1	131624
1000	1200	1200	1500	1	131625
1200	1500	1200	1500	1	131626
1500	2000	1500	2000	1	131627
2000	2500	2000	3000	1	131628
PANELS WITH WATTHOUR METER					
80	100	200	100	2	131629
125	150	200	150	2	131630
160	200	200	200	2	131631
200	300	200	300	2	131632
250	300	300	300	2	131633
300	400	300	400	2	131634
400	500	500	600	2	131635
500	600	500	600	2	131636
600	800	800	800	2	131637
800	1000	800	1000	2	131638
1000	1200	1200	1500	2	131639
1200	1500	1200	1500	2	131640
1500	2000	1500	2000	2	131641
2000	2500	2000	3000	2	131642

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS WITH TIME LIMIT OIL SWITCH TRIP

EQUIPMENT



‡ Panels up to 800 amp., 1 ½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

(Oil switch trip coil and current coils of ammeter and watthour meter are **secondary** for all panels.)

A = H.E. A.C. ammeter with......amp. scale.

T.R. = D.P. time limit overload relay.

C.H. = Card holder.

O.S. = T.P.S.T.......amp. automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism (one secondary coil). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.) *

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				CAT. NO.	
Panel	Ammeter	Oil Switch	Current Transformers	Without Watthour Meter	With Watthour Meter
50	60	200	60	131643	131660
65	80	200	80	131644	131661
80	100	200	100	131645	131662
100	120	200	150	131646	131663
125	150	200	150	131647	131664
160	200	200	200	131648	131665
200	250	200	300	131649	131666
250	300	300	300	131650	131667
300	400	300	400	131651	131668
400	500	500	600	131652	131669
500	600	500	600	131653	131670
600	800	800	800	131654	131671
800	1000	800	1000	131655	131672
1000	1200	1200	1500	131656	131673
1200	1500	1200	1500	131657	131674
1500	2000	1500	2000	131658	131675
2000	2500	2000	3000	131659	131676

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS WITH INSTANTANEOUS OIL SWITCH TRIP

EQUIPMENT

(Oil switch trip coils and current coils of ammeter and watthour meter are **secondary** for all panels.)

A = H.E. A.C. ammeter with...... amp. scale.

A.S. = Three-way ammeter switch for connecting **A** in each phase.

I.R. = D.P. instantaneous overload relay (for Fig. 2 only).

C.H. = Card holder.

O.S. = T.P.S.T....... amp. automatic Type...... oil switch mounted on pipe framework back of panel, with operating mechanism (double coil for Fig. 1 and single coil for Fig. 2). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.)*

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers...... amp.

Busbars must be ordered separately; see "Busbar Copper."

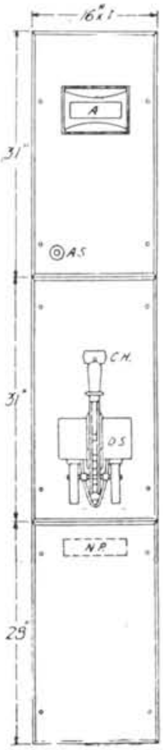


Fig. 1

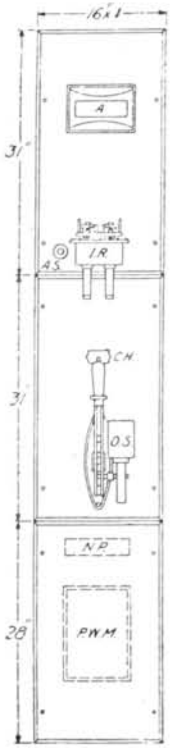


Fig. 2

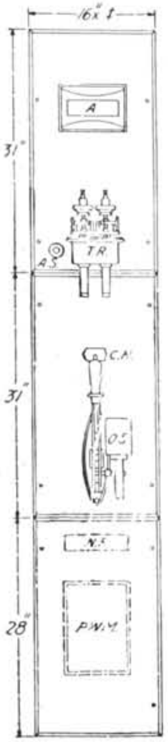
‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				Fig. No.	Cat. No.
Panel	Ammeter	Oil Switch	Current Transformers		
PANELS WITHOUT WATTHOUR METER					
80	100	200	100	1	131677
100	120	200	150	1	131678
125	150	200	150	1	131679
160	200	200	200	1	131680
200	250	200	300	1	131681
250	300	300	300	1	131682
300	400	300	400	1	131683
400	500	500	600	1	131684
500	600	500	600	1	131685
600	800	800	800	1	131686
800	1000	800	1000	1	131687
1000	1200	1200	1500	1	131688
1200	1500	1200	1500	1	131689
1500	2000	1500	2000	1	131690
2000	2500	2000	3000	1	131691
PANELS WITH WATTHOUR METER					
80	100	200	100	2	131692
125	150	200	150	2	131693
160	200	200	200	2	131694
200	250	200	300	2	131695
250	300	300	300	2	131696
300	400	300	400	2	131697
400	500	500	600	2	131698
500	600	500	600	2	131699
600	800	800	800	2	131700
800	1000	800	1000	2	131701
1000	1200	1200	1500	2	131702
1200	1500	1200	1500	2	131703
1500	2000	1500	2000	2	131704
2000	2500	2000	2000	2	131705

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS WITH TIME LIMIT OIL SWITCH TRIP



‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

EQUIPMENT

(Oil switch trip coil and current coils of ammeter and watthour meter are **secondary** for all panels.)

A = H.E. A.C. ammeter with......amp. scale.

A.S. = Three-way ammeter switch **for** connecting **A** in each phase.

T.R. = D.P. time limit overload relay.

C.H. = Card holder.

O.S. = T.P.S.T.......amp. automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism (one secondary coil). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.) *

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				CAT. NO.	
Panel	Ammeter	Oil Switch	Current Transformers	Without Watthour Meter	With Watthour Meter
50	60	200	60	131706	131723
65	80	200	80	131707	131724
80	100	200	100	131708	131725
100	120	200	150	131709	131726
125	150	200	150	131710	131727
160	200	200	200	131711	131728
200	250	200	300	131712	131729
250	300	300	300	131713	131730
300	400	300	400	131714	131731
400	500	500	600	131715	131732
500	600	500	600	131716	131733
600	800	800	800	131717	131734
800	1000	800	1000	131718	131735
1000	1200	1200	1500	131719	131736
1200	1500	1200	1500	131720	131737
1500	2000	1500	2000	131721	131738
2000	2500	2000	3000	131722	131739

* See General Information, Page 2.

SINGLE-CIRCUIT FEEDER PANELS
WITH INSTANTANEOUS OR TIME LIMIT OIL SWITCH TRIP

EQUIPMENT

(Oil switch trip coils and current coils of indicating wattmeter and watthour meter are secondary for all panels.)

P.I.W. = H.E. polyphase indicating wattmeter with......kw. scale.

I.R. = D.P. instantaneous overload relay (for Fig. 1 only).

T.R. = D.P. time limit overload relay (for Fig. 2 only).

C.H. = Card holder.

O.S. = T.P.S.T.......amp. automatic Type......oil switch mounted on pipe framework back of panel, with operating mechanism (double coil for Fig. 1 and single coil for Figs. 2 and 3). (200 amp. switches are 4500 volt; 300 and 500 amp. are 7500 volt Type K5; others are Type K12.) *

N.P. = Name plate (on only one panel in a complete switchboard).

P.W.M. (optional) = Polyphase watthour meter with metal cover, Type DS4.

Two current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

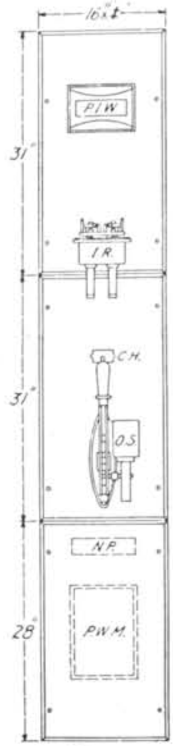


Fig. 1

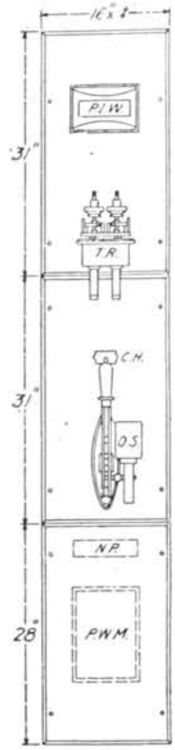


Fig. 2

‡ Panels up to 800 amp., 1½ in. thick.
‡ Panels above 800 amp., 2 in. thick.

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY			P.I.W. SCALE IN KW.			Fig. No.	CAT. NO.	
Panel	Oil Switch	Current Transformers	240 Volts	480 Volts	600 Volts		Without Watthour Meter	With Watthour Meter
PANELS WITH INSTANTANEOUS OIL SWITCH TRIP								
80	200	100	40	80	100	1	131740	131755
100	200	150	50	100	120	1	131741	131756
125	200	150	70	125	150	1	131742	131757
160	200	200	100	175	200	1	131743	131758
200	200	300	100	200	250	1	131744	131759
250	300	300	150	250	300	1	131745	131760
300	300	400	175	350	400	1	131746	131761
400	500	600	200	400	500	1	131747	131762
500	500	600	250	500	600	1	131748	131763
600	800	800	350	700	800	1	131749	131764
800	800	1000	400	800	1000	1	131750	131765
1000	1200	1500	500	1000	1200	1	131751	131766
1200	1200	1500	600	1500	1500	1	131752	131767
1500	1500	2000	1000	1750	2000	1	131753	131768
2000	2000	3000	1000	2000	2500	1	131754	131769
PANELS WITH TIME LIMIT OIL SWITCH TRIP								
80	200	100	40	80	100	2	131770	131785
100	200	150	50	100	120	2	131771	131786
125	200	150	70	125	150	2	131772	131787
160	200	200	100	175	200	2	131773	131788
200	200	300	100	200	250	2	131774	131789
250	300	300	150	250	300	2	131775	131790
300	300	400	175	350	400	2	131776	131791
400	500	600	200	400	500	2	131777	131792
500	500	600	250	500	600	2	131778	131793
600	800	800	350	700	800	2	131779	131794
800	800	1000	400	800	1000	2	131780	131795
1000	1200	1500	500	1000	1200	2	131781	131796
1200	1200	1500	600	1500	1500	2	131782	131797
1500	1500	2000	1000	1750	2000	2	131783	131798
2000	2000	3000	1000	2000	2500	2	131784	131799

* See General Information, Page 2.

DOUBLE-CIRCUIT
THREE-PHASE FEEDER PANELS

240, 480 AND 600 VOLTS
8 TO 200 AMPERES PER CIRCUIT

The panels listed are for controlling two circuits of equal capacity, the panel rating being the total ampere capacity of the two circuits. If so ordered, any panel will be furnished with an equipment suitable for two circuits of different capacities providing the ampere capacity of either circuit does not exceed 200 amperes.

DIAGRAM OF CONNECTIONS

For double-circuit panels use two duplicate diagrams as shown for single-circuit panels, page 16.

IMPORTANT—NOTE BEFORE ORDERING

1. Do not forget "Information which should accompany orders"—see page 5.
2. Avoid ordering *panels of larger capacity than necessary* for present requirements, for reasons given under "Rating of Feeder Panels."
3. Always consider carefully the question of "Oil Switch Rupturing Capacity" in order to determine if panels are suitable for future as well as present requirements.
4. Unless otherwise ordered, panels will be furnished for 600 volts and 60 cycles. See *Voltage* and *Frequency* in General Information.
5. *Lightning Arresters* are not included with these panels.

DOUBLE-CIRCUIT FEEDER PANELS

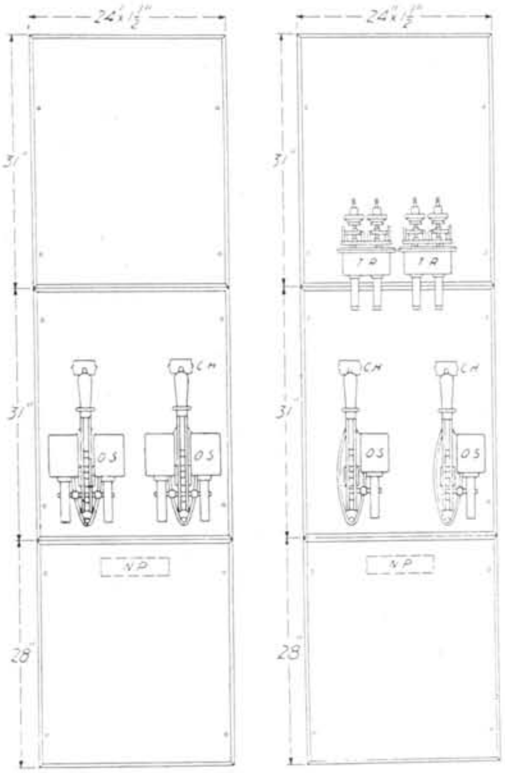


Fig. 1 Fig. 2

EQUIPMENT

(Oil switch trip coils are **secondary** for all panels.)

T.R. = *Two* D.P. time limit overload relays (for Fig. 2 only).

C.H. = *Two* card holders.

O.S. = *Two* T.P.S.T. 200 amp. automatic K5 oil switches mounted on pipe framework back of panel, each with operating mechanism (double coil for Fig. 1 and single coil for Fig. 2).

N.P. = Name plate (on only one panel in a complete switchboard).

Four current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

AMPERE CAPACITY		CAT. NO.	
Panel	Current Transformers	With Instantaneous Oil Switch Trip Fig. 1	With Time Limit Oil Switch Trip Fig. 2
16	10	131800	131811
24	15	131801	131812
32	20	131802	131813
50	30	131803	131814
60	40	131804	131815
100	60	131805	131816
130	80	131806	131817
160	100	131807	131818
250	150	131808	131819
320	200	131809	131820
400	300	131810	131821

DOUBLE-CIRCUIT FEEDER PANELS

EQUIPMENT

(Oil switch trip coils and current coils of ammeters are **secondary** for all panels.)

A = *Two* H.E. A.C. ammeters with......amp. scale.

T.R. = *Two* D.P. time limit overload relays (for Fig. 2 only).

C.H. = *Two* card holders.

O.S. = *Two* T.P.S.T. 200 amp. automatic K5 oil switches mounted on pipe framework back of panel, each operating mechanism (double coil for Fig. 1 and single coil for Fig. 2).

N.P. = Name plate (on only one panel in a complete switchboard).

Four current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

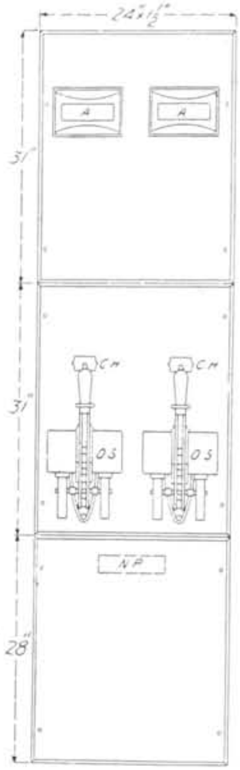


Fig. 1

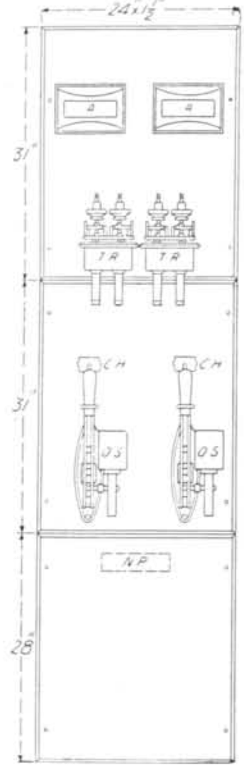


Fig. 2

AMPERE CAPACITY			CAT. NO.	
Panel	Ammeters	Current Transformers	With Instantaneous Oil Switch Trip Fig. 1	With Time Limit Oil Switch Trip Fig. 2
16	10	10	131822	131837
20	12	15	131823	131838
24	15	15	131824	131839
32	20	20	131825	131840
40	25	30	131826	131841
50	30	30	131827	131842
60	40	40	131828	131843
80	50	60	131829	131844
100	60	60	131830	131845
130	80	80	131831	131846
160	100	100	131832	131847
200	120	150	131833	131848
250	150	150	131834	131849
320	200	200	131835	131850
400	250	300	131836	131851

DOUBLE-CIRCUIT FEEDER PANELS

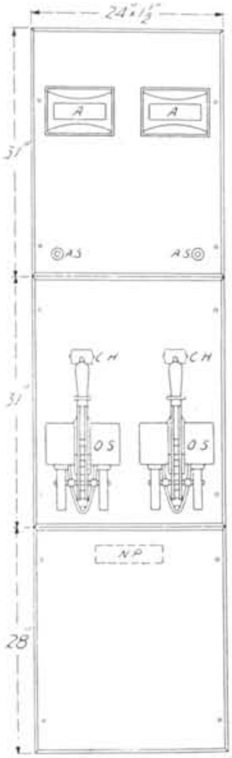


Fig. 1

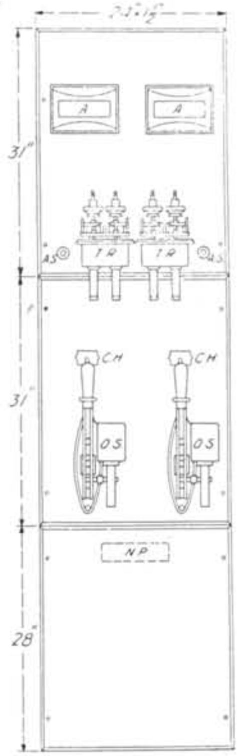


Fig. 2

EQUIPMENT

(Oil switch trip coils and current coils of ammeters are **secondary** for all panels.)

A = *Two* H.E. A.C. ammeters with......amp. scale.

A.S. = *Two* three-way ammeter switches for connecting **A** in each phase.

T.R. = *Two* D.P. time limit overload relays (for Fig. 2 only).

C.H. = *Two* card holders.

O.S. = *Two* T.P.S.T. 200 amp. automatic K5 oil switches mounted on pipe framework back of panel, each operating mechanism (double coil for Fig. 1 and single coil for Fig. 2).

N.P. = Name plate (on only one panel in a complete switchboard).

Four current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

AMPERE CAPACITY			CAT. NO.	
Panel	Ammeters	Current Transformers	With Instantaneous Oil Switch Trip Fig. 1	With Time Limit Oil Switch Trip Fig. 2
16	10	10	131852	131867
20	12	15	131853	131868
24	15	15	131854	131869
32	20	20	131855	131870
40	25	30	131856	131871
50	30	30	131857	131872
60	40	40	131858	131873
80	50	60	131859	131874
100	60	60	131860	131875
130	80	80	131861	131876
160	100	100	131862	131877
200	120	150	131863	131878
250	150	150	131864	131879
320	200	200	131865	131880
400	250	300	131866	131881

DOUBLE-CIRCUIT FEEDER PANELS

EQUIPMENT

(Oil switch trip coils and current coils of wattmeters are **secondary** for all panels.)

P.I.W. = *Two* H.E. polyphase indicating wattmeters with......kw. scale.

I.R. = *Two* D.P. instantaneous overload relays (for Fig. 1 only).

T.R. = *Two* D.P. time limit overload relays (for Fig. 2 only).

C.H. = *Two* card holders.

O.S. = *Two* T.P.S.T. 200 amp. automatic K5 oil switches mounted on pipe framework back of panel, each with operating mechanism (single coil).

N.P. = Name plate (on only one panel in a complete switchboard).

Four current transformers......amp.

Busbars must be ordered separately; see "Busbar Copper."

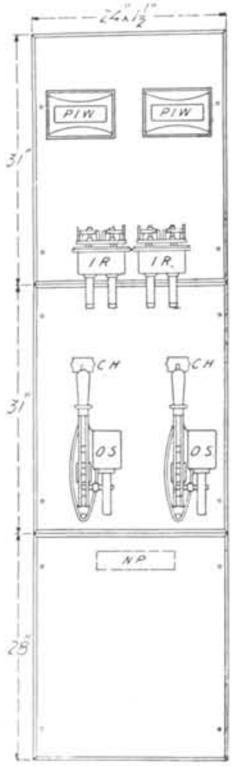


Fig. 1

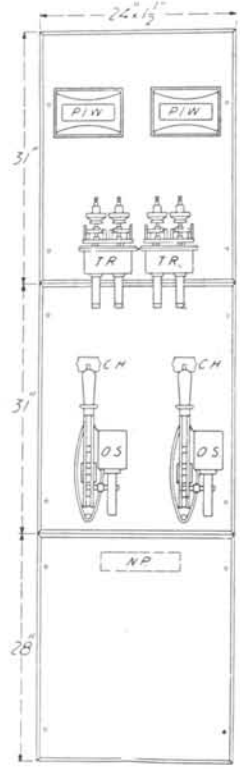


Fig. 2

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY		P.I.W. SCALE IN KW.			CAT. NO.	
Panel	Current Transformers	240 Volts	480 Volts	600 Volts	With Instantaneous Oil Switch Trip Fig. 1	With Time Limit Oil Switch Trip Fig. 2
16	10	4	8	10	131882	131897
20	15	5	10	12	131883	131898
24	15	6	12	15	131884	131899
32	20	7	15	20	131885	131900
40	30	10	20	25	131886	131901
50	30	12	25	30	131887	131902
60	40	15	30	40	131888	131903
80	60	20	40	50	131889	131904
100	60	25	50	60	131890	131905
130	80	30	60	80	131891	131906
160	100	40	80	100	131892	131907
200	150	50	100	120	131893	131908
250	150	70	125	150	131894	131909
320	200	100	175	200	131895	131910
400	300	100	200	250	131896	131911

TA REGULATOR PANELS AND COMBINATION TA REGULATOR AND EXCITER MOTOR PANELS

For Forms L & K Regulators

240, 480 AND 600 VOLTS
8 TO 300 AMPERES

DIAGRAMS OF CONNECTIONS

IMPORTANT—NOTE BEFORE ORDERING

1. Do not forget "Information which should accompany orders"—see page 5.
2. Unless otherwise ordered panels will be furnished for 600 volts and 60 cycles. See *Voltage* and *Frequency* in General Information.
3. Regulator equipments as listed are intended for maintaining *constant bus voltage.* A current transformer is required if the regulator is to be *compounded* and suitable transformers are listed on page 41. When ordering always state where current transformer is to be connected.
4. When TA regulators are used, provision should be made for *paralleling exciters.* Separate panels for exciter control are therefore necessary.
5. See General Information for method of determining ampere capacity of panel required for a given motor.

These panels cannot be used with any motors which require a controller or starting equipment mounted on the panel; for instance, those Form K motors which do not have self-contained starting compensators.

DIAGRAMS OF CONNECTIONS

These connections are representative and apply only for the conditions shown. The connections differ somewhat depending upon the number of exciters with which a regulator is used.

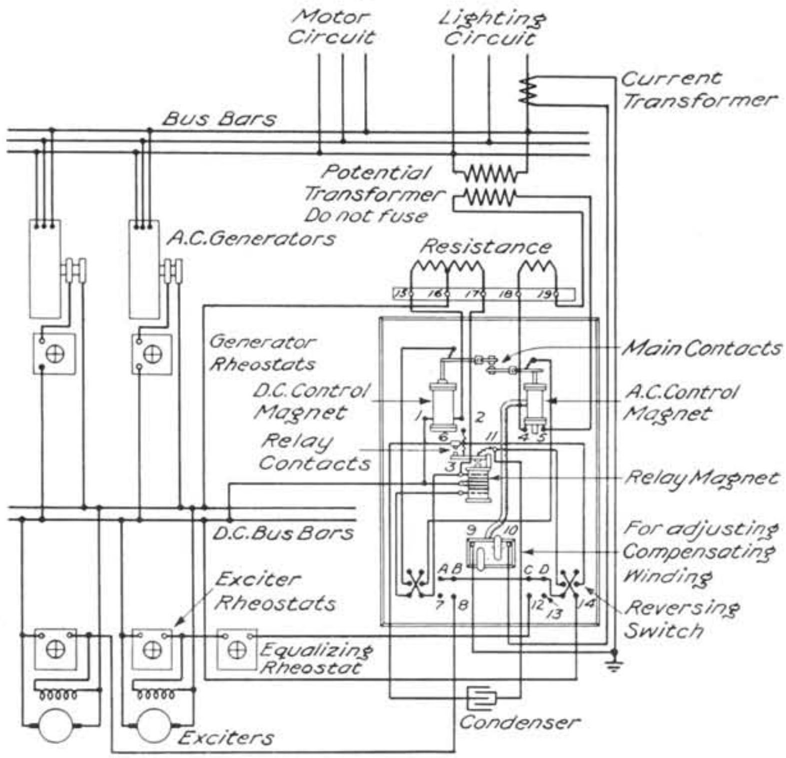


Fig. 1
Type TA Form L Regulator with Two Exciters and Several Generators

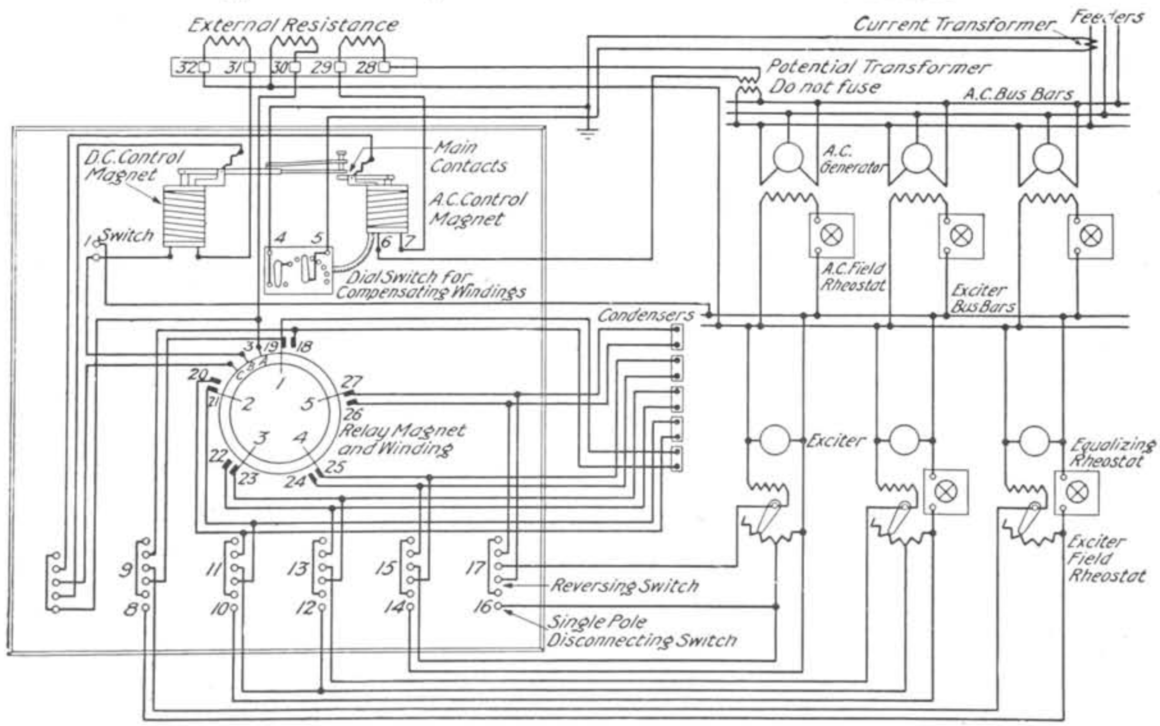


Fig. 2
Type TA Form K5 Regulator with Three Exciters and Several Generators

TA REGULATOR PANELS

EQUIPMENT

L = Drilling and mounting only, for one TA regulator, Form L (for Fig. 1 only).

K = Drilling and mounting only, for one TA regulator, Form K (for Fig. 2 only).

N.P. = Name plate (on only one panel in a complete switchboard).

One—200 watt 220/110, 440/110 or 550/110 volts potential transformer.

R (optional) = *One*, *two* or *three* handwheels and mountings for equalizer rheostats.

Regulator, equalizer rheostats, condensers and compensators **are not included.**

When A.C. or exciter buses extend across panel they must be ordered separately; see "Busbar Copper."

Current transformer for regulator must be ordered separately—see page 31, paragraph 3.

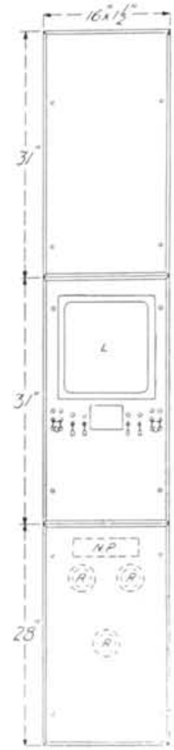


Fig. 1

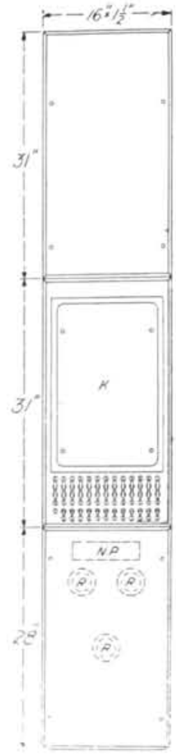


Fig. 2

Panels in Fig. 2 cannot be used for regulators larger than K12
Unless otherwise ordered panels will be furnished for 600 volts

Quantity of R	CAT. NO.	
	With Form L Regulator, Fig. 1	With Form K Regulator, Fig. 2
None	113812	113816
One	113813	113817
Two	113814	113818
Three	113815	113819

COMBINATION TA REGULATOR AND EXCITER MOTOR PANELS

WITH INSTANTANEOUS OIL SWITCH TRIP

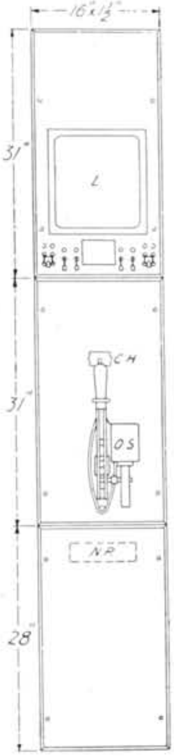


Fig. 1

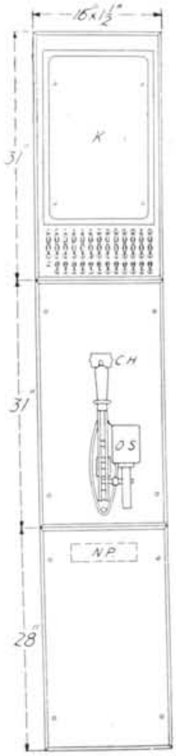


Fig. 2

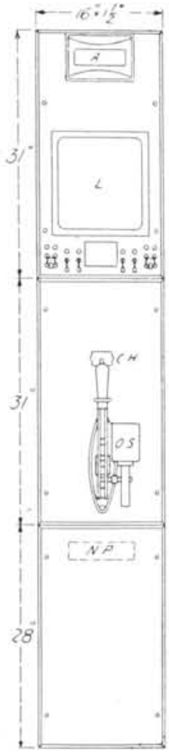


Fig. 3

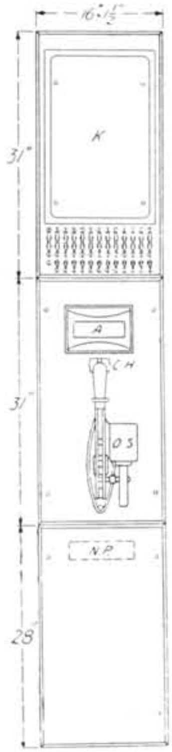


Fig. 4

EQUIPMENT

A = H.E. A.C. ammeter (secondary) with...... amp. scale (Figs. 3 and 4 only).

L = Drilling and mounting only for one TA regulator, Form L (Figs. 1 and 3 only).

K = Drilling and mounting only for one TA regulator Form K (Figs. 2 and 4 only.)

C.H. = Card holder.

O.S. = T.P.S.T....... amp. automatic K5 oil switch, mounted on pipe framework back of panel, with operating mechanism (single secondary coil). (200 amp. switches are 4500 volts; 300 amp. switches are 7500 volts.)

N.P. = Name plate (on only one panel in a complete switchboard).

One—200 watt 440/110 (or 550/110) volts potential transformer.

One—Current transformer (for **A** and **O.S.** only).

Regulator, equalizer rheostats, condensers and compensators **are not included.** Equalizer rheostats must be mounted on exciter panels.

Current transformer for regulator must be ordered separately —see page 31, paragraph 3.

Busbars must be ordered separately; see "Busbar Copper."

Panels in Figs. 2 and 4 cannot be used for regulators largers than K12
Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				CAT. NO.			
Panel	Ammeter Figs. 3 and 4 Only	Oil Switch	Current Transformer	Fig. 1	Fig. 2	Fig. 3	Fig. 4
8	10	200	10	131912	131985	132002	132019
10	12	200	15	131913	131986	132003	132020
12	15	200	15	131914	131987	132004	132021
16	20	200	20	131915	131988	132005	132022
20	25	200	30	131916	131989	132006	132023
25	30	200	30	131917	131990	132007	132024
30	40	200	40	131918	131991	132008	132025
40	50	200	50	131975	131992	132009	132026
50	60	200	60	131976	131993	132010	132027
65	80	200	80	131977	131994	132011	132028
80	100	200	100	131978	131995	132012	132029
100	120	200	150	131979	131996	132013	132030
125	150	200	150	131980	131997	132014	132031
160	200	200	200	131981	131998	132015	132032
200	250	200	300	131982	131999	132016	132033
250	300	300	300	131983	132000	132017	132034
300	400	300	400	131984	132001	132018	132035

COMBINATION TA REGULATOR AND EXCITER MOTOR PANELS WITH TIME LIMIT OIL SWITCH TRIP

EQUIPMENT

L = Drilling and mounting only for one TA regulator, Form L.

T.R. = S.P. time limit overload relay.

A = H.E. A.C. ammeter (secondary) with ...... amp. scale (for Fig. 2 only).

C.H. = Card holder.

O.S. = T.P.S.T....... amp. automatic K5 oil switch, mounted on back of panel, with operating mechanism (single secondary coil). (200 amp. switches are 4500 volts; 300 amp. switches are 7500 volts.)

N.P. = Name plate (on only one panel in a complete switchboard).

One—200 watt 440/110 (or 550/110) volt potential transformer.

One—Current transformer...... amp. (for **O.S.** and **A** only).

Regulator, equalizer rheostats, condensers and compensators **are not included.** Equalizer rheostats must be mounted on exciter panels.

Current transformer for regulator must be ordered separately—see page 31, paragraph 3.

Busbars must be ordered separately; see "Busbar Copper."

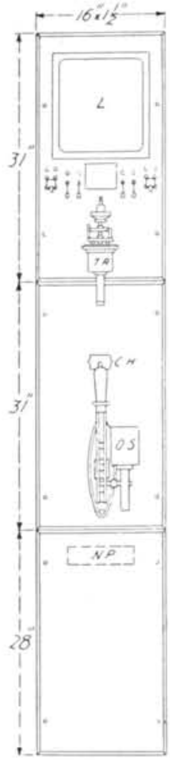


Fig. 1

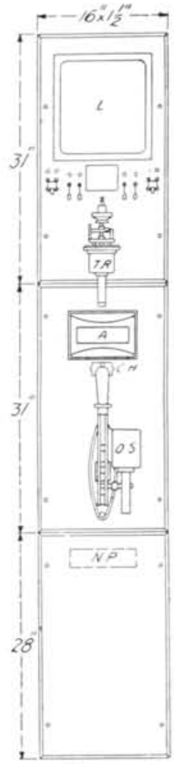


Fig. 2

Unless otherwise ordered panels will be furnished for 600 volts

AMPERE CAPACITY				CAT. NO.	
Panel	Ammeter Fig. 2 Only	Oil Switch	Current Transformer	Fig. 1	Fig. 2
8	10	200	10	132036	132053
10	12	200	15	132037	132054
12	15	200	15	132038	132055
16	20	200	20	132039	132056
20	25	200	30	132040	132057
25	30	200	30	132041	132058
30	40	200	40	132042	132059
40	50	200	60	132043	132060
50	60	200	60	132044	132061
65	80	200	80	132045	132062
80	100	200	100	132046	132063
100	120	200	150	132047	132064
125	150	200	150	132048	132065
160	200	200	200	132049	132066
200	250	200	300	132050	132067
250	300	300	300	132051	132068
300	400	300	400	132052	132069

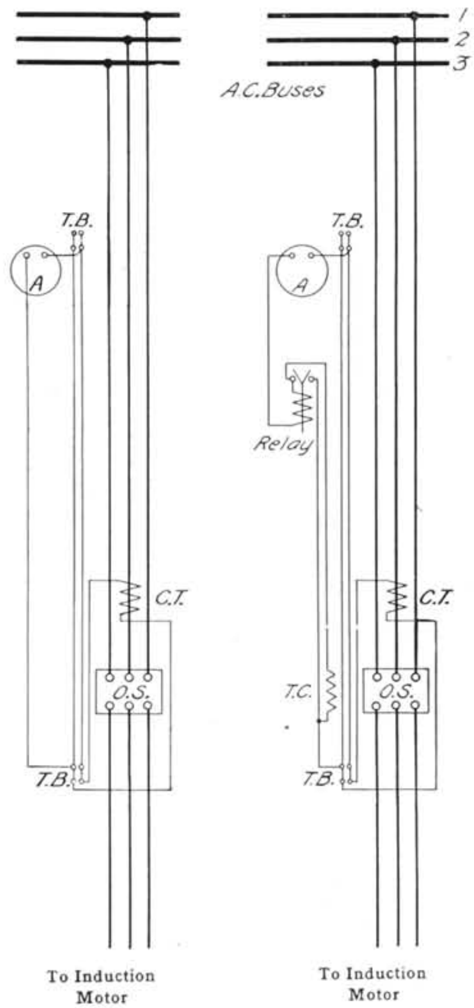
THREE-PHASE INDUCTION MOTOR PANELS
For Exciter Motor-Generator Sets

240, 480 AND 600 VOLTS
8 TO 300 AMPERES

IMPORTANT—NOTE BEFORE ORDERING

1. Do not forget "Information which should accompany orders"—see page 5.
2. Always consider the question of "Oil Switch Rupturing Capacity" in order to determine if panels are suitable for future as well as present requirements.
3. See General Information for method of determining *ampere capacity of panel required for a given induction motor*
4. These panels cannot be used with any motors which require a controller or starting equipment mounted on the panel: for instance, those Form K motors which do not have self-contained starting compensators.

DIAGRAMS OF CONNECTIONS FOR THREE-PHASE INDUCTION MOTOR PANELS



KEY TO SYMBOLS

A = Ammeter.
B.A.S. = Bell alarm switch.
C.T. = Current transformer.
O.S. = Oil switch.
T.B. = Terminal board for secondary leads.
T.C. = Trip coil on oil switch.

THREE-PHASE INDUCTION MOTOR PANELS

EQUIPMENT

(Oil switch trip coils and current coils of ammeter are **secondary** for all panels.)

A (optional) = H.E. A.C. ammeter with......amp. scale.

T.R. = S.P. time limit overload relay (for Fig. 2 only).

C.H. = Card holder.

O.S. = T.P.S.T.......amp. automatic K5 oil switch mounted on pipe framework back of panel, with operating mechanism (single coil). (200 amp. switches are 4500 volts; 300 amp. switches are 7500 volts.)

N.P. = Name plate (on only one panel in a complete switchboard).

One current transformer......amp.

Busbars must be ordered separately; see "Busbar Copper."

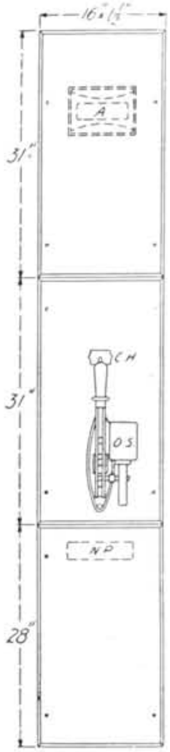


Fig. 1

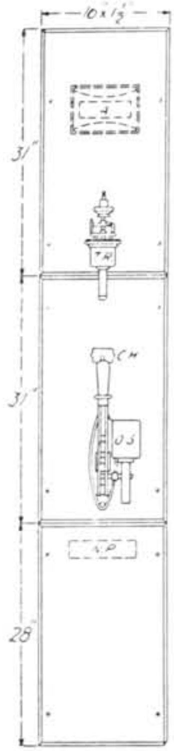


Fig. 2

AMPERE CAPACITY				CAT. NO.			
Panel	Ammeter	Oil Switch	Current Transformer	With Instantaneous Oil Switch Trip Fig. 1		With Time Limit Oil Switch Trip Fig. 2	
				Without Ammeter	With Ammeter	Without Ammeter	With Ammeter
8	10	200	10	132070	132087	132104	132121
10	12	200	15	132071	132088	132105	132122
12	15	200	15	132072	132089	132106	132123
16	20	200	20	132073	132090	132107	132124
20	25	200	30	1320 4	132091	132108	132125
25	30	200	30	132075	132092	132109	132126
30	40	200	40	132076	132093	132110	132127
40	50	200	60	132077	132094	132111	132128
50	60	200	60	132078	132095	132112	132129
65	80	200	80	132079	132096	132113	132130
80	100	200	100	132080	132097	132114	132131
100	120	200	150	132081	132098	132115	132132
125	150	200	150	132082	132099	132116	132133
160	200	200	200	132083	132100	132117	132134
200	250	200	300	132084	132101	132118	132135
250	300	300	300	132085	132102	132119	132136
300	400	300	400	132086	132103	132120	132137

CURRENT TRANSFORMERS FOR TA REGULATORS

Cat. No.	Ampere Capacity	Ratio	Cat. No.	Ampere Capacity	Ratio
104695	5	1:1	104704	150	30:1
104696	10	2:1	104705	200	40:1
104697	15	3:1	104706	300	60:1
104698	20	4:1	104707	400	80:1
104699	30	6:1	104708	600	120:1
104700	40	8:1	104709	800	160:1
104701	60	12:1	41300	1000	200:1
104702	80	16:1	41301	1500	300:1
104703	100	20:1	41302	2000	400:1
			41303	3000	600:1
			41304	4000	800:1
			41305	6000	1200:1

When ordering state whether the current transformer is to be connected in the busbars to regulate for total generator output or in a particular feeder circuit.

BUSBAR COPPER

Busbars must be ordered separately for each panel as per the following sample order:

Item No. 1

One three-phase generator panel Cat. No.......

A.C. buses Cat. No......

Exciter buses Cat. No......

If the *total current* supplied to a bus by all panels in the board *does not exceed the minimum limits catalogued* for the different station kilowatt capacities, busbars may at once be chosen from the following tables since the ampere capacity of bus required for *any* panel will be within these limits. For all other cases the method described on the following page is recommended as a simple means of determining the ampere capacity of bus required.

Cat. Nos. of A.C. buses cover *one* set of three-phase buses of bare copper bar. The ultimate kilowatt capacity of the station must be taken into consideration in order that future additions may be made to the busbar without changing the bars already installed.

Catalogue numbers of exciter buses cover one positive and one negative bus of bare copper bar and are to be used only for panels listed herein. Exciter panels and buses are listed in S 413.

A.C. BUSES

ULTIMATE KW. CAPACITY OF STATION			Ampere Capacity of Bus Required	CAT. NOS.		
240 Volts	480 Volts	600 Volts		For Panel 16 In. Wide With K5 Oil Switch	For Panel 16 In. Wide With K12 Oil Switch	For Panel 24 In. Wide
500	1000	1250	1 to 500	132138	132150	132162
500	1000	1250	501 to 1000	132139	132151	132163
500	1000	1250	1001 to 1500	132140	132152	132164
750	1500	1875	1 to 750	132141	132153	132165
750	1500	1875	751 to 1500	132142	132154	132166
750	1500	1875	1501 to 2250	132143	132155	132167
1250	2500	3100	1 to 1250	132144	132156	132168
1250	2500	3100	1251 to 2500	132145	132157	132169
1250	2500	3100	2501 to 3750	132146	132158	132170
1750	3500	4500	1 to 2500	132147	132159	132171
1750	3500	4500	2501 to 4000	132148	132160	132172
1750	3500	4500	4001 to 5200	132149	132161	132173

EXCITER BUSES
(Do not use for exciter panels)

Ampere Capacity of Bus Required	CAT. NOS.	
	For Panel 16 In. Wide	For Panel 24 In. Wide
1 to 500	132174	132177
501 to 1000	132175	132178
1001 to 1500	132176	132179

A SIMPLE METHOD OF DETERMINING BUS CAPACITY

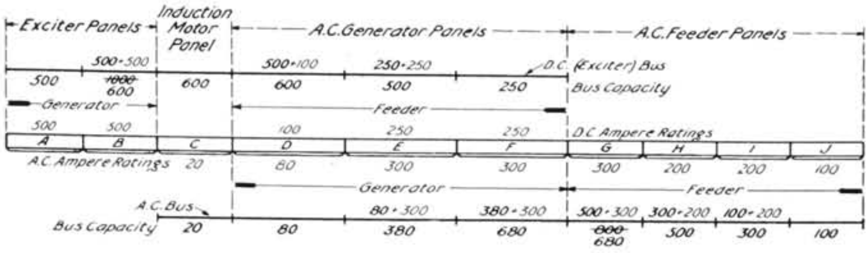


Fig. 1

Fig. 1 illustrates a simple diagrammatical method of determining the ampere capacity of bus required for any panel. The method is as follows:

1. Make a rough plan of the *entire board*, regardless of the number of panels to be ordered.

The Order of Panels shown is recommended, it being most economical of copper and best adapted to future extensions.

2. To avoid confusion keep on one side of board everything pertaining to exciter buses, and on other side everything pertaining to A.C. buses.
3. With single lines represent the exciter and A.C. buses across such panels as they actually extend and by means of arrows indicate that portion of each bus which is connected to feeders and that portion which is connected to generators. **Remember that "Generator" and "Feeder" arrows must always point toward each other,** otherwise the rules given below do not hold. Note also that the field circuits of A.C. generator panels are treated as D.C. feeders for the exciter bus.
4. On each panel mark its ampere rating, i.e., the maximum current it supplies to or takes from the bus. For A.C. generator panels the D.C. rating is the excitation of the machines.
5. Apply the following rules *consecutively*, and note their application in Fig. 1. (For the sake of clearness ampere ratings are shown in light face type and bus capacities in bold face type.)
   - (a) **Always begin with the tail of the arrow and treat "generator" and "feeder" sections of the bus separately.**
   - (b) **Bus capacity for first panel = Ampere rating of panel.**
   - (c) **Bus capacity for each succeeding panel = Ampere rating of panel *plus* bus capacity for preceding panel.** (See sums marked above the buses in Fig. 1.)
   - (d) **For a panel not connected to a bus extending across it, use the smaller value of the bus capacities already obtained for the two adjoining panels.** (See exciter bus for panel C.)
   - (e) **The bus capacity for any feeder panel need not exceed the maximum for the generator panels** (see A.C. bus for panel G) **and vice versa** (see exciter bus for panel B). Hence the corrections made in values obtained by applying rules (b) and (c).

The arrangement of panels shown in Fig. 1 is the one which is mostly used. The above method may, however, be applied to other arrangements, one of which is shown in Fig. 2. Here the generators must feed both ways to the feeders at either end of the board so that in determining A.C. bus capacities it is necessary to first consider the generators with the feeders at one end, and then with the feeders at the other end as shown by the dotted A.C. buses. The required bus capacities are then obtained by taking the maximum values for the two cases.

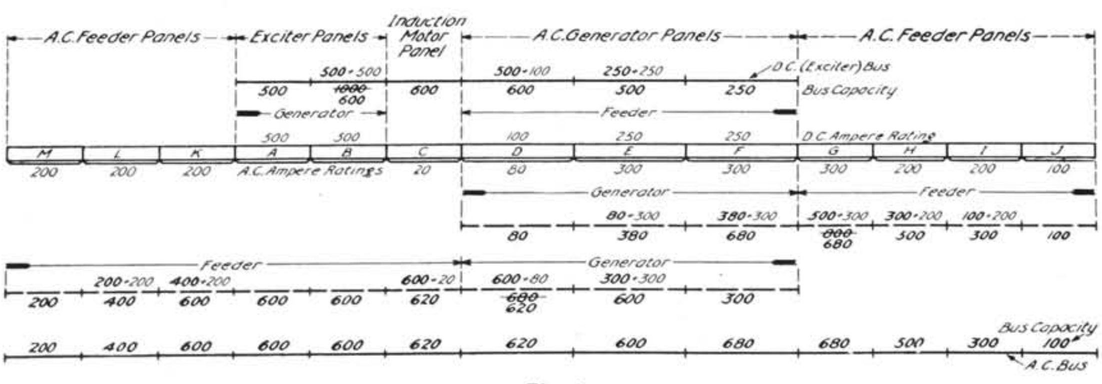
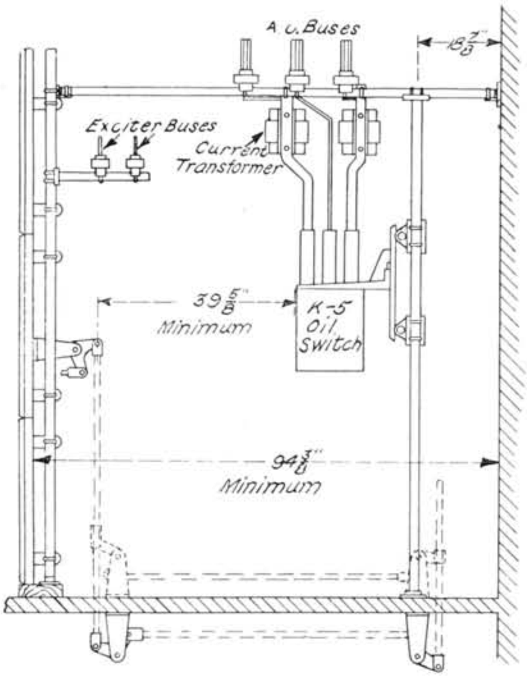
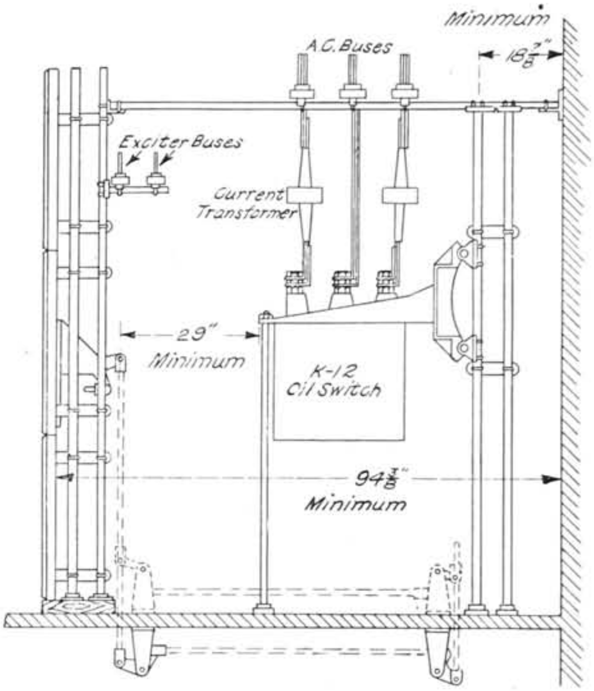


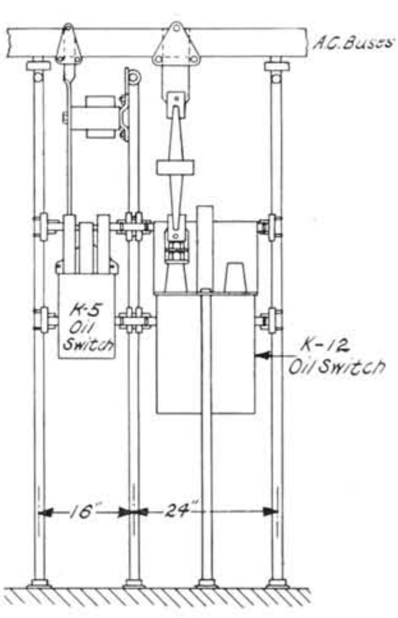
Fig. 2

240, 480 AND 600 VOLT A.C. SWITCHBOARD ARRANGEMENTS

Heavy broken lines in the following diagram show alternate locations for apparatus furnished by the General Electric Company. Light broken lines show material to be furnished by the purchaser.

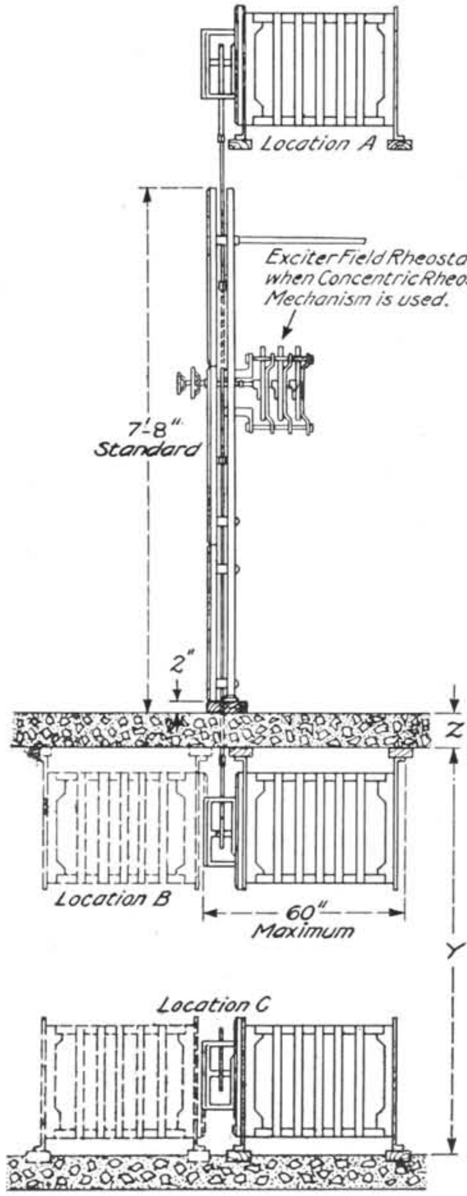






240, 480 AND 600 VOLT A.C. SWITCHBOARD ARRANGEMENTS

ALTERNATE LOCATIONS OF GENERATOR FIELD RHEOSTAT



Ample space should be provided or suitable provision made for ventilating rheostats.

Dimensions Y and Z should be given with the order.

GENERAL ELECTRIC COMPANY

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SUPPLY DEPARTMENT

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THOMSON DIRECT CURRENT TEST METER, TYPE CB-4

Periodical meter testing is of vital importance to every central station or isolated plant, since the revenue received depends upon the accuracy of the meters integrating the electrical energy sold.

1-2-10-20-40 AMPERE, 110-220 VOLT, TYPE CB-4, TEST METER

The customary method of making such tests has been by indicating instruments, and although there is no question regarding the accuracy of this method, the rapid growth of electric lighting and power industry demands that some way be provided whereby tests can be made more quickly and with the same degree of reliability. These requirements are met by the Thomson direct current test meter.

In using the test meter it is unnecessary that the load be constant since the only observations necessary are the number of disk revolutions of the meter undergoing test, and the pointer indications of the standard meter before and after test. The time-saving qualities of this meter will be appreciated when it is remembered that check tests are unnecessary, and readings once started can be continued irrespective of load fluctuations.

The test meter combines in one standard several capacities covering a range from light load to full load. This fact makes possible more rapid testing since no time is lost in changing standards.

Personal errors of observation are practically eliminated, and the use of a stop watch is unnecessary.

These reasons are sufficient to recommend the test meter to all users of direct current watthour meters.

CONSTRUCTION

Case

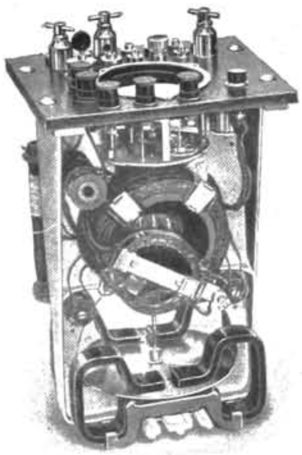
The test meter is enclosed in a quarter sawed oak carrying case of antique finish provided with a leather handle. It is of convenient size, being but 14 in. by 8 in. by 7 in. overall dimensions. The cover is provided with separable hinges which permit it to be quickly removed, facilitating testing in places where the projecting top when open would not leave room for the meter to stand.

Register

The register of the Thomson direct current test meter is large and easily read, and is placed in the top of the meter. This feature

NOTE.—The data in this publication are for the convenience of customers, and every effort is made to avoid error, but this Company does not guarantee their correctness, nor does it hold itself responsible for any errors or omissions in this publication. Subject to change without notice.
**Supersedes No. 4942.*

is particularly advantageous when tests are being made at points of installation where there is no opportunity to place the meter close at hand and it must be set on the floor or some other place below the observer. The register is of the three-pointer type. The largest pointer indicates the disk revolutions directly on the dial which is subdivided into one hundred equal parts, so that it can be read to hundredths of a revolution. The two smaller pointers make one revolution for each ten or one hundred revolutions of the large pointer. It is, therefore, a very simple



1-2-10-20-40 AMPERE, 110-220 VOLT, TYPE CB-4 TEST METER WITH COVER REMOVED

matter to ascertain the number of revolutions of the disk by noting the position of the three pointers at the start and finish of each test. As the full load speed of the meter is less than 40 revolutions per minute, a 2½ minute test at this load can be made before a given indication is repeated.

Connections

Connections to the test meter are made by means of binding posts placed at the top of the meter.

The potential circuit is excited by making connections to the rubber covered binding posts mounted in front of the dial and also on the front of the carrying case. Terminals are also provided for the circuit actuating the register magnetic clutch.

On the single-voltage, one, and on the double-voltage, two of these terminals are mounted at the left of the dial. The other terminal is mounted on the front of the carrying case on both single- and double-voltage meters. This terminal forms the connection with the terminal for the potential circuit of the meter and for the register magnetic clutch. To these terminals is attached by means of a lamp cord, a pendent snap switch the opening or closing of which stops or starts the registering mechanism. The cord is of sufficient length to permit the meter being placed at some distance from the operator.

The resistance for all meters is mounted under a cage and attached to the front of the carrying case. Rubber covered binding posts serve as terminals for this resistance.

Locking Device

A little to the left of the dial is placed a knurled thumb nut by the aid of which the moving element can be raised from its jewel bearing and securely locked during transportation.

Fuse

A fuse plug located at the right of the dial is in series with the one- and two-ampere windings of the 1-2-10-20-40 ampere meters and in series with the five- and ten-ampere winding of the 5-10-50-100 ampere meters. This protects the fine wire windings in case they should be subjected to an accidental overload. The fuse plug is of the enclosed type, thus preventing the melted fuse wire from injuring the meter.

Jewel and Pivot

To produce a meter with the highest possible accuracy, both initially and throughout its entire period of usefulness, an indestructible bearing is essential, and with this in view the cup diamond has been adopted for the lower thrust bearing. The grinding of diamonds to a concave form has been so perfected by the General Electric Company that they are quite the equal of any other jewel bearing both in form and finish. The extreme hardness of the diamond renders it practically indestructible, and, therefore, of inestimable value in a meter with a rotating element.

The pivot is identical with that used for the ordinary sapphire bearing, and consists of a small piece of steel wire, hardened and highly polished, inserted in a removable, brass, shaft end.

Accessibility

The entire meter can be lifted from the case, thus making it easily accessible for calibration. When removed from the case, the meter will remain without support in an upright position, resting upon the magnets and central casting to which all parts are fastened.

Windings

The meter is furnished in two distinct ampere ratings, 1-2-10-20-40 ampere or 5-10-50-100 ampere, each with single 110 volt or double 110/220 volt potential windings. This latter form is particularly desirable for stations having the Edison three-wire system of distribution. The potential winding is suitable for use on voltages ranging ten per cent. either side of normal.

The 1-2-10-20-40 ampere meter has two current windings, one divided in two sections, the other in four sections. By means of plugs and connection straps, these windings may be connected in series or multiple giving the five different current capacities. The same method is followed in the 5-10-50-100 ampere meter. A diagram of connections accompanies the meter, fully describing the proper method of connecting in circuit. With any one of the combinations, the torque developed is the same provided the meter operates at the same per cent. of full load. In other words, when using the one-ampere winding with one ampere flowing, the torque is the same as that developed by the forty-ampere combination, with forty amperes flowing. This feature is extremely valuable as the test meter is never operating under light load conditions, thus eliminating any possible inaccuracies which might occur if it were operated at extremely light loads.

Heating Device

Rubber covered binding posts are provided for connecting that part of the potential circuit affected by temperature changes in circuit so that it may be brought quickly to a working temperature. These connections are shown in the diagram of connections and are known as the "heating connections." The temperature coefficient of the potential circuit and of the disk has been materially reduced shortening the length of time necessary for heating the potential circuit. At the same time the compensation for varying room temperatures has been retained. The heating connections on a 110 volt circuit should be maintained for a period of three minutes, on a 220 volt circuit for a period of two minutes before making the operating connections. When taking readings or in testing, the connections must always be for *operating*.

Torque

Realizing that continued accuracy is maintained by a high torque or turning moment, the General Electric Company has produced a test meter that has the highest possible torque, without impairing other necessary and desirable features. This extremely high torque has been obtained solely by efficient design.

Magnets

The permanent magnets are of the same design as those used in the Type C-6 and Type I meters. Four magnets are astatically arranged and rigidly mounted in two shoes. Actual service has proved this design to be extremely reliable and efficient.

Method of Calibration

Adjustment at full load is accomplished by loosening the two clamping screws which hold

4998-4 Thomson Direct Current Test Meter, Type CB-4

the magnets and then moving either one of the magnet shoes bodily. Moving the magnets toward the center of the disk increases the speed, while moving them toward the edge of the disk, decreases the speed.

Accuracy at light load is obtained by moving the starting coil up or down in a plane parallel to the field coils, to give the required compensation on light loads. This adjustment alters only the light load accuracy without affecting the calibration at full load.

Accuracy

Under all conditions found in central station practice, the accuracy of the direct current test meter is exceptional. The five separate current windings render it possible to obtain accurate registration from a ten-watt load to a four-kilowatt load. In other words, the meter can be used throughout a range of 400 [illegible]

Method of Operation

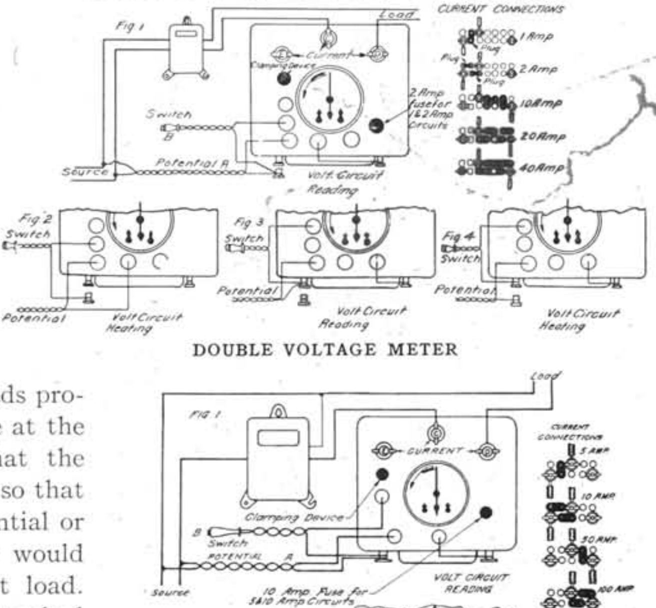
The proper current terminals of the test meter are connected between the load and the meter undergoing test. The potential circuit is connected by means of leads provided for that purpose across the line at the service switch. It is necessary that the meters be connected in this manner so that neither shall record losses in the potential or current circuits of the other, which would introduce appreciable errors at light load. The potential leads with snap switch attached are connected to the proper binding posts, as shown in the diagram of connections, and after it is ascertained that the large hand of the test meter is rotating counter-clockwise, the test meter register is stopped by opening the pendent snap switch and the positions of the pointers noted. The test meter is then started simultaneously with the counting of the disk revolutions of the meter being tested, and is stopped by opening the snap switch after the required number of revolutions have been counted, and the positions of the pointers are again noted.

The number of revolutions noted during test on the dial of the "CB-4" meter multiplied by the proper constant (depending on the capacity of current winding used) gives the watthours recorded by the test meter.

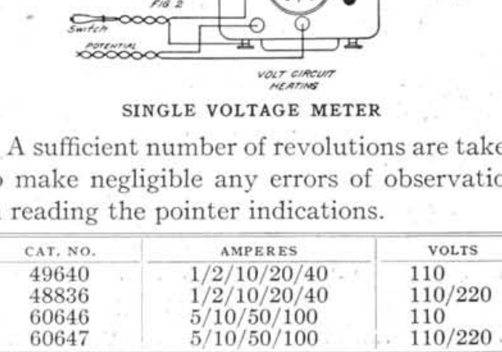
The number of disk revolutions counted on the meter under test multiplied by its calibrating constant equals the watthours recorded by this meter.

The ratio of the watthours recorded by the meter under test to the watthours recorded by the "CB-4" test meter multiplied by 100 equals percentage accuracy.

TYPE CB-4 PORTABLE TEST METER CONNECTED TO CHECK A TWO-WIRE TYPE C-6 METER



DOUBLE VOLTAGE METER



SINGLE VOLTAGE METER

A sufficient number of revolutions are taken to make negligible any errors of observation in reading the pointer indications.

CAT. NO.	AMPERES	VOLTS
49640	1/2/10/20/40	110
48836	1/2/10/20/40	110/220
60646	5/10/50/100	110
60647	5/10/50/100	110/220

HB

TELEPHONE PROTECTIVE EQUIPMENT

For Telephone Circuits Used in Power Distribution

DESCRIPTION	CAT. NO.	LIST PRICE	SHIP. WT. in Lb. (Approx.)	For Dimensions See Page 4, Fig. No.
Y-373 Form D telephone line insulating transformer	221243	**$76.00**	70	6
Y-373 Form C telephone line insulating transformer. For use only on telephone circuits used simultaneously for telegraphing or signalling	221242	**76.00**	65	6
Double-pole horn gap	201112	**36.00**	70	8
Combined double-pole, fused switch and lightning arrester (lightning arrester is Cat. No. 166612).. For use on telephone circuits of which the insulators have a dry arc-over voltage not exceeding 50,000 volts. It may be used on telephone circuits having higher insulation if the double-pole, horn gap Cat. No. 201112 is installed on the line side of it. In that case the fixed gaps (⅛ in.) of the double-pole horn gap limit the potential to ground	201111	**52.00**	55	7
Extra fuse holder including fuse, Cat. No. 121077, for Cat. No. 201111	121075	**3.50**	..	..
Fuse wire in asbestos for Cat. No. 201111	121077	**.10**	..	..
Vacuum tube lightning arrester	148057	**3.50**	1.5	..
Combined vacuum and air gap arrester	166612	**6.00**	3	9
Vacuum tube for Cat. Nos. 148057 and 166612 arresters	140116	**2.10**	0.5	..
Knurled cylinder for Cat. No. 166612 arrester	58035	**.15**	..	..

A complete line of protective equipment for telephone circuits used in connection with power distribution systems was developed by the General Electric Company several years ago. Hundreds of installations are in successful operation today. G-E telephone protective equipment now embodies many improvements based on wide experience in this line of work.

The protection of telephone lines is of importance from the standpoint of safety as well as from the standpoint of improved telephone service. Complete equipment is available for the protection of telephone lines paralleling high tension transmission lines even when carried on the same poles, and will give the degree of safety and quietness that telephone dispatching demands.

To properly protect a telephone line used in power distribution, particularly one paralleling a high tension transmission line (see Page 2, Class 4), it is necessary that all of the devices recommended on Page 2 be used. None of these devices is alone sufficient to give the degree of safety and quietness that telephone dispatching demands. Each device performs a function not only towards the line and instruments, but also towards the other devices.

The subject of protection is discussed herein; the problems are classified and recommendations for the proper equipment are made. A description of each device recommended is given. For a more complete discussion reference should be made to G-E Publication X-265, "Protection of Telephone Circuits Used in Power Distribution." No attempt is made in the latter or herein to make recommendations on telephone line construction.

Fig. 1
Telephone Line Insulating Transformer

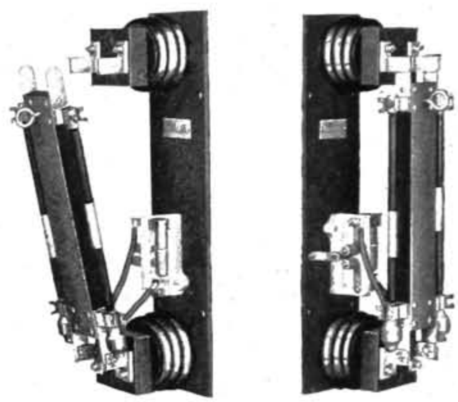


Fig. 2
Combined Double-pole Fused Switch and Lightning Arrester
Cat. No. 201111

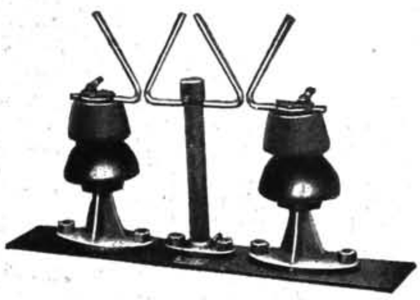


Fig. 3
Double-pole Horn Gap
Cat. No. 201112

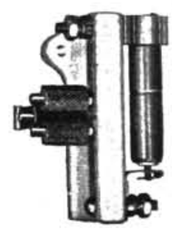


Fig. 4
Combined Vacuum and Air Gap Arrester
Cat. No. 166612

TELEPHONE PROTECTIVE EQUIPMENT

CLASSIFICATION OF TELEPHONE CIRCUITS FROM THE STANDPOINT OF PROTECTION

As the position of the telephone circuit with respect to the transmission circuit determines the likelihood of troubles due to crosses or induction, the telephone ciruits are classified with this point in view:

CLASS 1. *Telephone circuits which do not cross or parallel power lines.*

CLASS 2. *Telephone circuits which cross but do not parallel power lines.*

CLASS 3. *Telephone circuits which parallel power lines but are not on the same towers or poles and do not cross power lines.*

CLASS 4. *Telephone circuits which are on the towers or poles with the power lines.*

SPECIFIC RECOMMENDATIONS FOR PROTECTION

CLASS 1. *Telephone circuits which do not parallel or cross power lines.*

Disturbances: Lightning.

Recommendations: Vacuum tube lightning arresters (Cat. No. 148057) from each line to ground at all telephone stations.

CLASS 2. *Telephone circuits which cross but do not parallel power lines.*

Disturbances: These circuits are subject to lightning disturbances and to contact with the high-voltage power lines through broken wires, etc. They are not subject, to any extent, to electromagnetic or electrostatic induction.

Recommendations:

1. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) in series with the main telephone line on both sides of crossing at nearest telephone stations.
2. Lightning arresters (Cat. No. 166612) at all other stations.

CLASS 3. *Telephone circuits which parallel power lines, but are not on the same towers or poles and do not cross power lines.*

Disturbances: These circuits are subject to lightning disturbances, and to electromagnetic and electrostatic induction. They are not subject to contact with the power lines.

Recommendations:

1. Insulating transformers (Cat. No. 221243) at all telephone stations.
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Drainage coils, preferably one at each end of the line.

Diagram of connections: A diagram of connections for the apparatus used on this class of telephone circuits is shown in Fig. 5. The double-pole horn gap shown on the diagram is not used on this class of circuit but on circuits coming under Class 4.

CLASS 4. *Telephone circuits which are carried on the towers or poles with the power lines.*

Disturbances: These circuits are subject to lightning disturbances, electrostatic and electromagnetic induction, and to crosses with the power lines.

Recommendations:

1. Insulating transformers (Cat. No. 221243) at all telephone stations.
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Double-pole horn gap (Cat. No. 201112) across line at each station on line side of all other apparatus for protection of insulators on telephone circuit in case of crosses with the power lines after series fuses are blown.
4. Drainage coils with fuses installed at each end of line; possibly an additional coil at the middle if the voltage to ground is not held to a safe value by two coils.

Diagram of connections: A diagram of the connections for the apparatus used on this class of telephone circuits is shown in Fig. 5.

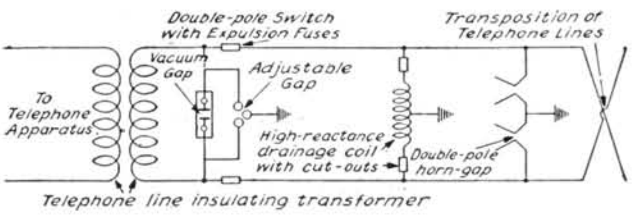


Fig. 5

Diagram of Connections for Protective Apparatus Recommended for Telephone Lines, Classes 3 and 4

TELEPHONE LINE INSULATING TRANSFORMERS

The purposes of the telephone line insulating transformers are:

1st.—To safeguard the users of telephones from the dangers of high voltage due either to induction or to accidental contact between telephone and power lines.

2nd.—To improve the telephone service by increasing the insulation of the telephone line as a whole through the insulating barrier it places between the interior wiring, instruments, batteries, etc., and the line.

The combination of this transformer with other protective equipment as recommended above, affords the greatest safety to the telephone instrument and user, even in the extreme case of actual contact between the high potential and telephone lines.

If the telephone line is sufficiently well insulated and the protective devices recommended are used, there is no reason why service should not be continued over the telephone line in spite of a ground on the high tension system.

DESCRIPTION

Several thousand G-E telephone line insulating transformers are in service today on telephone circuits used in conjunction with transmission systems having voltages as high as 150,000. These transformers are giving complete satisfaction in the prevention of accidents and in making speech transmission possible under extremely adverse conditions. It is expected that the new transformer will meet with still greater success. Both electrically and mechanically the transformer has been improved. Ample insulation has always been given first consideration in the design of the telephone line insulating transformer but the insulation of the new transformer has been made even greater than in the old one. The talking efficiency has been raised. The coefficient of losses in speech transmission has been reduced to less than 40 per cent of its former value. The high frequency

TELEPHONE PROTECTIVE EQUIPMENT

TELEPHONE LINE INSULATING TRANSFORMERS (Cont'd)

talking currents are transformed with small loss, while at the same time the magnetizing current, which must be supplied by the ringing generator, is very small. Tests show that the magnetizing current taken by this transformer is about half the current passed by a standard 1000-ohm bell.

The transformer is assembled in a weatherproof steel case, and may be installed out of doors.

Cat. No. 221243 transformer is recommended for general use and will be supplied unless conditions are special and Cat. No. 221242 is specifically called for.

Cat. No. 221243 transformer has a single winding in both primary and secondary, has more iron, and is of lower resistance than the Cat. No. 221242. As many as 10 or 12 stations equipped with this transformer can be connected to the same line if the resistance of the line is not too great and the best commercial five-bar magneto generators are used.

Cat. No. 221242 transformer has a double winding in both primary and secondary, making available a neutral tap in both windings. This neutral tap serves in special cases for any of the various combination circuit arrangements, such as simultaneous telegraphing or signalling over the same wires without disturbing the telephone instruments.

The neutral tap also permits grounding the neutral, if desired. This is not generally recommended because unless the telephone line is perfectly balanced (which is seldom the case), grounding the neutral tends to make the line noisy due to earth currents, both direct and alternating, shunted into the telephone line.

COMBINED DOUBLE-POLE FUSED SWITCH AND LIGHTNING ARRESTER

The purpose of this device is to provide means for manually disconnecting the telephone circuit so that the telephone apparatus can be handled without danger, and for automatically opening the telephone circuit (series fuse) in case the induced line current should reach such a magnitude as to endanger the telephone apparatus. The vacuum tube of the arrester is connected between lines and hence tends to equalize potentials between lines. The adjustable air gaps of the arresters are connected between lines and ground for discharging lightning disturbances, thus protecting the telephone equipment against lightning.

The voltage of the telephone lines on which this device is used must not exceed 250 volts between wires. If, on account of induction, the voltage is higher, drainage coils should be used to reduce it.

DOUBLE-POLE HORN GAP

The purpose of this device is to protect the telephone apparatus, telephone line insulators, and lightning protective equipment against the power line voltage in the case of a cross between the power lines and the telephone line. The other telephone protective equipment is designed to protect the telephone apparatus against lightning and similar transitory disturbances. They will not withstand the transmission line voltage. In case of a cross the fuses on the combined switch and lightning arrester will at once blow, but the insulator on the line side of the fuses and the telephone line insulators will still be subject to the strain of the line voltage. The double-pole horn gap connected outside of the other apparatus provides a means for relieving this strain.

COMBINED VACUUM AND AIR GAP ARRESTERS

The combined vacuum and air gap arrester, Cat. No. 166612, is the lightning arrester part of the combined double-pole fused switch and lightning arrester and may also be used separately on Class 2 circuits.

The purpose of this arrester is to protect against lightning and to equalize a difference in potential between lines. The former is provided by the adjustable air gaps between lines and ground. Protection against lightning is provided by the vacuum gap which as will be noticed from Fig. 5, is connected between lines. An adjustable air gap is in shunt with the vacuum gap to provide an additional discharge path between lines and to be available in case the vacuum tube should be removed from service. The vacuum tube is the same as that used in the vacuum tube lightning arrester. The insulation to ground is designed with reference to the maximum gap between the knurled cylinders from line to ground. The air gaps are adjustable from 0 to $\frac{3}{16}$ inch. The voltage of the telephone lines on which this device is used must not exceed 250 volts between wires. If, on account of induction, the voltage is higher, drainage coils should be used to reduce it.

DRAINAGE COILS

Drainage coils are used to relieve the telephone lines of induced potentials existing between the telephone circuit as a whole and ground, caused by the position of the telephone circuit in the electrostatic field of the high-voltage power circuit. They perform this function by providing for discharge to ground a path of low impedance for equal currents from each wire of the circuit but a high impedance between the wires and from individual wires to ground. The number of these coils must be kept as low as possible since, as the coils are inductances across the line, they take a comparatively high exciting current from the low frequency ringing generator and under certain conditions may also affect telephone transmission. The installation of one drainage coil at each end of the line should usually be sufficient. If necessary, a third may be installed at the center of the line.

Lighting transformers of small size with 2200/1100-volt windings may be used as drainage coils. The high tension windings should be connected in series, the middle point grounded, and the secondaries left open. Standard transformer cutouts should be used and should be fused in accordance with the maximum rated current-carrying capacity of the primary. The mistake must not be made of using too small a transformer as this might result in the burning out of the transformer at a time when it is most needed. To determine whether the transformers selected are of the proper size, connect the transformers to the circuit as stated above and at the locations selected. The number used in the test must be the same as the number that will be used in service or the test will be valueless. Read the current in the ground wire. As both sides of the circuit discharge through the ground wire, the current will be double the current in the winding. From the current in the winding and allowing a factor of safety of at least five, the necessary transformer rating can be determined. The size of the transformer may be as high as 20 kv-a. depending upon the amount of induction.

While the method of selection as outlined is somewhat cumbersome, it is the only satisfactory one on account of the number of factors which enter into this problem of induced voltage.

TELEPHONE PROTECTIVE EQUIPMENT

DRAINAGE COILS (Cont'd)

Where it is impossible or difficult to make such a test, an approximately correct selection can be made if the following information is furnished:

1. Length of power circuit.
2. Length of paralleling of power and telephone lines.
3. Frequency, voltage and phase connection of power system.
4. Spacing and arrangement of power line conductors, distance from ground and from telephone lines. (Preferably a sketch showing arrangement of circuits and giving all dimensions.)
5. Number of transpositions on power circuit and on telephone circuit.

The series cutouts in the drainage coil connection will protect the coils against a long-continued flow of excessive current such as might exist under arcing ground conditions on the power circuit. Frequent blowing of the fuses indicates that too small a transformer is being used.

Power companies usually have on hand transformers which can be used as drainage coils. The new 2300-volt Type H transformers cannot be thus used as they have no 1100-volt connection.

A special 1100-volt Type H transformer can be used by adding a lead for connecting the middle point of the primary winding to ground. This may be done by putting a threaded stud through the tank near the cover. A lead is then connected from the stud on the inside of the tank to the middle point of the winding and from the studs on the outside to the ground. Companies that have these transformers can do this themselves, but when companies intend to buy transformers for this purpose the work should be done in the factory so that care will be taken to prevent metal chips from getting into the winding.

DIMENSIONS

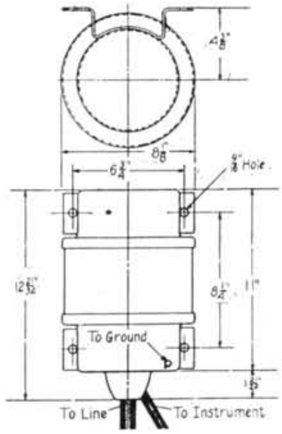


Fig. 6
Cat. Nos. 221242 and 221243
Y-373 Forms C and D

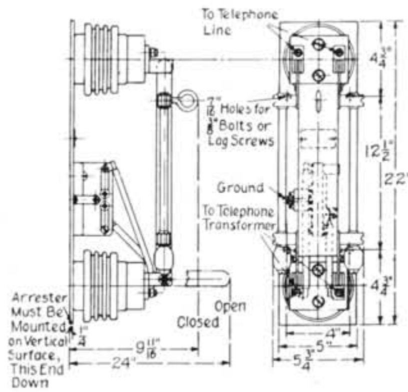


Fig. 7
Cat. No. 201111

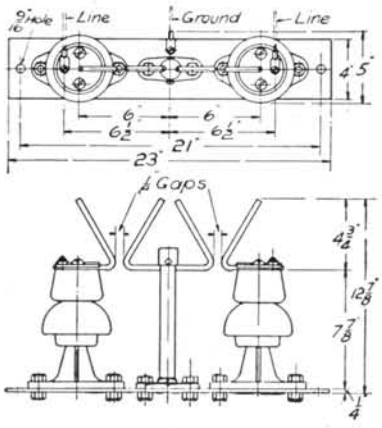


Fig. 8
Cat. No. 201112

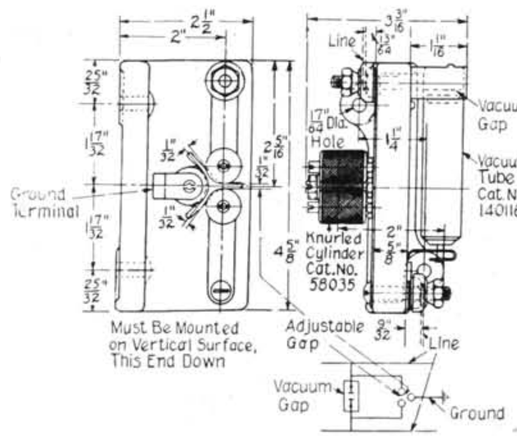


Fig. 9
Cat. No. 166612

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GENERAL ELECTRIC COMPANY, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

TELEPHONE PROTECTIVE EQUIPMENT

For Telephone Circuits Used in Power Distribution

DESCRIPTION	CAT. NO.	LIST PRICE	SHIP. WT. in Lb. (Approx.)	For Dimensions See Page 4, Fig. No.
Y-373 Form D telephone line insulating transformer	221243	**$80.00**	70	6
Y-373 Form C telephone line insulating transformer. For use only on telephone circuits used simultaneously for telegraphing or signalling	221242	**80.00**	65	6
Double-pole horn gap	201112	**33.00**	70	8
Combined double-pole, fused switch and lightning arrester (lightning arrester is Cat. No. 166612).. For use on telephone circuits of which the insulators have a dry arc-over voltage not exceeding 50.000 volts. It may be used on telephone circuits having higher insulation if the double-pole, horn gap Cat. No. 201112 is installed on the line side of it. In that case the fixed gaps (⅛ in.) of the double-pole horn gap limit the potential to ground	201111	**56.00**	55	7
Extra fuse holder including fuse, Cat. No. 121077, for Cat. No. 201111	121075	**5.67**	..	..
Fuse wire in asbestos for Cat. No. 201111	121077	**.16**	..	..
Vacuum tube lightning arrester	148057	**3.70**	1.5	..
Combined vacuum and air gap arrester	166612	**6.00**	3	9
Vacuum tube for Cat. Nos. 148057 and 166612 arresters	140116	**2.20**	0.5	..
Knurled cylinder for Cat. No. 166612 arrester	58035	**.15**	..	..

A complete line of protective equipment for telephone circuits used in connection with power distribution systems was developed by the General Electric Company several years ago. Hundreds of installations are in successful operation today. G-E telephone protective equipment now embodies many improvements based on wide experience in this line of work.

The protection of telephone lines is of importance from the standpoint of safety as well as from the standpoint of improved telephone service. Complete equipment is available for the protection of telephone lines paralleling high tension transmission lines even when carried on the same poles, and will give the degree of safety and quietness that telephone dispatching demands.

Properly to protect a telephone line used in power distribution, particularly one paralleling a high tension transmission line (see Page 2, Class 4), it is necessary that all of the devices recommended on Page 2 be used. None of these devices is alone sufficient to give the degree of safety and quietness that telephone dispatching demands. Each device performs a function not only towards the line and instruments, but also towards the other devices.

The subject of protection is discussed herein; the problems are classified and recommendations for the proper equipment are made. A description of each device recommended is given. For a more complete discussion reference should be made to G-E Publication X-265, "Protection of Telephone Circuits Used in Power Distribution." No attempt is made in the latter or herein to make recommendations on telephone line construction.

Fig. 1
Telephone Line Insulating Transformer

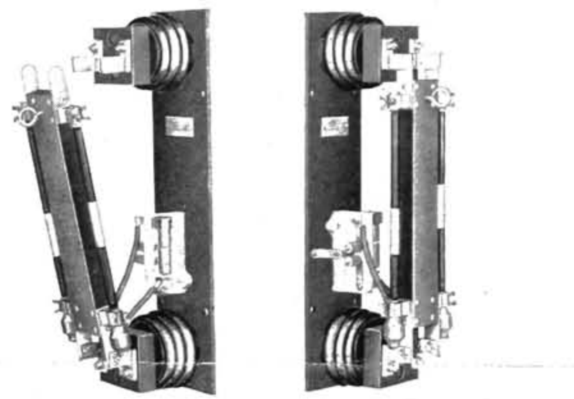

Fig. 2
Combined Double-Pole Fused Switch and Lightning Arrester
Cat. No. 201111

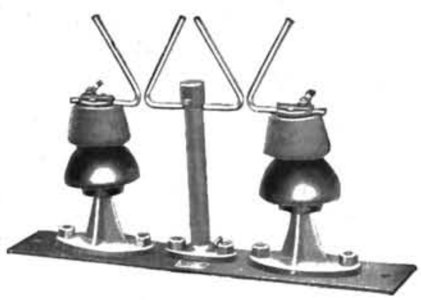

Fig. 3
Double-Pole Horn Gap
Cat. No. 201112

Fig. 4
Combined Vacuum and Air Gap Arrester
Cat. No. 166612

Prices and data in this publication are subject to change without notice.
2-4-21

TELEPHONE PROTECTIVE EQUIPMENT

CLASSIFICATION OF TELEPHONE CIRCUITS FROM THE STANDPOINT OF PROTECTION

As the position of the telephone circuit with respect to the transmission circuit determines the likelihood of troubles due to crosses or induction, the telephone ciruits are classified with this point in view:

CLASS 1. *Telephone circuits which do not cross or parallel power lines.*

CLASS 2. *Telephone circuits which cross but do not parallel power lines.*

CLASS 3. *Telephone circuits which parallel power lines but are not on the same towers or poles and do not cross power lines.*

CLASS 4. *Telephone circuits which are on the towers or poles with the power lines.*

SPECIFIC RECOMMENDATIONS FOR PROTECTION

CLASS 1. *Telephone circuits which do not parallel or cross power lines.*

Disturbances: Lightning.

Recommendations: Vacuum tube lightning arresters (Cat. No. 148057) from each line to ground at all telephone stations.

CLASS 2. *Telephone circuits which cross but do not parallel power lines.*

Disturbances: These circuits are subject to lightning disturbances and to contact with the high-voltage power lines through broken wires, etc. They are not subject, to any extent, to electromagnetic or electrostatic induction.

Recommendations:

1. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) in series with the main telephone line on both sides of crossing at nearest telephone stations.
2. Lightning arresters (Cat. No. 166612) at all other stations.

CLASS 3. *Telephone circuits which parallel power lines, but are not on the same towers or poles and do not cross power lines.*

Disturbances: These circuits are subject to lightning disturbances, and to electromagnetic and electrostatic induction. They are not subject to contact with the power lines.

Recommendations:

1. Insulating transformers (Cat. No. 221243) at all telephone stations.
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Drainage coils, preferably one at each end of the line.

Diagram of connections: A diagram of connections for the apparatus used on this class of telephone circuits is shown in Fig. 5. The double-pole horn gap shown on the diagram is not used on this class of circuit but on circuits coming under Class 4.

CLASS 4. *Telephone circuits which are carried on the towers or poles with the power lines.*

Disturbances: These circuits are subject to lightning disturbances, electrostatic and electromagnetic induction, and to crosses with the power lines.

Recommendations:

1. Insulating transformers (Cat. No. 221243) at all telephone stations.
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Double-pole horn gap (Cat. No. 201112) across line at each station on line side of all other apparatus for protection of insulators on telephone circuit in case of crosses with the power lines after series fuses are blown.
4. Drainage coils with fuses installed at each end of line; possibly an additional coil at the middle if the voltage to ground is not held to a safe value by two coils.

Diagram of connections: A diagram of the connections for the apparatus used on this class of telephone circuits is shown in Fig. 5.

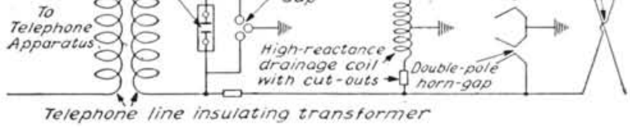

Fig. 5

Diagram of Connections for Protective Apparatus Recommended for Telephone Lines, Classes 3 and 4

TELEPHONE LINE INSULATING TRANSFORMERS

The purposes of the telephone line insulating transformers are:

1st.—To safeguard the users of telephones from the dangers of high voltage due either to induction or to accidental contact between telephone and power lines.

2nd.—To improve the telephone service by increasing the insulation of the telephone line as a whole through the insulating barrier it places between the interior wiring, instruments, batteries, etc., and the line.

The combination of this transformer with other protective equipment as recommended above, affords the greatest safety to the telephone instrument and user, even in the extreme case of actual contact between the high potential and telephone lines.

If the telephone line is sufficiently well insulated and the protective devices recommended are used, there is no reason why service should not be continued over the telephone line in spite of a ground on the high tension system.

DESCRIPTION

Several thousand G-E telephone line insulating transformers are in service today on telephone circuits used in conjunction with transmission systems having voltages as high as 150,000. These transformers are giving complete satisfaction in the prevention of accidents and in making speech transmission possible under extremely adverse conditions. It is expected that the new transformer will meet with still greater success. Both electrically and mechanically the transformer has been improved. Ample insulation has always been given first consideration in the design of the telephone line insulating transformer but the insulation of the new transformer has been made even greater than in the old one. The talking efficiency has been raised. The coefficient of losses in speech transmission has been reduced to less than 40 per cent of its former value. The high frequency

TELEPHONE PROTECTIVE EQUIPMENT

TELEPHONE LINE INSULATING TRANSFORMERS (Cont'd)

talking currents are transformed with small loss, while at the same time the magnetizing current, which must be supplied by the ringing generator, is very small. Tests show that the magnetizing current taken by this transformer is about half the current passed by a standard 1000-ohm bell.

The transformer is assembled in a weatherproof steel case, and may be installed out of doors.

Cat. No. 221243 transformer is recommended for general use and will be supplied unless conditions are special and Cat. No. 221242 is specifically called for.

Cat. No. 221243 transformer has a single winding in both primary and secondary, has more iron, and is of lower resistance than the Cat. No. 221242. As many as 10 or 12 stations equipped with this transformer can be connected to the same line if the resistance of the line is not too great and the best commercial five-bar magneto generators are used.

Cat. No. 221242 transformer has a double winding in both primary and secondary, making available a neutral tap in both windings. This neutral tap serves in special cases for any of the various combination circuit arrangements, such as simultaneous telegraphing or signalling over the same wires without disturbing the telephone instruments.

COMBINED DOUBLE-POLE FUSED SWITCH AND LIGHTNING ARRESTER

The purpose of this device is to provide means for manually disconnecting the telephone circuit so that the telephone apparatus can be handled without danger, and for automatically opening the telephone circuit (series fuse) in case the induced line current should reach such a magnitude as to endanger the telephone apparatus. The vacuum tube of the arrester is connected between lines and hence tends to equalize potentials between lines. The adjustable air gaps of the arresters are connected between lines and ground for discharging lightning disturbances, thus protecting the telephone equipment against lightning.

DOUBLE-POLE HORN GAP

The purpose of this device is to protect the telephone apparatus, telephone line insulators, and lightning protective equipment against the power line voltage in the case of a cross between the power lines and the telephone line. The other telephone protective equipment is designed to protect the telephone apparatus against lightning and similar transitory disturbances. They will not withstand the transmission line voltage. In case of a cross the fuses on the combined switch and lightning arrester will at once blow, but the insulator on the line side of the fuses and the telephone line insulators will still be subject to the strain of the line voltage. The double-pole horn gap connected outside of the other apparatus provides a means for relieving this strain.

COMBINED VACUUM AND AIR GAP ARRESTERS

The combined vacuum and air gap arrester, Cat. No. 166612, is the lightning arrester part of the combined double-pole fused switch and lightning arrester and may also be used separately on Class 2 circuits.

The purpose of this arrester is to protect against lightning and to equalize a difference in potential between lines. The former is provided by the adjustable air gaps between lines and ground. Protection against lightning is provided by the vacuum gap which as will be noticed from Fig. 5, is connected between lines. An adjustable air gap is in shunt with the vacuum gap to provide an additional discharge path between lines and to be available in case the vacuum tube should be removed from service. The vacuum tube is the same as that used in the vacuum tube lightning arrester. The insulation to ground is designed with reference to the maximum gap between the knurled cylinders from line to ground. The air gaps are adjustable from 0 to $\frac{3}{16}$ inch.

DRAINAGE COILS

Drainage coils are used to relieve the telephone lines of induced potentials existing between the telephone circuit as a whole and ground, caused by the position of the telephone circuit in the electrostatic field of the high-voltage power circuit. They perform this function by providing for discharge to ground a path of low impedance for equal currents from each wire of the circuit but a high impedance between the wires and from individual wires to ground. The number of these coils must be kept as low as possible since, as the coils are inductances across the line, they take a comparatively high exciting current from the low frequency ringing generator and under certain conditions may also affect telephone transmission. The installation of one drainage coil at each end of the line should usually be sufficient. If necessary, a third may be installed at the center of the line.

Lighting transformers of small size with 2200/1100-volt windings may be used as drainage coils. The high tension windings should be connected in series, the middle point grounded, and the secondaries left open. Standard transformer cutouts should be used and should be fused in accordance with the maximum rated current-carrying capacity of the primary. The mistake must not be made of using too small a transformer as this might result in the burning out of the transformer at a time when it is most needed. To determine whether the transformers selected are of the proper size, connect the transformers to the circuit as stated above and at the locations selected. The number used in the test must be the same as the number that will be used in service or the test will be valueless. Read the current in the ground wire. As both sides of the circuit discharge through the ground wire, the current will be double the current in the winding. From the current in the winding and allowing a factor of safety of at least five, the necessary transformer rating can be determined. The size of the transformer may be as high as 20 kv-a. depending upon the amount of induction.

While the method of selection as outlined is somewhat cumbersome, it is the only satisfactory one on account of the number of factors which enter into this problem of induced voltage.

TELEPHONE PROTECTIVE EQUIPMENT

DRAINAGE COILS (Cont'd)

Where it is impossible or difficult to make such a test, an approximately correct selection can be made if the following information is furnished:

1. Length of power circuit.
2. Length of paralleling of power and telephone lines.
3. Frequency, voltage and phase connection of power system.
4. Spacing and arrangement of power line conductors, distance from ground and from telephone lines. (Preferably a sketch showing arrangement of circuits and giving all dimensions.)
5. Number of transpositions on power circuit and on telephone circuit.

The series cutouts in the drainage coil connection will protect the coils against a long-continued flow of excessive current such as might exist under arcing ground conditions on the power circuit. Frequent blowing of the fuses indicates that too small a transformer is being used.

Power companies usually have on hand transformers which can be used as drainage coils. The new 2300-volt Type H transformers cannot be thus used as they have no 1100-volt connection.

A special 1100-volt Type H transformer can be used by adding a lead for connecting the middle point of the primary winding to ground. This may be done by putting a threaded stud through the tank near the cover. A lead is then connected from the stud on the inside of the tank to the middle point of the winding and from the studs on the outside to the ground. Companies that have these transformers can do this themselves, but when companies intend to buy transformers for this purpose the work should be done in the factory so that care will be taken to prevent metal chips from getting into the winding.

DIMENSIONS

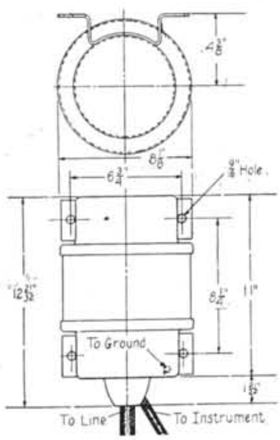

Fig. 6
Cat. Nos. 221242 and 221243
Y-373 Forms C and D

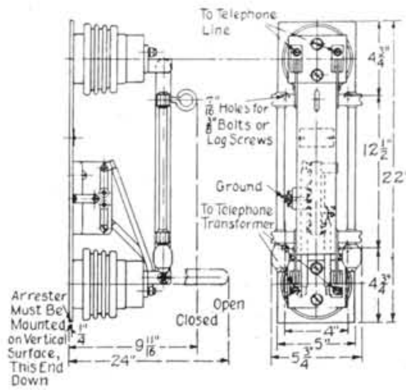

Fig. 7
Cat. No. 201111

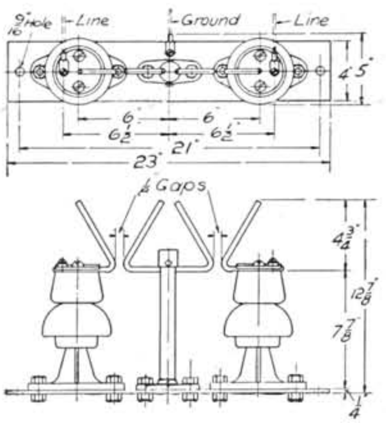

Fig. 8
Cat. No. 201112

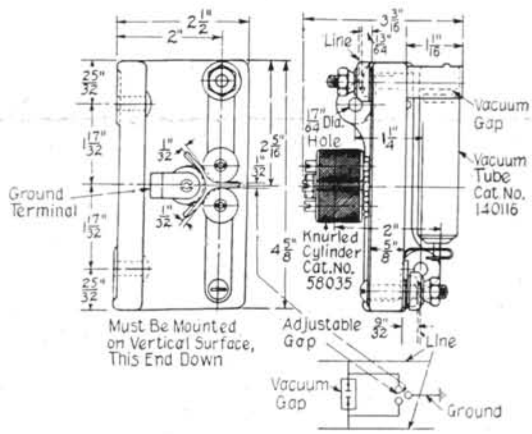

Fig. 9
Cat. No. 166612

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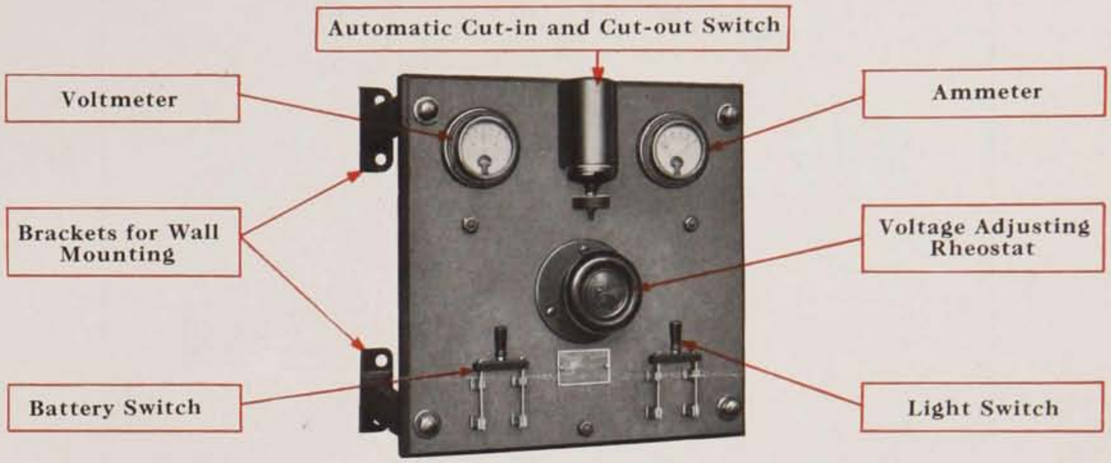
GENERATORS AND PANELS
FOR ISOLATED PLANTS



PANEL

GENERATORS and PANELS of this type are furnished for 1250, 1500, 2000 or more watts output at 35 volts for use with 16-cell lead plate batteries.

GENERATORS HAVE FOUR POLES and are simple, reliable, and efficient. They are furnished complete with base, pulley, and field rheostat unless otherwise specified. Voltage may be varied between 32 and 42 volts by means of the field rheostat.

PANELS ARE MADE of black marine finished slate and are arranged for wall mounting. They are equipped with:

Zero center ammeter for reading the charging or discharging current.

Voltmeter for reading generator voltage.

Automatic cut-in and cut-out switch which will not close the charging circuit until the generator voltage has reached the proper value and which will open the circuit immediately upon reversal of the current.

Double-pole knife switches for controlling the battery and the lighting circuits.

Rheostat mounting, cut-outs, fuses, etc.

GENERATOR

(OVER)

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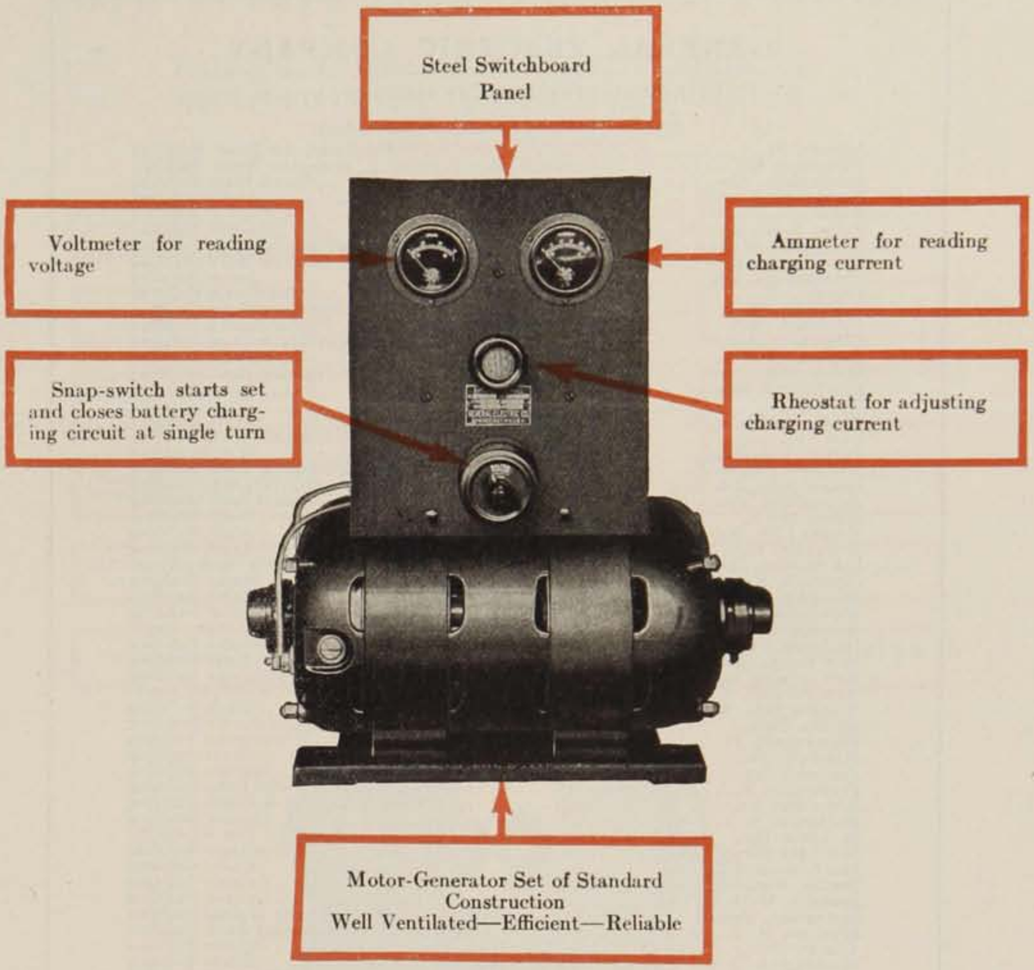
For all CANADIAN Business refer to Canadian General Electric Co., Ltd., Toronto, Ont.

SMALL BATTERY CHARGING OUTFITS

For Charging Ignition and Lighting Batteries



RATINGS

175 watts output at 12, 18 or 24 volts.
250 watts output at 12, 18 or 24 volts.
375 watts output at 36 volts.
500 watts output at 48 volts.
750 watts output at 72 volts.

Field rheostat on panel has sufficient resistance to reduce the voltage generated to 25 per cent of the rated voltage of the outfit. These Battery Charging Outfits are furnished for operation on the ordinary incandescent lighting circuits. The use of the single switch makes it impossible to open the motor circuit without at the same time opening the circuit between the generator and the battery.

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.

Fort Wayne Department — Fort Wayne, Ind.

62551A — 3-5-17

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Companhia General Electric do Brazil.......Rio de Janeiro
Cia. General Electric Sudamericana.......Buenos Aires
Mexican General Electric Co.......City of Mexico
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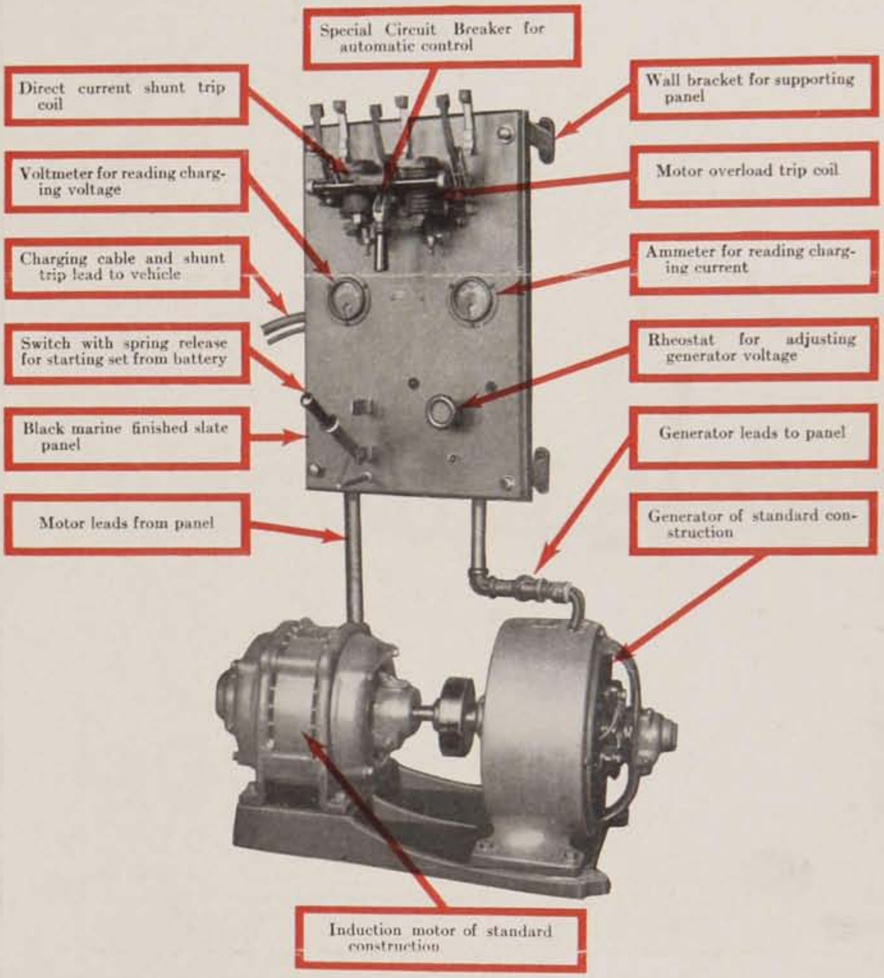
Representatives and Agents in all Countries

For all CANADIAN Business refer to Canadian General Electric Co., Ltd., Toronto, Ont.

INDIVIDUAL VEHICLE TAPER CHARGING SET WITH AUTOMATIC PANEL

FOR USE IN CONNECTION WITH VEHICLE EQUIPPED WITH AMPERE-HOUR METER



This automatic panel is designed to open both the motor and generator circuits when battery has been charged to the extent for which the ampere-hour meter on vehicle has been set.

The motor-generator starts from the battery and therefore does not necessitate the use of any starting device for the induction motor. This insures correct polarity of the charging current.

These outfits have been standardized for charging the regular batteries, (Edison or Lead), in use on electric vehicles and trucks.

Panel and set are shipped separately; the conduit and cables are not included as part of the outfit.

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.
FORT WAYNE DEPARTMENT

62556

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES (Address nearest Office)

Atlanta, Ga.	Third National Bank Building
Baltimore, Md.	Lexington Street Building
Birmingham, Ala.	Brown-Marx Building
Boston, Mass.	84 State Street
Buffalo, N. Y.	Electric Building
Butte, Mont.	Electric Building
Charleston, W. Va.	Charleston National Bank Building
Charlotte, N. C.	Commercial National Bank Building
Chattanooga, Tenn.	James Building
Chicago, Ill.	Monadnock Building
Cincinnati, Ohio	Provident Bank Building
Cleveland, Ohio	Illuminating Building
Columbus, Ohio	Columbus Savings & Trust Building
Dayton, Ohio	Schwind Building
Denver, Colo.	First National Bank Building
Des Moines, Iowa	Hippee Building
Duluth, Minn.	Fidelity Building
Elmira, N. Y.	Hulett Building
Erie, Pa.	Marine National Bank Building
Fort Wayne, Ind.	1600 Broadway
Hartford, Conn.	Hartford National Bank Building
Indianapolis, Ind.	Traction Terminal Building
Jacksonville, Fla.	Heard National Bank Building
Joplin, Mo.	Miner's Bank Building
Kansas City, Mo.	Dwight Building
Knoxville, Tenn.	Bank & Trust Building
Los Angeles, Cal.	Corporation Building, 724 S. Spring Street
Louisville, Ky.	Starks Building
Memphis, Tenn.	Randolph Building
Milwaukee, Wis.	Public Service Building
Minneapolis, Minn.	410 Third Ave., North
Nashville, Tenn.	Stahlman Building
New Haven, Conn.	Second National Bank Building
New Orleans, La.	Maison-Blanche Building
New York, N. Y.	Equitable Building, 120 Broadway
Niagara Falls, N. Y.	Gluck Building
Omaha, Neb.	Union Pacific Building
Philadelphia, Pa.	Witherspoon Building
Pittsburg, Pa.	Oliver Building
Portland, Ore.	Electric Building
Providence, R. I.	Turks Head Building
Richmond, Va.	Virginia Railway & Power Building
Rochester, N. Y.	Granite Building
St. Louis, Mo.	Pierce Building
Salt Lake City, Utah	Newhouse Building
San Francisco, Cal.	Rialto Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building
Springfield, Mass.	Massachusetts Mutual Building
Syracuse, N. Y.	Onondaga County Savings Bank Building
Toledo, Ohio	Spitzer Building
Washington, D. C.	Evans Building
Youngstown, Ohio	Stambaugh Building

For MICHIGAN Business refer to General Electric Co. of Michigan

Detroit, Mich.	Dime Savings Bank Building

For TEXAS, OKLAHOMA and ARIZONA Business refer to
Southwest General Electric Co. (Formerly Hobson Electric Co.)

Dallas, Tex.	1701 N. Market Street
El Paso, Tex.	500 San Francisco Street
Houston, Tex.	Third and Washington Streets
Oklahoma City, Okla.	Terminal Building

Motor Agencies in all large cities and towns

Partial List of FOREIGN Sales Offices

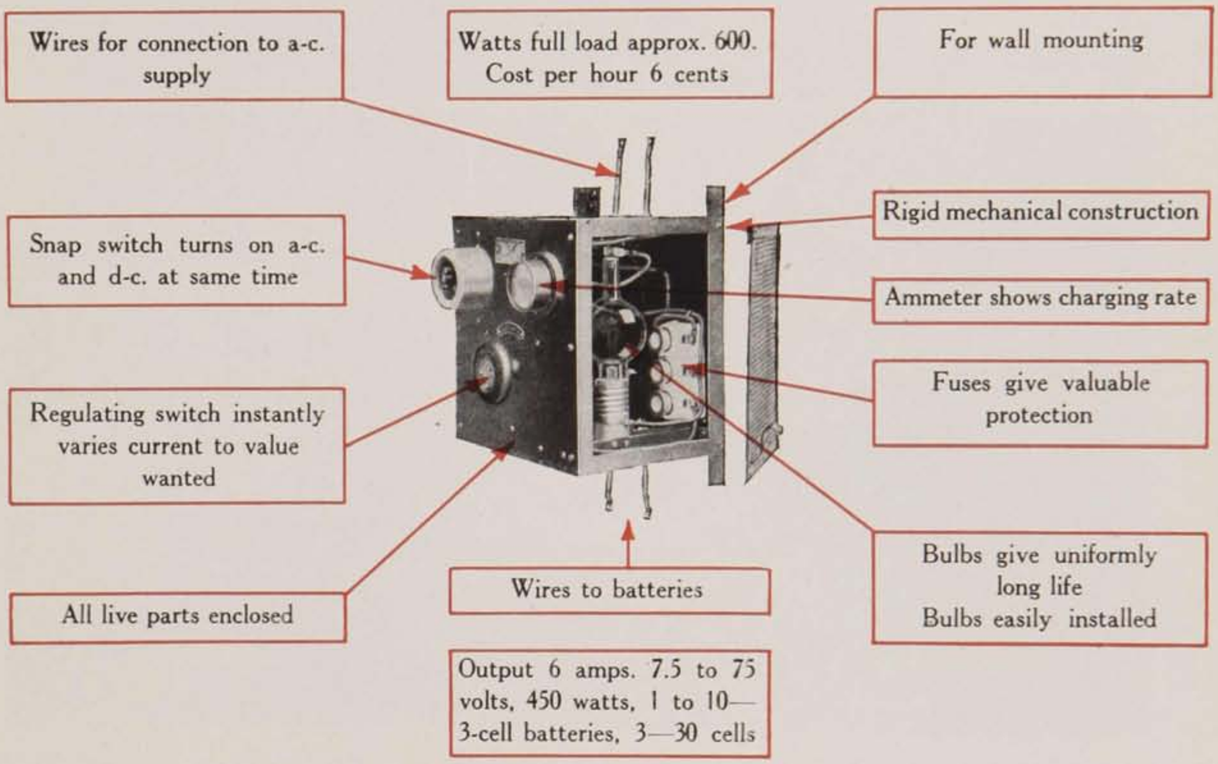
General Electric Co., Foreign Dept.	Schenectady, N. Y.
General Electric Co., Foreign Dept.	Equitable Bldg., 120 Broadway, New York City
General Electric Co. of N. Y.	83 Cannon St., London, E. C., England
Australian General Electric Co.	Melbourne and Sydney
Companhia General Electric do Brazil	Rio de Janeiro
Cia. General Electric Sudamericana	Buenos Aires
Mexican General Electric Co.	City of Mexico
South African General Electric Co.	Johannesburg and Cape Town

Representatives and Agents in all Countries

For all CANADIAN Business refer to Canadian General Electric Co., Ltd., Toronto, Ont.

Tungar RECTIFIER

A new battery charger for use with alternating current. Developed by the General Electric Company's Research Laboratory.



Some Facts About the Tungar

Low first cost	Low bulb cost	Easily installed	Extremely simple
Low operating cost	Long bulb life	No moving parts	No fire risk
High efficiency	Self starting	No oiling or greasing	No floor space

Batteries cannot discharge through rectifier

The Tungar Rectifier is made by the

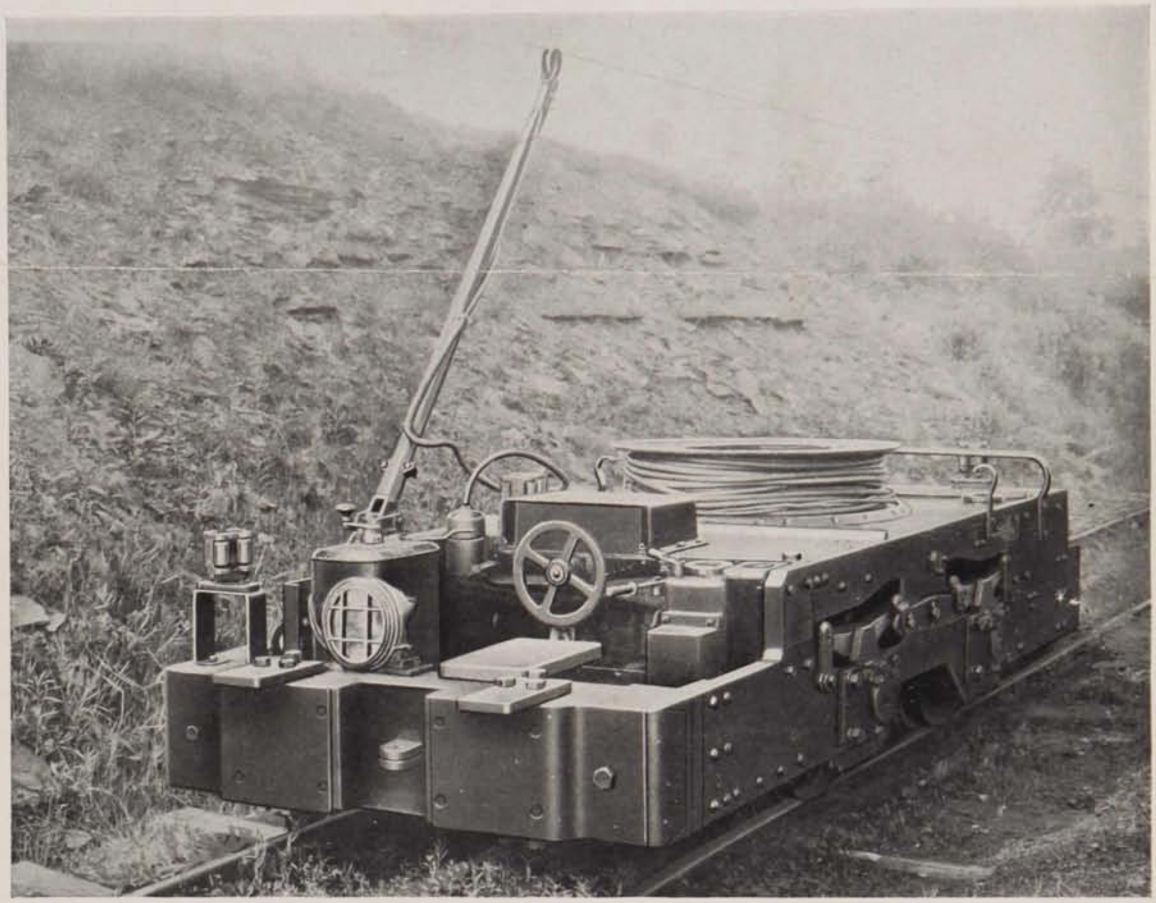
GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

MINE LOCOMOTIVES

TROLLEY TYPE—GATHERING

Equalized Leaf Springs *Electric Braking* *Improved Cable Reel*



SIX-TON GATHERING LOCOMOTIVE WITH ELECTRIC BRAKING CONTROLLER AND EQUALIZED SEMI-ELLIPTICAL LEAF SPRINGS, TYPE LME-2T6-A

The work done by gathering locomotives calls for a large amount of starting and stopping which when done by hand brakes requires a considerable amount of work on the part of the motorman. On this locomotive, BRAKING is done ELECTRICALLY by simply moving the reverse handle to the braking position and operating control handle as in starting. This scheme saves much time and reduces the wear on the brakeshoes and wheel treads as wheels do not lock.

By the use of substantial semi-elliptical LEAF SPRINGS with EQUALIZER BAR on uneven tracks the changes in wheel load are transmitted to the other wheels, thus reducing chances for derailment, improving the riding qualities of the locomotive, reducing wear on the track, and adding to the comfort of the motorman.

Ask our nearest office for complete information

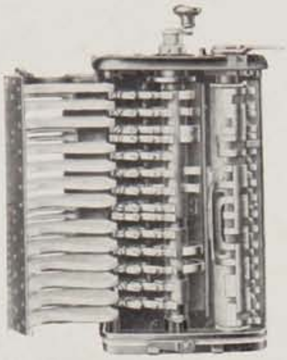
GENERAL ELECTRIC COMPANY, Schenectady, N. Y.

Sales offices in all large cities

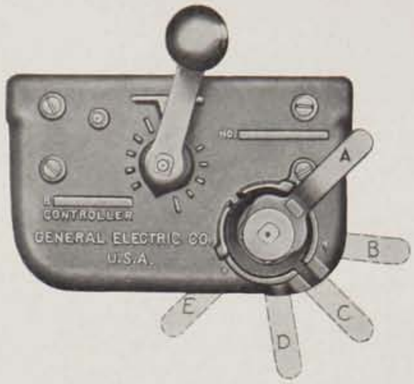
1-18-21

64200-A
Class 410

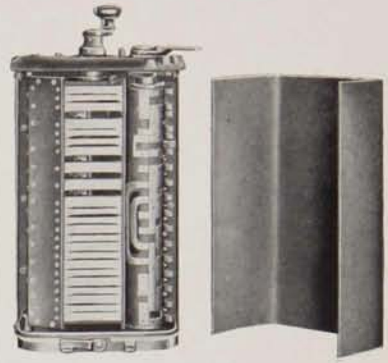
B-58 Electric Braking Controller



ARC CHUTE OPEN



A—Braking Forward
B—Motoring Forward
C—Off
D—Motoring Reverse
E—Braking Reverse



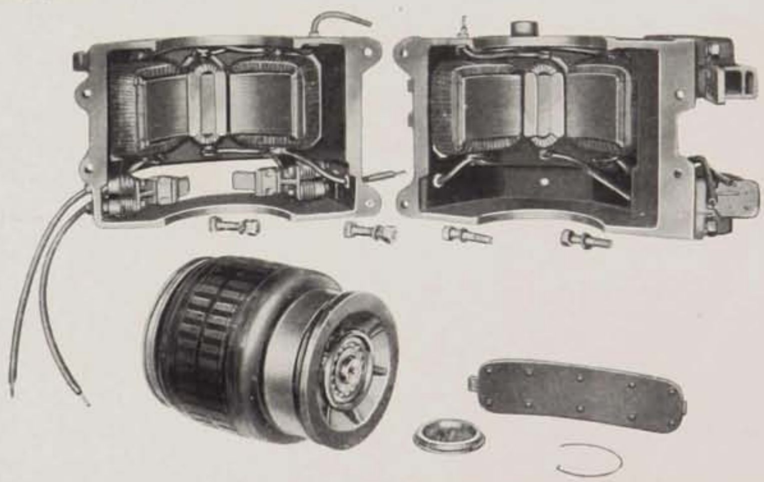
ARC CHUTE CLOSED

Why There is Economy in the Use of This Controller

The reverse cylinder of the electric braking controller on this Gathering Locomotive has four points—two for each direction of motion. The motors are connected in the regular motoring position for the first of these points. To stop, the main cylinder is thrown off, and the reverse cylinder moved to the second—or braking point. The main cylinder is again thrown on, and the motors brake the locomotive.

There is marked economy in electric braking, for it eliminates skidding and resulting flat spots on the wheels—it prevents a careless operator from reversing the motor for stops, which is a severe shock to gears, and needless use of power. The series parallel feature requires the motorman to always start in series because the first point gives series motor operation. This reduces the peak load and also power to start the trip. Slow running must be done on series points. Starting and running in series means a minimum loss in resistance and a corresponding saving of power.

Consider how these points can be applied to your requirements to give efficient service and to lower maintenance costs.

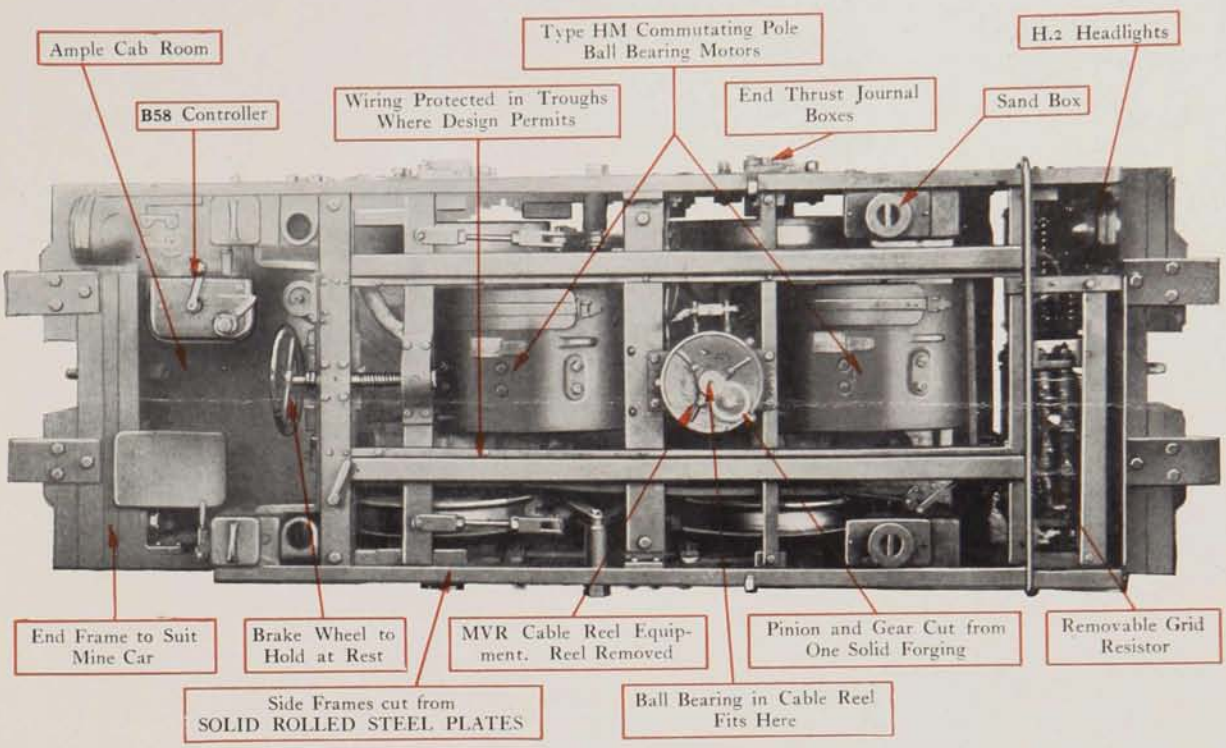


STANDARD SINGLE REDUCTION HM MOTOR, SHOWING ARMATURE REMOVED

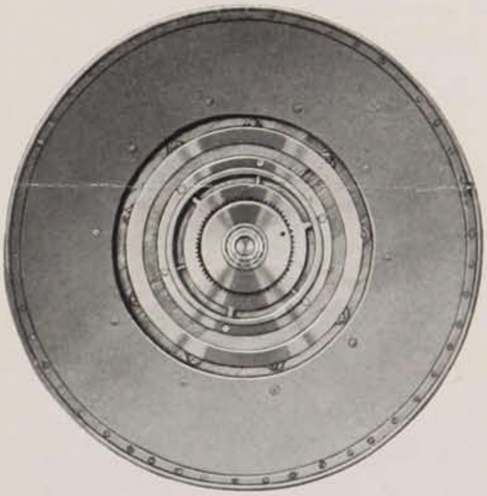
The HM motors are of the series wound, totally enclosed commutating pole, split frame type. The axle brackets and suspension lugs being on lower frame render the motor readily accessible for inspection and repairs without having to untruck. A large hand hole fitted with dust proof cover is provided over the commutator end through which commutator and brushes may be inspected. The armature is carried in separate heads clamped between the motor frames and is provided with self-aligning ball bearings. Practically the only attention required is reasonable inspection, replenishing the bearing lubricant and renewal of worn out brushes.

GATHERING LOCOMOTIVE

SHOWING CAB SPACE AND RELATIVE POSITION OF EQUIPMENT



Cable Reel Equipment



The cable reel equipment is an improved form of the vertical-axis motor-driven type that has been used successfully for a number of years. No change has been made in the ball-bearing motor but the bearing mechanism of the reel itself has been modified so as to secure greater stability and better wearing qualities. Instead of a large diameter of bearing made up of a considerable number of small balls, the reel now rotates on a heavy-duty type combination thrust and step ball bearing mounted at the center of the reel disk. The double-reduction driving train is made up entirely of forged-steel gears and heat-treated pinions. The cable reel motor is designed to give the same torque regardless of variation in voltage conditions.

FORM F ELECTRIC CABLE EQUIPMENT

GENERAL ELECTRIC COMPANY

GENERAL OFFICE: SCHENECTADY, N. Y.

SALES OFFICES (Address nearest Office)

Atlanta, Ga.......... Citizens and Southern Bank Building
Baltimore, Md.................Lexington Street Building
Birmingham, Ala..................Brown-Marx Building
Boston, Mass.........................84 State Street
Buffalo, N. Y......................Electric Building
Butte, Mont........................Electric Building
Charleston, W. Va......Charleston National Bank Building
Charlotte, N. C........Commercial National Bank Building
Chattanooga, Tenn.....................James Building
Chicago, Ill. ....Monadnock Building
Cincinnati, Ohio................Provident Bank Building
Cleveland, Ohio...................Illuminating Building
Columbus, Ohio...................The Hartman Building
Dayton, Ohio...........Dayton Savings & Trust Building
Denver, Colo................U. S National Bank Building
Des Moines, Iowa......................Hippee Building
Detroit, Mich..............Dime Savings Bank Building
Duluth Minn........................Fidelity Building
Elmira, N. Y..........................Hulett Building
Erie, Pa..........................Commerce Building
Fort Wayne, Ind......................1600 Broadway
Grand Rapids, Mich....Commercial Savings Bank Building
Hartford, Conn..........Hartford National Bank Building
Indianapolis, Ind..............Traction Terminal Building
Jacksonville, Fla...........Heard National Bank Building
Joplin, Mo.......................Miners Bank Building
Kansas City, Mo......................Dwight Building
Knoxville, Tenn.....................Burwell Building
Little Rock, Ark.................Southern Trust Building
Los Angeles, Calif...Corporation Building, 724 S. Spring St.
Louisville, Ky.........................Starks Building
Memphis, Tenn......................Exchange Building
Milwaukee, Wis..................Public Service Building
Minneapolis, Minn.................410 Third Ave., North
Nashville, Tenn.....................Stahlman Building
Newark, N. J............................671 Broad Street
New Haven, Conn..........Second National Bank Building
New Orleans, La.................Maison Blanche Building
New York, N. Y.........Equitable Building, 120 Broadway
Niagara Falls, N. Y.......................Gluck Building
Omaha, Neb..........................Electric Building
Philadelphia, Pa...................Witherspoon Building
Pittsburgh, Pa..........................Oliver Building
Portland, Ore..........................Electric Building
Providence, R. I......................Turks Head Building
Richmond, Va..........Virginia Railway & Power Building
Rochester, N. Y........................Granite Building
St. Louis, Mo...........................Pierce Building
Salt Lake City, Utah.................Newhouse Building
San Francisco, Calif......................Rialto Building
Seattle, Wash..........................Colman Building
Spokane, Wash.........................Paulsen Building
Springfield, Mass............Third National Bank Building
Syracuse, N. Y...Onondaga County Savings Bank Building
Toledo, Ohio............................Spitzer Building
Trenton N. J.........Broad Street, National Bank Building
Washington, D. C.....Commercial National Bank Building
Worcester, Mass...................State Mutual Building
Youngstown, Ohio.................. Stambaugh Building

For TEXAS, OKLAHOMA and ARIZONA Business refer to Southwest General Electric Co.

Dallas, Tex..........................Interurban Building
El Paso, Tex.....................500 San Francisco Street
Houston, Tex...............Third and Washington Streets
Oklahoma City, Okla.................1 West Grande Ave.

For HAWAIIAN Business refer to Catton, Neill & Co., Ltd., Honolulu

Motor and Lamp Agencies in all large cities and towns

Distributors for the General Electric Company outside of the United States

INTERNATIONAL GENERAL ELECTRIC COMPANY INC.

New York City 120 Broadway	General Sales Offices Schenectady, N. Y.	London 83 Cannon St.

AGENTS AND REPRESENTATIVES

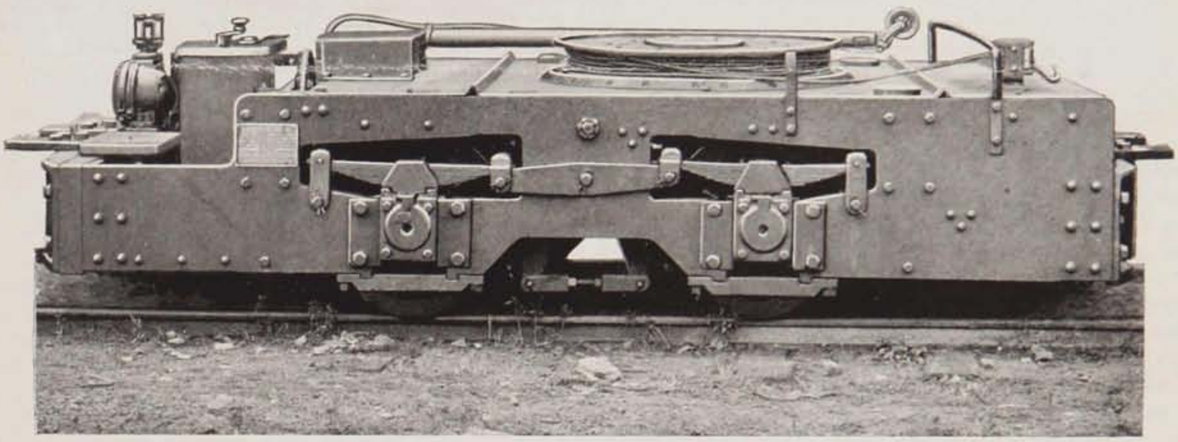
ARGENTINA: General Electric, S. A., Buenos Aires
AUSTRALIA: Australian General Electric Company, Ltd., Sydney and Melbourne
BELGIUM AND COLONIES: Societe d' Electricite et de Mecanique Procedes Thomson-Houston & Carels Societe Anonyme, Brussels, Belgium
BOLIVIA: International Machinery Company, La Paz and Oruro
BRAZIL: General Electric, S. A., Rio de Janeiro and Sao Paulo
CANADA: Canadian General Electric Company, Ltd., Toronto
CHILE: International Machinery Company, Santiago, Antofagasta and Valparaiso
CHINA: Andersen, Meyer & Company, Ltd., Shanghai. International General Electric Company (General Office for the Far East excluding Japan and China), Shanghai
COLOMBIA: Wesselhoeft & Poor, Bogota, Barranquilla and Medellin
CUBA: General Electric Company of Cuba, Havana
DUTCH EAST INDIES: International General Electric Company, Inc., Soerabaia, Java
ECUADOR: Carlos Cordovez, Guayaquil and Quito
EGYPT: British Thomson-Houston Company, Ltd., Cairo
FRANCE AND COLONIES: Compagnie Francaise Thomson-Houston, 10 Rue de Londres, Paris
GREAT BRITAIN AND IRELAND: British Thomson-Houston Company, Ltd., Rugby, England. International General Electric Company, Inc., London, E. C., 4
GREECE AND COLONIES: Compagnie Francaise Thomson-Houston, Paris, France
INDIA: British Thomson-Houston Company, Ltd., Calcutta and Bombay. International General Electric Company, Inc., Calcutta
ITALY AND COLONIES: Franco Tosi Societa Anonima, Milan
JAPAN: Shibaura Engineering Works, Tokyo. Tokyo Electric Company, Ltd., Kawasaki, Kanagawa-Ken
MEXICO: Mexican General Electric Company, City of Mexico and Guadalajara
NEW ZEALAND: National Electrical and Engineering Company, Ltd., Auckland, Dunedin, Christchurch and Wellington
PARAGUAY: General Electric, S. A., Buenos Aires, Argentina
PERU: W. R. Grace & Company, Lima
PHILIPPINE ISLANDS: Pacific Commercial Company, Manila
PORTO RICO: International General Electric Company, Inc., San Juan
PORTUGAL AND COLONIES: Compagnie Francaise Thomson-Houston, Agence d'Espagne, Madrid
RUSSIA: Wseobshtchaia Electricheskaia Kompania, Petrograd and Vladivostok
SOUTH AFRICA: South African General Electric Company, Ltd., Johannesburg and Capetown
SPAIN AND COLONIES: Compagnie Francaise Thomson-Houston, Agence d'Espagne, Madrid
URUGUAY: General Electric, S. A., Montevideo
VENEZUELA: Wesselhoeft & Poor, Caracas

12-20

MINE LOCOMOTIVES

TROLLEY TYPE—GATHERING

Equalized Leaf Spring *Electric Braking* *Improved Cable Reel*



Six-ton Gathering Locomotive with Electric Braking Controller and Equalized Semi-elliptic Leaf Springs, Type LME-2T6-A

The work done by gathering locomotives calls for a large amount of starting and stopping which when done by hand brakes requires a considerable amount of work on the part of the motorman. On this locomotive, BRAKING is done ELECTRICALLY by simply moving the reverse handle to the braking position and operating control handle as in starting. This scheme saves much time and reduces the wear on the brakeshoes and wheel treads as wheels do not lock.

By the use of substantial semi-elliptic LEAF SPRINGS with EQUALIZER BAR on uneven tracks the changes in wheel load are transmitted to the other wheels, thus reducing chances for derailment, improving the riding qualities of the locomotive, reducing wear on the track, and adding to the comfort of the motorman.

Ask our nearest office for complete information

General Electric Company, Schenectady, N. Y.

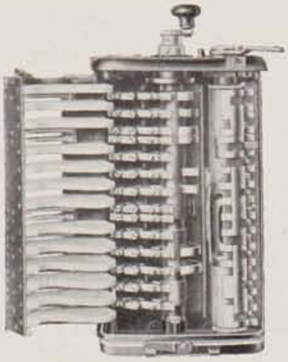
SALES OFFICES IN ALL LARGE CITIES

(OVER)

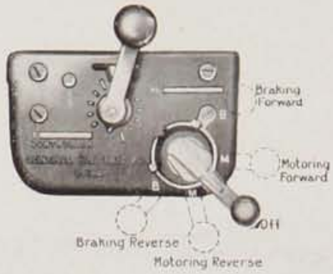
8-23-21

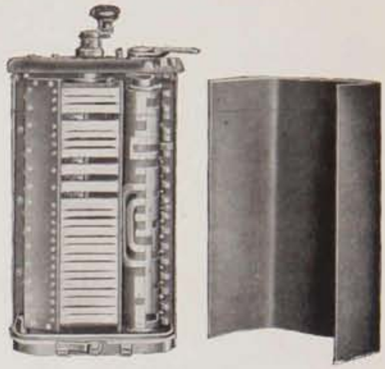
64200-B
Class 411

B-58 Electric Braking Controller



Arc Chute Open





Arc Chute Closed

Why There is Economy in the Use of This Controller

The reverse cylinder of the electric braking controller on this Gathering Locomotive has four points—two for each direction of motion. The motors are connected in the regular motoring position for the first of these points. To stop, the main cylinder is thrown off, and the reverse cylinder moved to the second—or braking point. The main cylinder is again thrown on, and the motors brake the locomotive.

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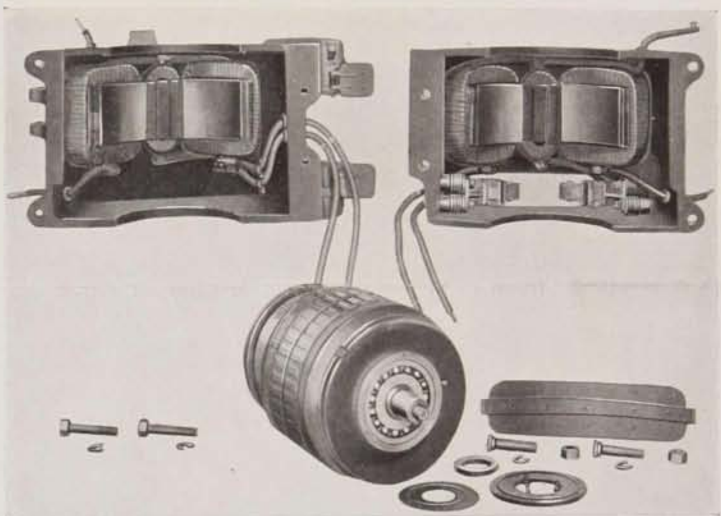
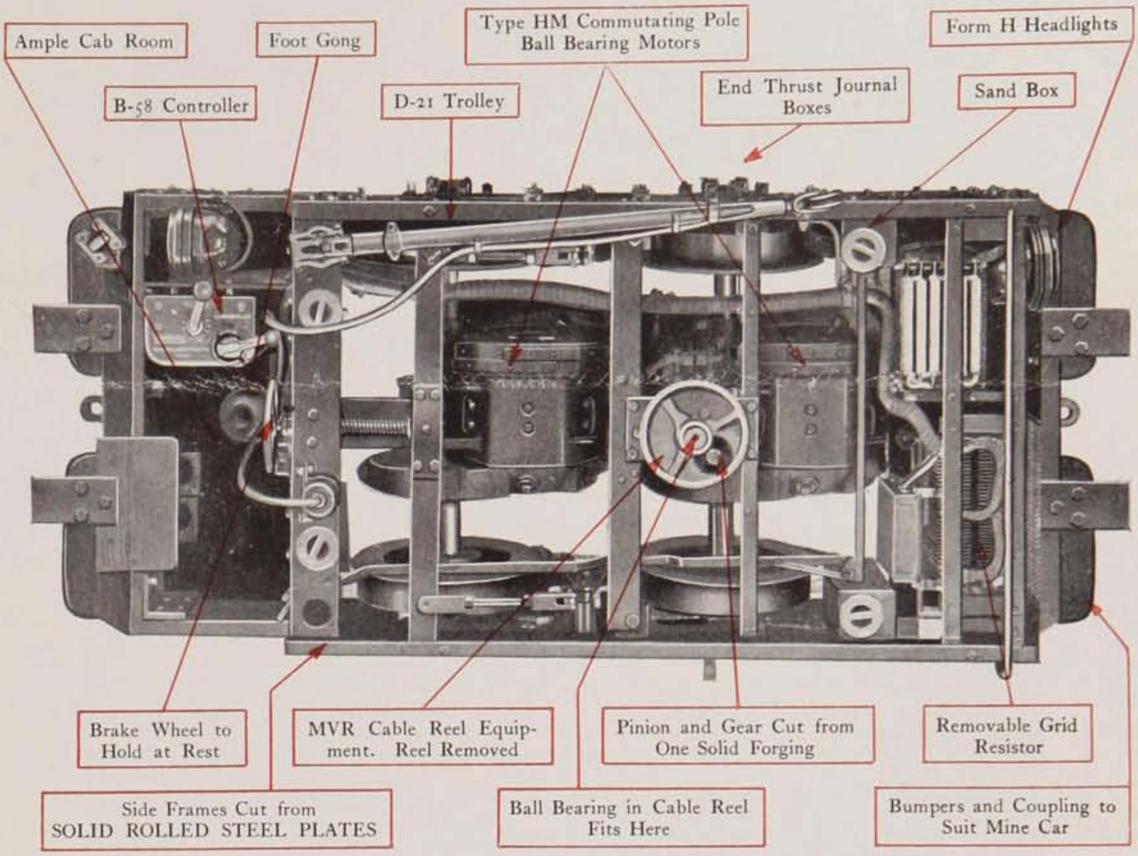
Consider how these points can be applied to your requirements to give efficient service and to lower maintenance costs.



STANDARD SINGLE REDUCTION HM MOTOR PARTLY DISASSEMBLED

The HM motors are of the series wound, totally enclosed commutating pole, split frame type. The axle brackets and suspension lugs being on lower frame render the motor readily accessible for inspection and repairs without having to untruck. A large handhole fitted with dust proof cover is provided over the commutator end through which commutator and brushes may be inspected. The armature is carried in separate heads clamped between the motor frames and is provided with self-aligning ball bearings. Practically the only attention required is reasonable inspection, replenishing the bearing lubricant and renewal of worn out brushes.

Gathering Locomotive Showing Cab Space and Relative Position of Equipment

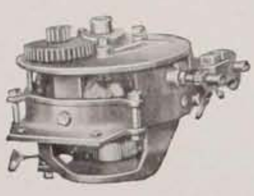


Electric Cable Reel Equipment

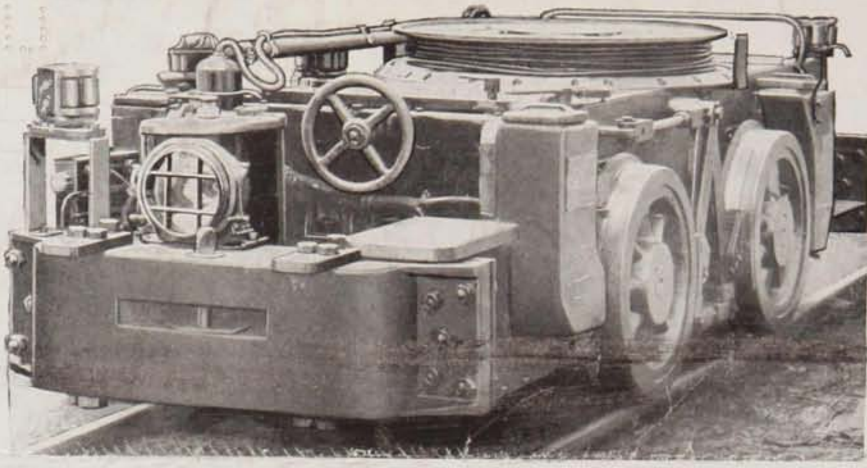
The electric cable reel equipment is an improved form of the vertical axis motor-driven type that has been used successfully for a number of years. These cable reels are self-contained and can be installed on a locomotive by providing two supporting bars and arranging the deck covers of the locomotive to conform. Accessory parts consist of cable guides, motor resistors, switch for reel motor circuit, and a transfer switch for changing the locomotive circuit from reel to trolley.

The reel rotates on a heavy duty type combination thrust and radial ball-bearing mounted at the center of the reel casting. The intermediate gear and pinion are cut from one solid blank and the internal gear is cut from a forged steel ring. The gearing is heat treated which results in long life.

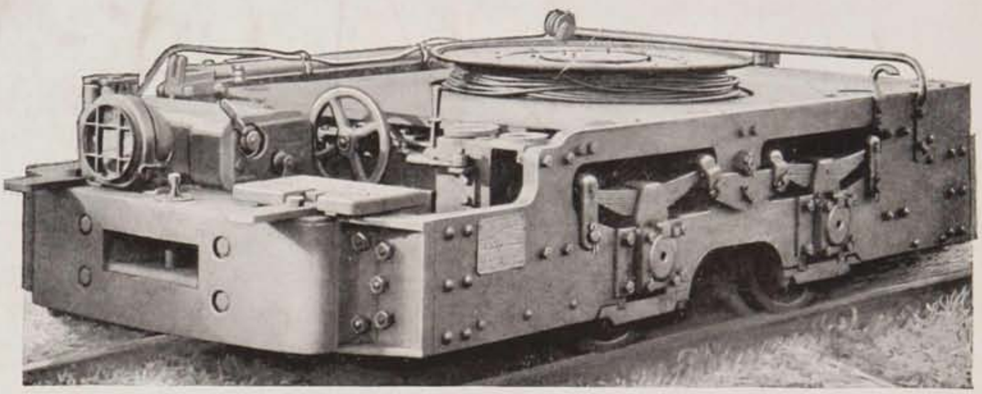
When using the cable reel, the cable hook is attached to the trolley wire in the entry opposite the room neck. The transfer switch is then thrown to the proper position, the reel motor switch snapped on, and the trolley pulled down. The cable reel motor automatically acts as a brake when paying out cable and immediately winds it up when the direction of the locomotive travel is reversed. The action is analogous to that of a spring having infinite length.



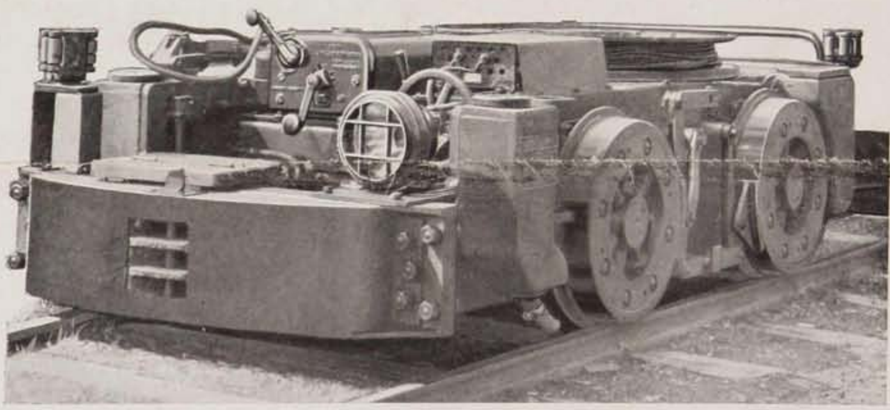
Form F Motor and Reel



6-ton Gathering Locomotive with Electric Braking Controller and Coil Journal Springs—Type LM-2T6-NN



Low Height, 4-ton Gathering Locomotive with Electric Braking Controller and Equalized Semi-elliptic Leaf Springs—Type LME-2T4-C



Low Height, 4-ton Gathering Locomotive with Electric Braking Controller, Coil Journal Springs and Demountable Steel Tires—Type LM-2T4-GG

SMALL TRANSFORMERS AND AUTO-TRANSFORMERS

TYPE M TRANSFORMERS FOR USE IN CONDUIT WIRING INSTALLATIONS

Fig. 1.
Transformer for Conduit Wiring Installations

This design is particularly adapted to lighting oil well rigs, irrigation plants, mines and to other uses where conduit wiring is required.

Caps are provided with nipples threaded at both ends through which 12-in. leads are brought out. This arrangement permits the ready attachment of standard conduit fittings.

PRIMARY 440 VOLTS—SECONDARY 110 VOLTS—50/140 Cycles

Cat. No.	Watts	WT. IN LB.		DIMENSIONS IN INCHES	
		Net	Ship.	Depth	Wall Space
236154	100	13	15	3⅞	7¼ by 4⅞ 8¾ by 4⅞*
236155	250	18	20	3⅞	8⅝ by 4⅞ 10⅛ by 4⅞*
236156	500	30	35	4½	9⅝ by 5½ 11⅛ by 5½*

* Overall dimensions, including nipples.

INSULATING TRANSFORMERS

Fig. 2.
Insulating Transformer

Insulating Transformers, arranged for 1:1 or 2:1 ratio, are for such uses as insulating lighting from power circuits, insulating telephone circuits (before rectification) from lighting circuits, etc.

Due to the series-multiple feature of both primary and secondary, these transformers can also be used for transforming 220-volt circuits to 110, or 110-volt circuits to 220, and 110 or 220 to 220/110, 3-wire.

PRIMARY 110/220 VOLTS—SECONDARY 110/220 VOLTS—50/140 Cycles

Cat. No.	Type	Kv-a.	DIMENSIONS IN INCHES		WT. IN LB.	
			Depth	Wall Space	Ship.	Net
166688	M	1	5⅛	11⅛ by 6½	45	35
166690	M	2	6	12⅜ by 7⅝	75	60
166692	M	3	6	14¼ by 7⅝	100	80
189911	M	5	7⅝	15¼ by 9⅝	145	125
177157	H	7.5	26	*18 by 18½	475	390
179474	H	10	28½	*18½ by 21	560	460
179475	H	15	32	*22 by 22½	825	685
236300	H	25	42	*24 by 24½	1205	995

* Floor space.

INSULATING TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 110/220 VOLTS—SECONDARY 110/220 VOLTS—50/140 Cycles

Cat. No.	Type	Kv-a.	Depth	Wall Space	Ship.	Net
245327	M	1	5⅛	10 by 6½ 11½ by 6½*	45	35
245328	M	2	6	10⅞ by 7⅝ 12⅜ by 7⅝*	75	60
245329	M	3	6	12¾ by 7⅝ 14¼ by 7⅝*	100	80
245330	M	5	7⅝	14¼ by 9⅝ 15¾ by 9⅝*	145	125

* Overall dimensions, including nipples.
Appearance like Fig. 1.

SIGN LIGHTING TRANSFORMERS

Fig. 3.
Transformer for Sign Lighting

Sign Lighting Transformers are designed for use in connection with the lighting of large or small advertising, municipal, civic or other display signs.

Primary windings are arranged for series-multiple and may therefore be connected to either 110- or 220-volt circuits. Secondaries are similarly arranged to give full output at 11 or 22 volts.

These designs are provided with lugs for fastening to wall or to the back of the sign, and can be readily connected to all signs without changing their wiring.

PRIMARY 110/220 VOLTS—SECONDARY 11/22 VOLTS—50/140 Cycles

Watts Cap.	Cat. No.	Ship. Wt. in. Lb.	DIMENSIONS IN INCHES	
			Depth	Wall Space
250	76676	20	3⅝	8⅛ by 4⅞
500	76678	30	4¼	9⅛ by 5½
750	146138	40	4¼	9⅞ by 5½
1000	76680	50	4⅞	11 by 6½
1500	146139	55	4⅞	11¾ by 6½
2000	76683	80	5⅜	12⅜ by 7⅝

AUTO-TRANSFORMERS

Fig. 4.
Auto-transformer for Two- or Three-wire Service

Auto-transformers are economical substitutes for ordinary transformers. They are of particular value where both voltages are low, or where a comparatively small change in voltage is required.

They are designed for single-phase, two-phase and open delta transformation, but are not satisfactory for transforming power three to two-phase, or vice versa, as special taps must be provided to obtain the proper voltage ratio. (*Auto-transformers continued—See other side.*)

GENERAL ELECTRIC COMPANY

AUTO-TRANSFORMERS

PRIMARY 220 VOLTS—SECONDARY 110 VOLTS, 2-WIRE OR 110/220 3-WIRE—50/140 Cycles

Cat. No.	Type	*Kv-a.	DIMENSIONS IN INCHES Depth	Wall Space
79883	M	1	4½	8⅞ by 5½
79884	M	1.5	5⅛	10⅜ by 6½
79885	M	2	5⅛	10⅞ by 6½
79886	M	3	5⅛	12 by 6½
79887	M	4	6	12⅜ by 7⅝
79888	M	5	6	13 by 7⅝
189909	M	7.5	7⅝	9⅝ by 14¼
183910	M	10	7⅝	9⅝ by 15⅜
79891	H	15	**26	†18½ by 18

* Kv-a. output at 110 volts, 2-wire or allowable unbalancing at 110/220 volts, 3-wire.
** Height.
† Floor space.

Fig. 5.
Three- or Two-phase Auto-transformer

AUTO-TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 220 VOLTS—SECONDARY 110 VOLTS, 2-WIRE OR 110/220, 3-WIRE—50/140 Cycles

245345	M	1	4½	8 by 5½
245346	M	1.5	5⅛	9¼ by 6½
245347	M	2	5⅛	9¾ by 6½
245348	M	3	5⅛	10⅞ by 6½
245349	M	4	6	10¾ by 7⅝
245350	M	5	6	11½ by 7⅝
245351	M	7.5	7⅝	13 by 9⅝
245352	M	10	7⅝	14⅛ by 9⅝

Appearance like Fig. 1.

Fig. 6.
Transformer for Signal Lighting

AUTO-TRANSFORMERS (THREE TO TWO-PHASE)

MTQ Auto-transformers are designed to transform power efficiently and cheaply from three to two-phase, 4-wire, or vice-versa, with outputs of 1 to 25 kv-a.

The principal application of the MTQ Auto-transformer is to adapt polyphase motors to existing circuits. They are not suitable, however, for 3-wire, 2-phase service, or to operate motors with inter-connected phases.

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 4-WIRE—50/140 Cycles

Cat. No.	Type	Kv-a. Output	DIMENSIONS IN INCHES Depth	Wall Space
223996	MTQ	1	4	13⅜ by 3¾
223997	MTQ	3	3⅞	16⅛ by 4⅞
223998	MTQ	5	4½	16¼ by 5½
223999	MTQ	7.5	5⅛	18¼ by 6½
224000	MTQ	10	5⅛	20 by 6½
224001	MTQ	15	6	18⅛ by 7⅝
224002	MTQ	20	6	20¼ by 7⅝
224003	MTQ	25	6	22¼ by 7⅝

Fig. 7.
Transformer for Heavy Currents at Low-voltage

AUTO-TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 4-WIRE—50/140 Cycles

245331	MTQ	1	4	12½ by 3¾ 14 by 3¾*
245332	MTQ	3	3⅞	13⅝ by 4⅞ 15⅛ by 4⅞*
245333	MTQ	5	4½	13¾ by 5½ 15¼ by 5½*
245334	MTQ	7.5	5⅛	15⅝ by 6½ 17⅛ by 6½*
245335	MTQ	10	5⅛	17¼ by 6½ 18¾ by 6½*
245336	MTQ	15	6	16¼ by 7⅝ 17¾ by 7⅝*
245337	MTQ	20	6	18¼ by 7⅝ 19¾ by 7⅝*
245338	MTQ	25	6	20⅜ by 7⅝ 21⅞ by 7⅝*

*Overall dimensions, including nipples.
Appearance like Fig. 1.

GENERAL

Transformers built on Type M parts are suitable for use on circuits 600 volts and below—capacities 15–5000 watts, 50 to 140 cycles and to 3000 watts, 25 to 49 cycles.

Many requirements for small transformers, however, are special but with this developed line of parts any such transformers may be built at a minimum of expense for development and the assurance of correct design, high class material and workmanship being employed. Illustrations Figs. 6 and 7 are specials. The following are some of the many uses to which Type M transformers are adapted:

- Low voltage heavy current testing equipment.
- Special transformers for indoor service.
- Compensators for 3-wire generators.
- Railway signal lighting.
- Operation of small low voltage motors from higher voltage circuits.

NOTE:—Type M Transformers are air-cooled. Type H are oil-cooled. Suspension hooks are furnished with Type H sizes. All sizes are suitable for either indoor or outdoor installation. Information on 25-cycle designs upon request.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Small Transformers and Auto-Transformers

The General Electric Company, after a complete investigation of the various demands for transformers of small capacity, at low voltage, has developed a uniform line of parts for manufacturing miniature air-cooled transformers (Type M), ranging from 15 to 5000 watts inclusive, 60 cycles, and to 3000 watts inclusive, 25 cycles, at voltages 600 and below.

Type M transformers are sufficiently attractive to permit of their installation in any place where good appearance is desired or necessary, and the construction may be for indoor or outdoor service.

The broad use of alternating current and the economy and ease with which its voltage and current may be varied through the medium of the Type M transformer to meet various requirements, has made alternating current preferable in all applications not inherently requiring direct current. The following pages list lines of Type M transformers and auto-transformers which have been standardized.

INSULATING TRANSFORMERS

Fig. 1
Type M Insulating Transformer

Fig. 2
Type M Insulating Transformer for Conduit Wiring Installations

Insulating Transformers, arranged for 1:1 or 2:1 ratio, are for such uses as insulating lighting from power circuits, insulating telephone circuits (before rectification) from lighting circuits, etc.

Due to the series-multiple feature of both primary and secondary, these transformers can also be used for transforming 220-volt circuits to 110, or 110-volt circuits to 220, and 110 or 220 to 220/110, 3-wire.

PRIMARY 110/220 VOLTS—SECONDARY 110/220 VOLTS—50/140 CYCLES

Type	Kv-a.	Cat. No.	List Price	DIMENSIONS IN INCHES (APPROX.)		WT. IN LB. (APPROX.)	
				Depth	Wall Space	Net	Ship.
M	1	166688	$55	5	11 by 6½	35	45
M	2	166690	75	6	12½ by 7½	60	75
M	3	166692	90	6	14½ by 7½	80	100
M	5	189911	130	7½	15½ by 9½	125	145
H	7.5	177157	135	**26	*18 by 18½	390	475
H	10	179474	165	**28½	*18½ by 21	460	560
H	15	179475	215	**32	*22 by 22½	685	825
H	25	236300	315	**42	*24 by 24½	995	1205

* Floor space.
** Height.

INSULATING TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 110/220 VOLTS—SECONDARY 110/220 VOLTS—50/140 CYCLES

M	1	245327	58	5	10 by 6½ 11½ by 6½*	35	45
M	2	245328	78	6	11 by 7½ 12½ by 7½*	60	75
M	3	245329	94	6	13 by 7½ 14½ by 7½*	80	100
M	5	245330	135	7½	14½ by 9½ 16 by 9½*	125	145

* Overall dimensions, including nipples.

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Sales Offices in all large cities

Mu

SIGN LIGHTING TRANSFORMERS

Sign Lighting Transformers are designed for use in connection with the lighting of large or small advertising, municipal, civic or other display signs.

Primary windings are arranged for series-multiple and may therefore be connected to either 110- or 220-volt circuits. Secondaries are similarly arranged to give full output at 11 or 22 volts.

These designs are provided with lugs for fastening to wall or to the back of the sign, and can be readily connected to all signs without changing their wiring.

Fig. 3
Transformer for Sign Lighting

PRIMARY 110/220 VOLTS—SECONDARY 11/22 VOLTS—50/140 CYCLES

Watts Cap.	Cat. No.	List Price	DIMENSIONS IN INCHES (APPROX.)		WT. IN LB. (APPROX.)	
			Depth	Wall Space	Net	Ship.
250	76676	$25	3½	8 by 5	15	20
500	76678	35	4½	9 by 5½	20	30
750	146138	40	4½	10 by 5½	25	40
1000	76680	50	5	11 by 6½	35	50
1500	146139	55	5	12 by 6½	40	55
2000	76683	75	5½	12½ by 7½	60	80

TYPE M TRANSFORMERS FOR USE IN CONDUIT WIRING INSTALLATIONS

This design is particularly adapted to lighting oil well rigs, irrigation plants, mines and to other uses where conduit wiring is required.

Caps are provided with nipples threaded at both ends through which 12-in. leads are brought out. This arrangement permits the ready attachment of standard conduit fittings.

Fig. 4
Transformer for Conduit Wiring Installations

PRIMARY 440 VOLTS—SECONDARY 110 VOLTS—50/140 CYCLES

Cat. No.	Watts	DIMENSIONS IN INCHES (APPROX.)		WT. IN LB. (APPROX.)	
		Depth	Wall Space	Net	Ship.
236154	100	4	7½ by 5 9 by 5*	13	15
236155	250	4	8½ by 5 10 by 5*	18	20
238156	500	4½	9½ by 5½ 11 by 5½*	30	35

* Overall dimensions, including nipples

NOTE:—Prices on Type M Transformers for Conduit Wiring installations furnished on request.

AUTO-TRANSFORMERS vs. TRANSFORMERS

When a comparatively small change in voltage is desired, or where both voltages are low, an auto-transformer can be used as successfully as a transformer and its reduced capacity will mean a considerable saving. Figure 5 shows the arrangement of an auto-transformer to obtain three-wire, 110/220-volt service from a 220-volt supply line.

The use of auto-transformers for supplying lighting circuits from power circuits having potentials above 250 volts is not, however, considered good practice.

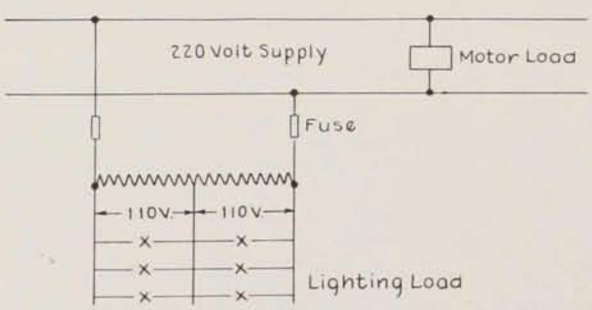


Fig. 5

AUTO-TRANSFORMERS

Auto-transformers are economical substitutes for ordinary transformers. They are of particular value where both voltages are low, or where a comparatively small change in voltage is required.

They are designed for single-phase, two-phase and open delta transformation, but are not satisfactory for transforming power three- to two-phase, or vice versa, as special taps must be provided to obtain the proper voltage ratio.

Fig. 6
Type M Auto-transformer for Two- or Three-wire Service

Fig. 7
Type M Auto-transformer for Conduit Wiring Installations

AUTO-TRANSFORMERS

PRIMARY 220 VOLTS—SECONDARY 110 VOLTS, 2-WIRE OR 110/220 3-WIRE—50/140 CYCLES

Type	†Kv-a.	Cat. No.	List Price	Dimensions in Inches (Approx.)		Wt. in Lb. (Approx.)	
				Depth	Wall Space	Net	Ship.
M	1	79883	$30	4½	9 by 5½	20	30
M	1.5	79884	40	5	10½ by 6½	30	40
M	2	79885	50	5	11 by 6½	35	45
M	3	79886	62	5	12 by 6½	40	50
M	4	79887	75	6	12½ by 7½	50	60
M	5	79888	87	6	13 by 7½	65	80
M	7.5	189909	120	7½	14 by 9½	110	130
M	10	189910	150	7½	15½ by 9½	130	155
H	15	79891	230	**26	*18½ by 18	385	465

** Height. * Floor space.

AUTO-TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 220 VOLTS—SECONDARY 110 VOLTS, 2-WIRE OR 110/220, 3-WIRE—50/140 CYCLES

Type	†Kv-a.	Cat. No.	List Price	Depth	Wall Space	Net	Ship.
M	† 1	245345	33	4½	8 by 5½ 9½ by 5½*	20	30
M	1.5	245346	43	5	9½ by 6½ 11 by 6½*	30	40
M	2	245347	53	5	10 by 6½ 11½ by 6½*	35	45
M	3	245348	65	5	11 by 6½ 12½ by 6½*	40	50
M	4	245349	78	6	11 by 7½ 12½ by 7½*	50	60
M	5	245350	90	6	11½ by 7½ 13 by 7½*	65	80
M	7.5	245351	123	7½	13 by 9½ 14½ by 9½*	110	130
M	10	245352	153	7½	14 by 9½ 15½ by 9½*	130	155

* Overall dimensions including nipples.
† Kv-a. output at 110 volts, 2-wire or allowable unbalancing at 110/220 volts, 3-wire.

MTQ AUTO-TRANSFORMERS (THREE TO TWO-PHASE)

MTQ Auto-transformers are designed to transform power efficiently and cheaply from three- to two-phase, 4-wire, or vice versa, with outputs of 1 to 25 kv-a.

The principal application of the MTQ Auto-transformer is to adapt polyphase motors to existing circuits. They are not suitable, however, for 3-wire, 2-phase service, or to operate motors with interconnected phases.

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 4-WIRE—50/140 CYCLES

Fig. 8
Three- or Two-phase Auto-transformer

Type	† Kv-a. Output	Cat. No.	List Price	Dimensions in Inches (Approx.)		Wt. in Lb. (Approx.)	
				Depth	Wall Space	Net	Ship.
MTQ	1	223996	$ 72	4	13½ by 4	15	25
MTQ	3	223997	82	4	16 by 5	30	40
MTQ	5	223998	100	4½	16½ by 5½	45	55
MTQ	7.5	223999	118	5	18 by 6½	55	70
MTQ	10	224000	132	5	20 by 6½	75	90
MTQ	15	224001	150	6	19½ by 7½	95	115
MTQ	20	224002	168	6	21½ by 7½	115	140
MTQ	25	224003	190	6	24 by 7½	135	160

MTQ AUTO-TRANFSORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 4-WIRE—50/140 CYCLES

Type	† Kv-a. Output	Cat. No.	List Price	Depth	Wall Space	Net	Ship.
MTQ	†1	245331	77	4	12½ by 3¾ 14 by 3¾*	15	25
MTQ	3	245332	87	4	15 by 5 16½ by 5 *	30	40
MTQ	5	245333	105	4½	15½ by 5½ 17 by 5½*	45	55
MTQ	7.5	245334	123	5	17 by 6½ 18½ by 6½*	55	70
MTQ	10	245335	137	5	19 by 6½ 20½ by 6½*	75	90
MTQ	15	245336	155	6	18 by 7½ 19½ by 7½*	95	115
MTQ	20	245337	173	6	20 by 7½ 21½ by 7½*	115	140
MTQ	25	245338	195	6	21½ by 7½ 23 by 7½*	135	160

* Overall dimensions, including nipples. † Kv-a. output at 220 volts, 4-wire.
Appearance like Fig. 4

NOTE:—Orders for MTQ Auto-transformers listed should not be placed without first ascertaining whether the two-phase circuit is 3- or 4-wire, in that an Auto-transformer arranged for a 4-wire circuit is not applicable to a 3-wire circuit or vice versa.

MTQ AUTO-TRANSFORMERS (THREE- TO TWO-PHASE)

MTQ Auto-transformers are designed to transform power efficiently and cheaply from three- to two-phase, 3-wire, or vice versa, with outputs of 1 to 25 kv-a.

The principal application of the MTQ Auto-transformer is to adapt polyphase motors to existing circuits. They are not suitable, however, for 4-wire, 2-phase service, or to operate motors with interconnected phases.

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 3-WIRE—50/140 CYCLES


Fig. 9
Three- or Two-phase Auto-transformer

Type	† Kv-a. Output	Cat. No.	List Price	Dimensions in Inches (Approx.)		Wt. in Lb. (Approx.)	
				Depth	Wall Space	Net	Ship.
MTQ	1	246751	$77	4	13 by 5	25	35
MTQ	3	246752	87	4½	15½ by 5½	35	45
MTQ	5	246753	105	5	18½ by 6½	65	75
MTQ	7.5	246754	123	5	20½ by 6½	80	95
MTQ	10	246755	137	6	19 by 7½	95	115
MTQ	15	246756	155	6	22 by 7½	130	150
MTQ	20	246757	178	6	25 by 7½	160	180
MTQ	25	246758	205	7½	22½ by 9½	185	210

MTQ AUTO-TRANSFORMERS FOR CONDUIT WIRING INSTALLATIONS

PRIMARY 220 VOLTS, THREE-PHASE—SECONDARY 220 VOLTS, TWO-PHASE, 3-WIRE— 50/140 CYCLES

Type	† Kv-a. Output	Cat. No.	List Price	Depth	Wall Space	Net	Ship.
MTQ	† 1	246759	82	4	12 by 5 13½ by 5 *	25	35
MTQ	3	246760	92	4½	14½ by 5½ 16 by 5½*	35	45
MTQ	5	246761	110	5	17½ by 6½ 19 by 6½*	65	75
MTQ	7.5	246762	128	5	19 by 6½ 20½ by 6½*	80	95
MTQ	10	246763	142	6	17½ by 7½ 19 by 7½*	95	115
MTQ	15	246764	160	6	20½ by 7½ 22 by 7½*	130	150
MTQ	20	246765	183	6	23½ by 7½ 25 by 7½*	160	180
MTQ	25	246766	210	7½	21 by 9½ 22½ by 9½*	185	210

* Overall dimensions, including nipples. Appearance like Fig. 4. † Kv-a. output at 220 volts, 3-wire.

NOTE:—Orders for MTQ Auto-transformers listed should not be placed without first ascertaining whether the two-phase circuit is 3- or 4-wire, in that an Auto-transformer arranged for a 3-wire circuit is not applicable to a 4-wire circuit or vice versa.

SPECIAL PROPOSITIONS

Many requirements for small transformers are special but with this developed line of parts any such transformers may be built at a minimum expense for development with the assurance of correct design, high grade material and workmanship being employed. Should the requirements be outside the standard ratings listed in this bulletin, propositions on special transformers may be secured from the nearest district office. Your request should state the voltage and frequency of the supply circuit available, the voltage at which the energy is to be utilized and the amount of energy to be transformed (Kv-a.).

The following are some of the many uses to which Type M transformers are adapted:

- Low voltage heavy current testing equipment.
- Special transformers for indoor service.
- Compensators for 3-wire generators.
- Operation of small low voltage motors from higher voltage circuits.
- Deriving 110-volt lighting from 220-volt supply.

NOTE:—Type M Transformers are air-cooled. Type H are oil-cooled. Suspension hooks are furnished with Type H sizes. All sizes are suitable for either indoor or outdoor installation. Information on 25-cycle designs upon request.

GENERAL ELECTRIC COMPANY

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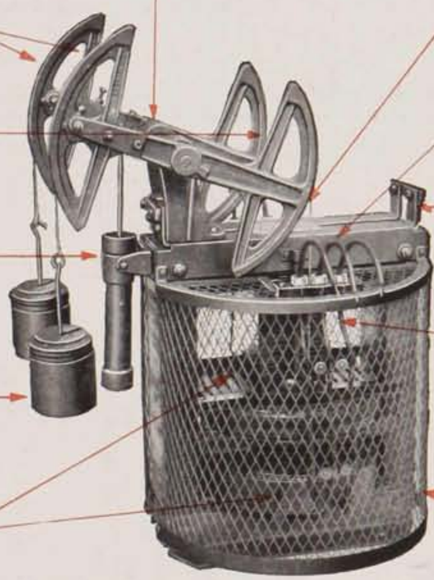
*Southwest General Electric Company

INTERNATIONAL GENERAL ELECTRIC CO., INC.
120 Broadway, New York City, and Schenectady, N. Y.
REPRESENTATIVES AND AGENTS IN ALL COUNTRIES

CONSTANT CURRENT TRANSFORMER

TYPE RV

Standard, 60 Cycles, 2300 Volts, Primary; 6.6 or 7.5 Amperes Secondary.
Can be furnished for any Primary Voltage up to 5000 Volts.
Any Frequency or any Secondary Current.
For Primary Voltage over 5000 Volts, Specify Type RJ.



Type RV Constant Current Transformer

The Constant Current Transformer is a single piece of apparatus which:

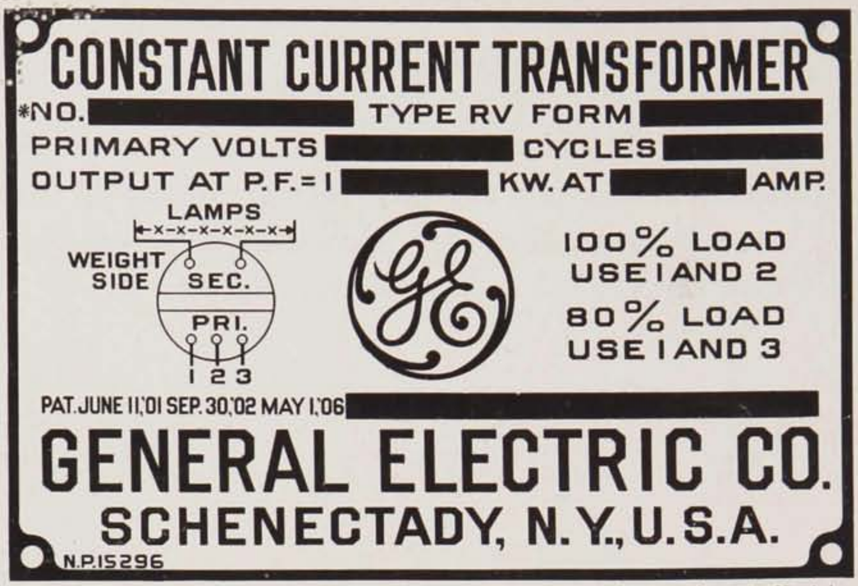
- **Insulates load circuit from supply circuit.**
- **Requires no skilled labor for operating or adjusting.**
- **Delivers the correct current to load circuit under *all* conditions of supply and load without change of adjustment.**
- **Protects lamps against variations of supply voltage or frequency, and against changes of load due to grounds or short circuits.**

GENERAL ELECTRIC COMPANY

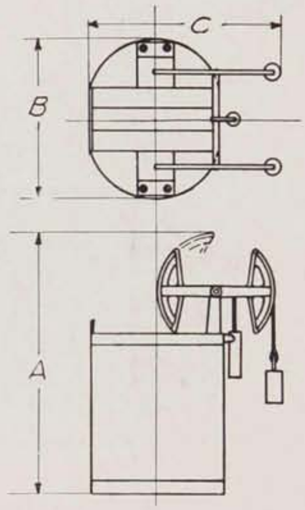
SCHENECTADY, N. Y.

(OVER)

DIMENSIONS AND WEIGHTS—TYPE RV TRANSFORMERS



* Note—All correspondence should bear reference to the rating given on the name plate, the No. being extremely important.



Cat. No.	Kw.	Amps.	Dimensions in Inches			Approx. Wt. in Lb.	
			A	B	C	Net	Ship.
197089	5	6.6	34	17	23	300	500
197091	10	6.6	37	20	25	475	650
197093	15	6.6	40	23	28	650	850
197095	20	6.6	44	25	30	800	1000
197097	25	6.6	48	27	34	1050	1450
197099	30	6.6	53	28	38	1250	1600

General Electric Company

General Office: Schenectady, N. Y.

Address Nearest City

Boston, Mass. Chicago, Ill. New York, N. Y. Denver, Colo. St. Louis, Mo. Philadelphia, Pa. San Francisco, Cal. Dallas, Tex. (So. West G-E Co.) Atlanta, Ga. Detroit, Mich. (G-E Co. of Mich.) Cincinnati, Ohio

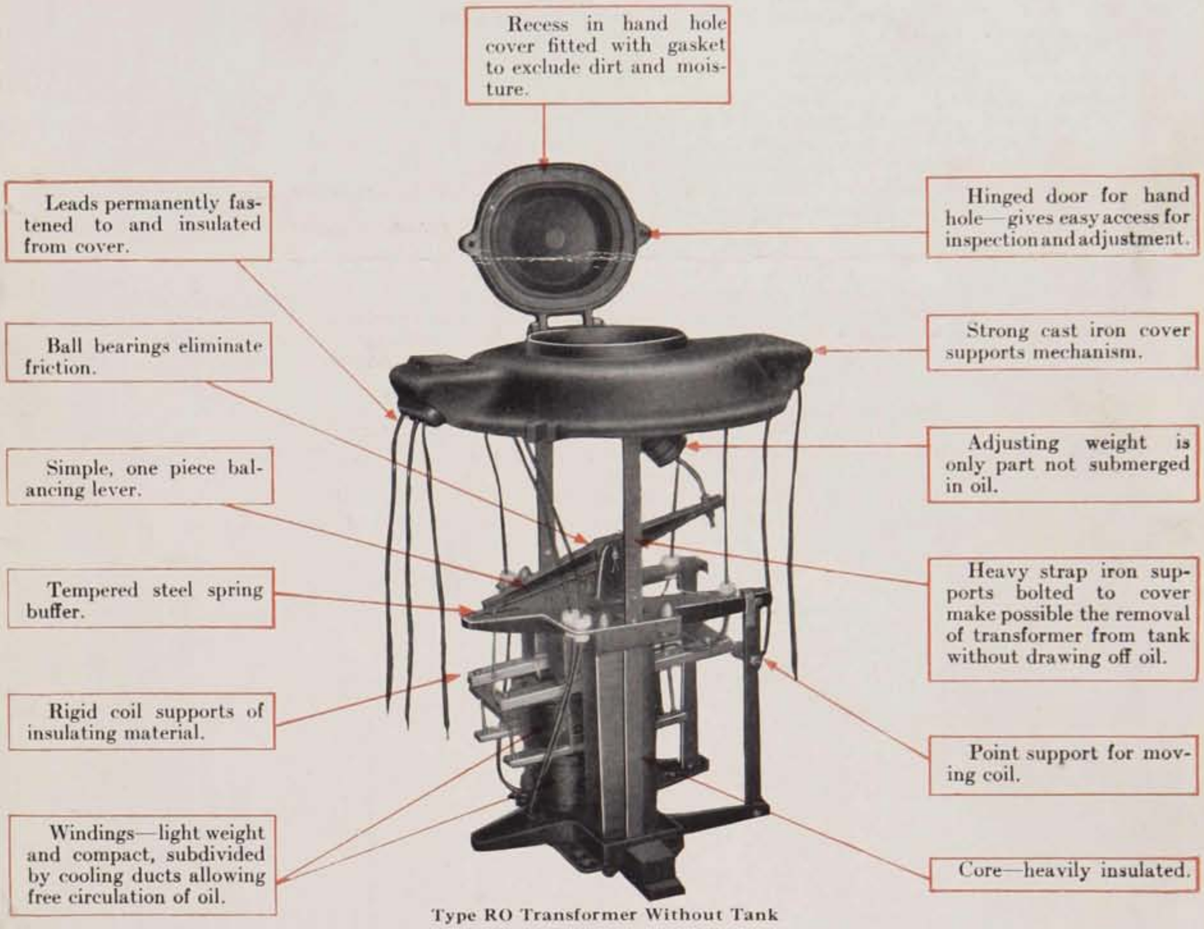
(OVER)

Constant Current Transformer

Type RO for Pole Mounting

Standard, 60 Cycles, 2000/2300 Volts, Primary; 6.6 Ampere Secondary

Can be furnished for any Commercial Primary Voltage, Frequency or Secondary Current



Type RO Transformer Without Tank

Will maintain constant current within 1 per cent of normal from full load to short circuit.

An outdoor weatherproof unit, oil cooled, designed for pole mounting, but may also be used in the central station or substation.

Requires no attendant or control panel.

Regulation entirely automatic and instantaneous—no taps for adjustments.

The first and only outdoor transformer that automatically maintains constant current.

Ask our nearest office for complete information

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

(OVER)

DESCRIPTION—TYPE RO TRANSFORMERS

The Type RO constant current transformers have been designed for controlling certain classes of street lighting where it is desirable to mount the transformer on a pole and operate it with an automatic oil time switch or a manually operated oil switch.

The theory of operation is the same as for the station type constant current transformers. The design, however, differs sufficiently to make the transformer automatic.

The regulation is such that constant secondary current is maintained from full load to short circuit within 1 per cent on either side of normal.

No adjustments or changes in taps are necessary. The regulation is entirely automatic and instantaneous in action.

A tap is provided in the 2300-volt primary so that the transformer will carry full load and regulate satisfactorily when operated on a 2000-volt circuit. The 2300-volt transformer is, moreover, designed so liberally that it will give good regulation on a 2400-volt circuit.

These transformers are designed to have an ultimate temperature rise not to exceed 55 deg. C. by resistance based on a surrounding temperature of 25 deg. C.

Series street lighting systems require constant current and constant current transformers have always required a substation with control panels and an attendant. On that account, it has been difficult to provide street lighting for smaller towns and villages where the revenue derived would not be sufficient to warrant the installation of a substation and attendant.

Larger cities also have experienced difficulty in solving the demand for higher intensities and more units in their suburbs. The growth of these outlying districts has been so rapid that it has been almost impossible to keep pace. When it becomes impracticable to run circuits from the central station, on account of the distance and the copper required, it is not always advisable to erect a substation. At any rate, the growth is usually so rapid that there is an interval before the substation can be erected when the lighting service is likely to be inefficient or ineffectual.

The Type RO transformer admirably fills this demand. In fact, it has been designed for this service. The efficiency is the same as for the station type transformer and the power-factor is 20 per cent higher than for any previous design of pole type regulating transformer.

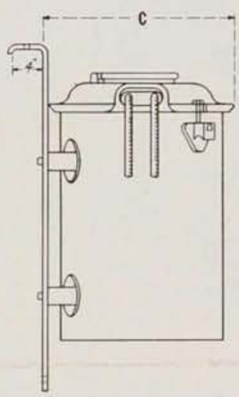
For the operation of Mazda C lamps, this transformer is ideal. The high internal reactance serves to protect the lamps at starting and acts instantaneously to check surges on the line which would tend to shorten the life of the lamps. The moving secondary coil with its high repulsion gives almost perfect regulation from full load to short circuit. It not merely protects the lamps from changes in current due to changes in secondary load but it also protects the lamps from fluctuations in primary voltage. Cat. No. 104227 cutouts with fuses are recommended to protect the transformer.

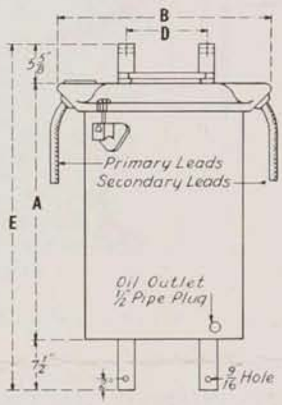
CONTROL DEVICES FOR RO TRANSFORMERS

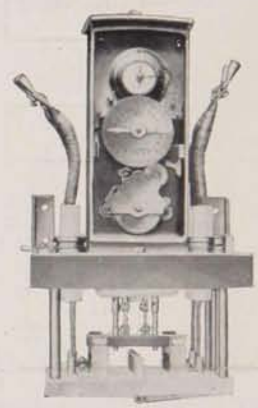
Time switches may be supplied equipped with either hand or electrically wound clocks. The former is wound every eight days, the latter is wound automatically by a small electric motor.

Manually operated oil circuit breakers, outdoor type may be used, also solenoid operated switches. The solenoid type is recommended where there is an existing Constant Current circuit and the RO transformer is operated as an auxiliary to this circuit.

5-kw. Type RO Transformer







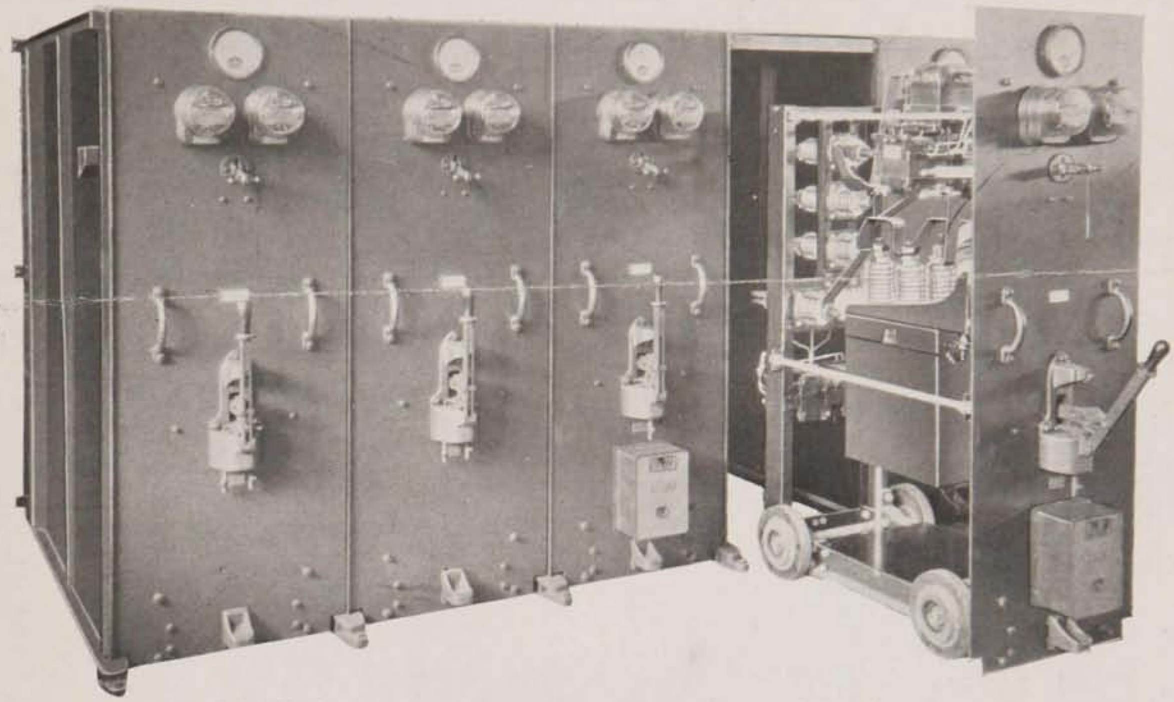
Type L Time Switch
with Oil Tank Removed

GENERAL DATA

Kw. Output (At Unity P-F. Load)	Cat. No.	† Oil Gal.	Wt. in lb. including oil (Approx.)		(No guarantees based on these data should be made without communicating with General Office)											Dimen. in in. (approx.)				
			Ship.	Net	Primary Amp.	Trans. Kv-a. Input	Secondary Load Volts	Efficiencies Full Load	3/4 Load	1/2 Load	1/4 Load	Primary Power-Factors Full Load	3/4 Load	1/2 Load	1/4 Load	A	B	C	D	E
1.0	197065	25	550	400	0.68	1.57	152	91.5	89.5	85.0	73.0	70	51	36	20	30	24	20	9	44
2.0	197066	35	750	550	1.34	3.08	303	93.0	91.0	87.0	77.0	70	51	36	20	35	26	22	10	48
3.0	197067	35	800	600	1.99	4.58	455	93.5	91.5	88.0	78.5	70	51	36	20	35	26	25	10	48
5.0	197068	40	900	700	3.31	7.62	758	94.0	92.1	89.0	80.0	70	51	36	20	35	29	25	11½	48
7.5	197069	40	925	725	4.94	11.37	1136	94.5	92.7	90.0	82.0	70	51	36	20	35	29	25	11½	48
10.0	197070	40	950	750	6.55	15.05	1515	95.0	93.5	91.0	83.5	70	51	36	20	35	29	25	11½	48
15.0	235826	60	2200	1775	9.65	22.2	2270	95.0	93.5	91.0	83.5	70	51	36	20	41	32	28	13	54
20.0	235827	60	2275	1875	12.95	29.8	3135	95.0	93.5	91.0	83.5	70	51	36	20	41	32	28	13	54

†G-E No. 21 Oil is regularly supplied and included in the price.
Suspension hooks are furnished with all Type RO transformers.

Standard Unit
Safety Enclosed Removable Truck Type Panels



Safety Enclosed Standard Unit Removable Truck Type Panel Switchboard
for 7500 Volts, 3-phase, 3-wire, with Type FK-12 Oil Circuit Breakers

This switchboard is made up of the removable truck type panels and can be supplied in separate units or built up to form a complete switchboard with its accessories. Connections are automatically broken as soon as truck is removed from compartment, positively insuring that workmen have no live parts to handle. One great advantage is obtained in that continuity of service is assured. Should a breakdown occur, a spare unit can immediately be placed in service without taking the power off the main bus thereby interrupting the service on other sections of switchboard; this gives great flexibility to the station.

These panels can be supplied for voltages up to 7500 and current carrying capacity up to 800 amperes; also in various combinations of oil circuit breaker, instrument transformers and meters.

SWITCHBOARD DEPARTMENT

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

CONSTRUCTION

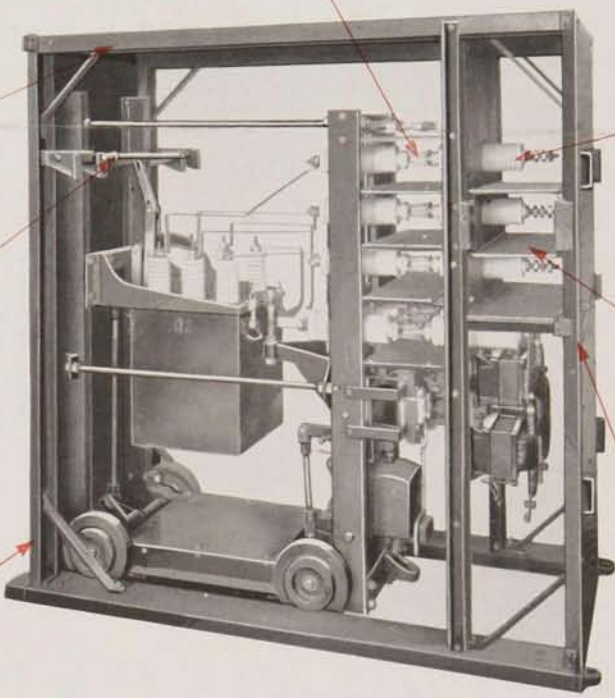
A standard unit safety enclosed removable truck panel consists of a sheet steel panel on which are mounted instruments, meters, oil circuit breakers and other appliances, truck framework to which are attached instrument transformers and disconnecting switch studs suitably mounted on insulators; and the stationary framework with sheet steel compartments for fuses and connections, and for receiving movable truck.

AUTOMATIC DISCONNECTING SWITCHES: All live parts are enclosed when these contacts complete the circuit by engaging the fixed contact in compartment.

FRAME: Of iron construction firmly bolted together giving great rigidity of structure which assures positive contact when truck is placed in position.

INTERLOCKING DEVICE: Absolutely prevents removal or replacement of truck with breaker closed. Provision for padlock on front of panel.

STEEL PANEL: Dust proof. Fire proof and indestructible. Skilled operator unnecessary. No live parts exposed.



STATIONARY DISCONNECTING STUDS: Upper set connected to busses; lower set, to incoming or outgoing leads. Barriers prevent accidental contact by one who enters compartments when truck is removed.

BUS COMPARTMENT: Bus bars can be continued from unit to unit through openings in side wall.

TWO SECTION STEEL DOOR: Rear of bus compartments accessible for inspection by opening hinged doors.

Safety Enclosed Unit Panel Removable Truck Type, 600-2500 Volts, A-C., 3-phase, 3-wire, with Solenoid Operated FK-12 Oil Circuit Breaker

REMOVABLE TRUCK: Mounted on wheels and when withdrawn the equipment is dead and accessible from all sides.

ASSEMBLY: Simple and compact assembly of parts allowing the mounting of potential and current transformers in the small space required for a unit.

INSTALLATION: The only preparation necessary in a station for these units is channel iron supports laid flush with floor and properly leveled.

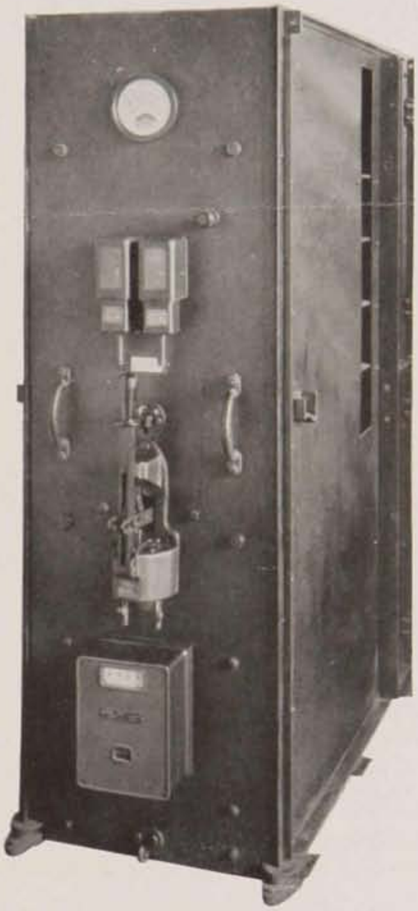
INSPECTION: A marked advantage of this type of construction is the ease with which inspection or replacement can be effected without interrupting service by simply having extra units available for replacements.

APPLICATION: The field of application for standard unit removable truck panels has been limited mainly to feeders but with the present method of transferring small wiring from truck to stationary section, units can be built for generator and exciter control.

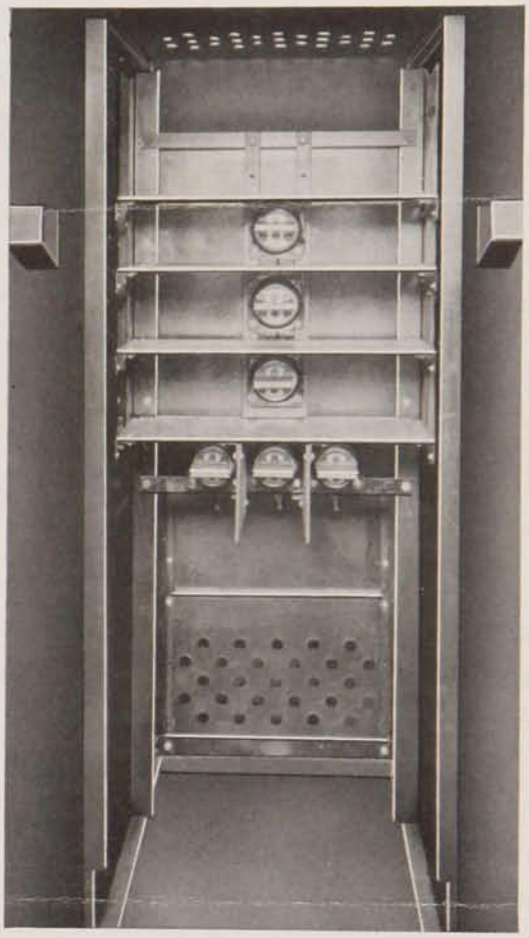
The construction is such that extensions can be readily made to meet changed or new conditions.

SAFETY: These units are particularly serviceable in industrial plants or in any location where employees have little or no electrical knowledge.

Safety Enclosed Unit Panels
Removable Truck Type



(Front View)
Safety Enclosed Unit Panel Removable Truck Type.
7500 Volts, 500 Amperes

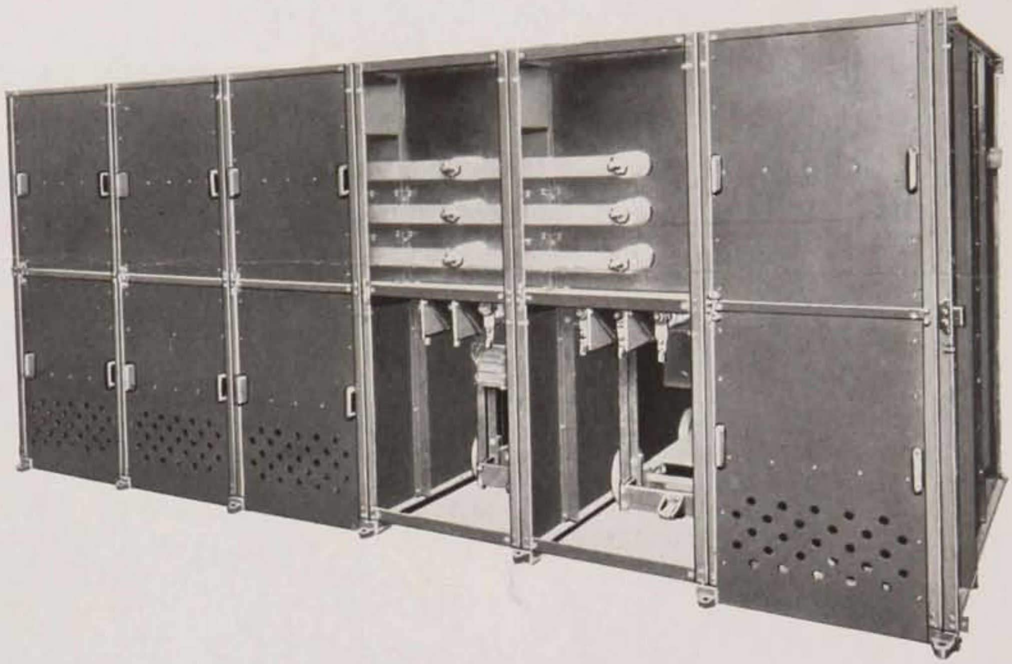


(Rear View)
Safety Enclosed Unit Panel Removable Truck Type.
Showing Arrangement of Barriers

These standard unit safety enclosed removable truck type panels are inherently accident proof. Danger of contact with live parts by even the most inexperienced operators has been removed by the design.

Safety Enclosed Unit Panels

Removable Truck Type



Safety Enclosed Unit Switchboard Removable Truck Type, 7500 Volts, A-C., 3-phase, 3-wire. Two Section of Doors Removed to Show Busses and Feeder Terminals

Considered from every view point, either installed as single unit panels, or as several units combined to make a standard unit switchboard (rear view shown above) this steel panel construction and compact arrangement of switchboard control equipment meet all safety requirements.

SWITCHBOARD DEPARTMENT

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

STANDARD UNIT SAFETY ENCLOSED STATIONARY PANEL

Safety Enclosed Unit Panel Stationary Type, with D-C Motor Starter and Rheostat (Front View)

These panels are intended primarily as distributing panels for light and power; and feeder panels for small lighting and power plants. They are especially applicable in factories where inexperienced or unskilled employees have access to the switchboard and where the open type of switch is subject to accidental contact.

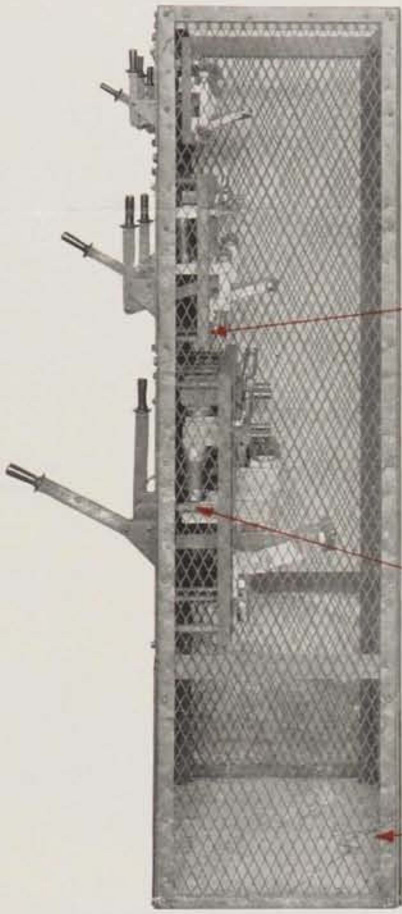
SWITCHBOARD DEPARTMENT
GENERAL ELECTRIC COMPANY
Schenectady, N. Y.

9-18-19

67110
Classes 219 & 314

Standard Unit
Safety Enclosed Stationary Panel

A panel or switchboard made up of the standard unit safety enclosed Types LR-1 or LR-3 lever switches practically eliminates the chance of human contact with line current carrying parts.



(Side View)
Safety Enclosed Unit Panel, Stationary Type
Switches 250 Volts, 30 to 600 Amperes

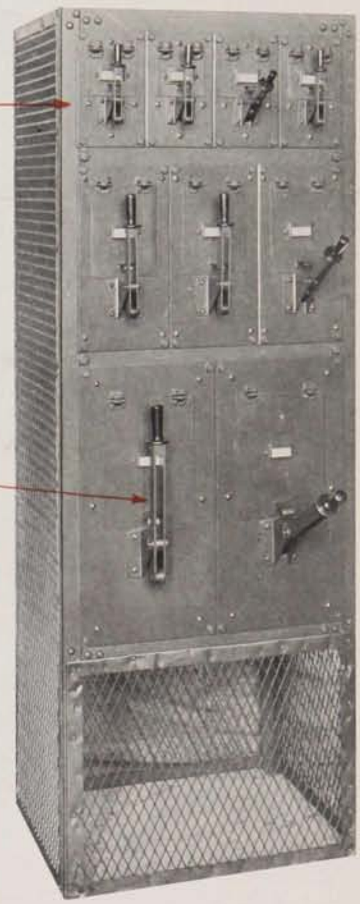
STEEL PANELS are 3/16 in. thick. Other dimensions are graded so that when mounted on a panel they present uniform appearance.

CURRENT CARRYING ELEMENTS of switch are mounted on a slate base supported by iron studs at back of steel panel.

OPERATING LEVER is vertical when switch is closed and at an angle of 60 deg. with panel when switch is open.

FUSE AND CONTACT STUD always dead when fuse door is open and under this condition can be handled without danger.

FRAME AND GRILLE forms a self-supporting structure. The grille effectively guards against contact with live parts back of panel.



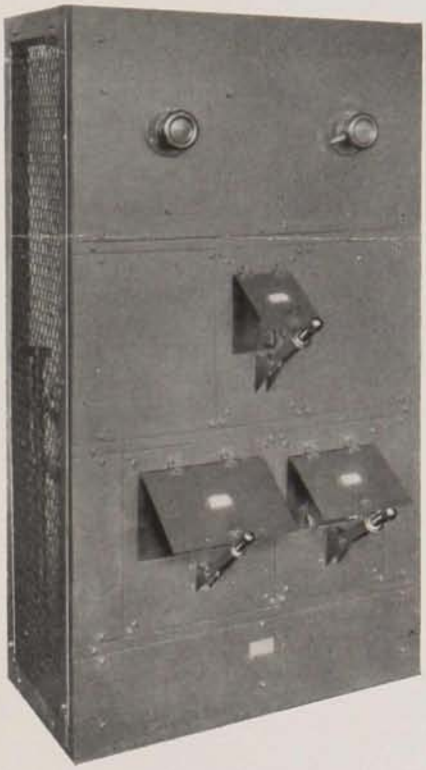
(Front View)
Safety Enclosed Unit Panel, Stationary Type
Switches 250 Volts, 30 to 600 Amperes

The panel may be made up of switches varying in capacities, either 250 or 600 volts, from 30 to 600 amperes. Lever switch parts are similar to the standard as used for front of board switches.

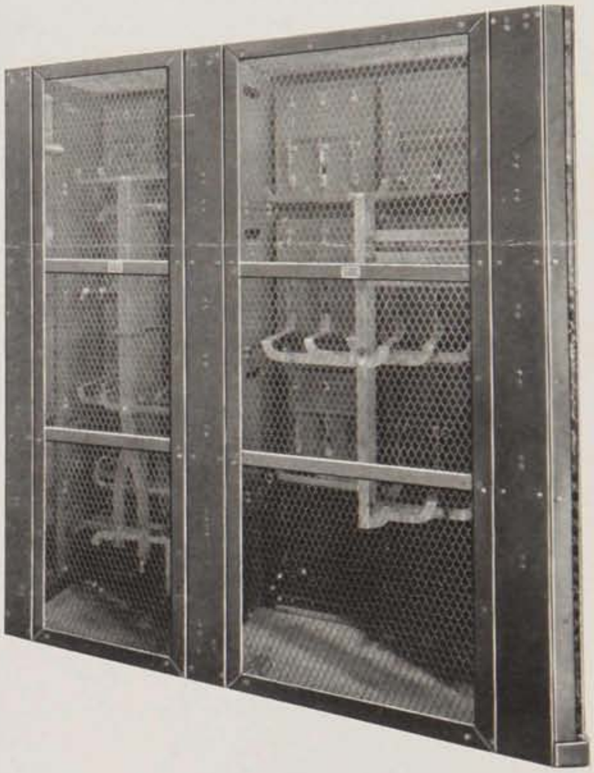
Each switch unit has on the steel front a hinged sheet steel door opening upward and located directly behind the operating handle so that door cannot be opened when handle is vertical and switch closed.

The switches can be locked in the open position by a padlock, which arrangement is of considerable advantage, and conforms strictly with modern safety standards.

Standard Unit
Safety Enclosed Stationary Panel



(Front View)
Safety Enclosed Unit Panel, Stationary Type
250 Volts, with D-C. Motor Starter
and Rheostat



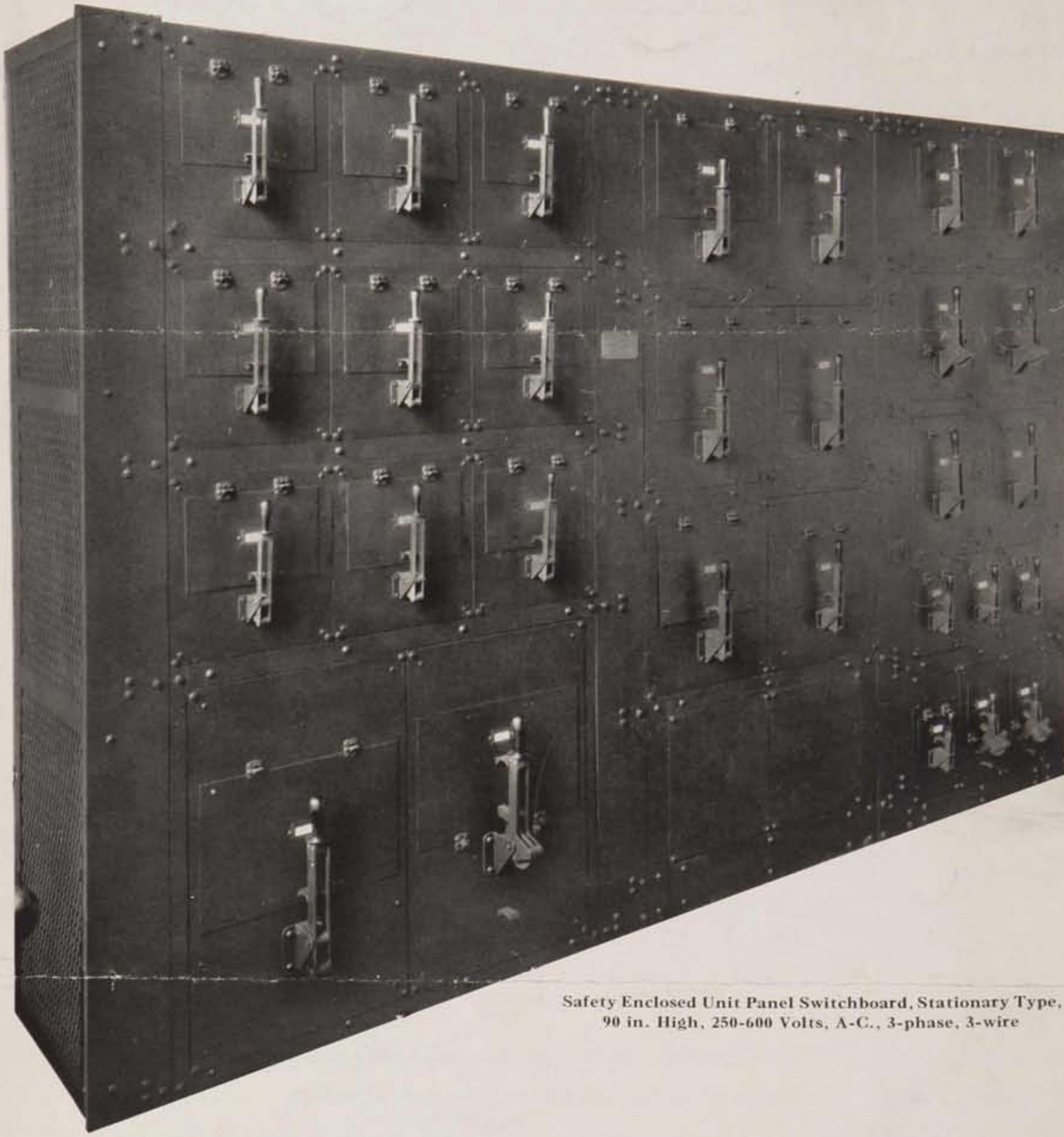
(Back View)
Safety Enclosed Unit Switchboard, Stationary Type
250-600 Volts, A-C., 3-phase, 3-wire, Showing
Arrangement of Connections

The above pictures illustrate some of the advantages of this construction and indicate a range of application for either a-c. or d-c. circuits.

The right-hand picture shows slate supports which are provided for the support of the connection bars or cable terminals at side of the panel in such a manner that all outgoing or incoming leads can be run straight to their terminals from either the top or the bottom of the panel.

The left-hand picture illustrates how fuse chamber is accessible only when switch is open.

Standard Unit
Safety Enclosed Stationary Panel



Safety Enclosed Unit Panel Switchboard, Stationary Type, 90 in. High, 250-600 Volts, A-C., 3-phase, 3-wire

These panels may be combined into a switchboard which presents a pleasing appearance and offers all the advantages of Dead Front safety operation.

The rapidly growing demand for safer means of handling electrical control apparatus is filled when a switchboard of this type for lighting or small power service is installed.

TYPE FK-52-B OIL CIRCUIT BREAKERS

GENERAL. Type FK-52-B oil circuit breakers are conservatively rated, liberally designed, and contain the best materials. High interrupting capacity and economy in floor space are features. The 15,000-volt breakers can be mounted on 4-feet centers and the 25,000-volt breakers on 6-feet centers.

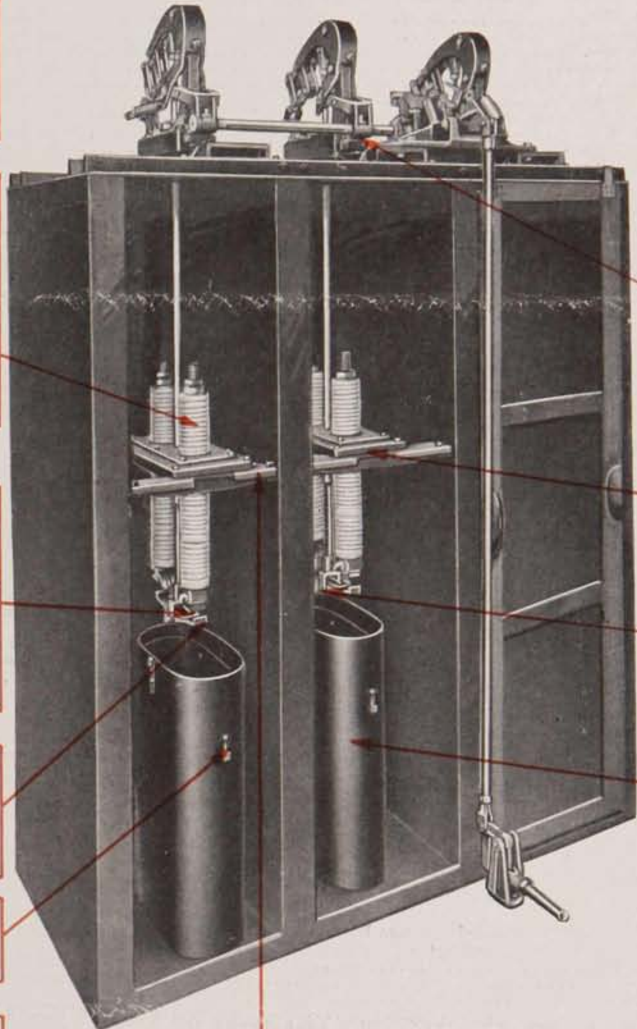
TANK LIFTER permits of easy removal of the oil tanks. Is interchangeable among all units so that only one per station is required.

BUSHINGS for 15,000 volts are of one-piece wet-process porcelain extending below the level of the oil. For 25,000 volts a short extension is clamped to the main insulator, thus giving the contacts a greater depth in the oil.

MAIN CONTACTS are of laminated brush construction making end contact with heavy and uniform pressure, without tendency to force any laminations of the brush apart. Wiping motion at closing keeps the contacts clean.

The arc is broken on RENEWABLE SECONDARY CONTACTS, which close before and open after the main contacts.

OIL GAUGES and GAS VENTS are provided for all tanks.



Type FK-52-B, T-P.S-T., 25,000-Volt, 800 Amp., Hand-Operated Oil Circuit Breaker in Cell

OIL. G-E No. 6, having a high ignition point and resistance to carbonization, is regularly furnished with each breaker.

OPERATING MECHANISM is designed to produce parallel movement of blades. Has rustproof parts and non-corrosive pins. Breaker opens by gravity assisted by springs on the mechanism. Provision is made for the insertion of a removable lever for emergency operation.

FRAME is a separate steel casting for each unit.

PIVOTED SUPPORT allows free motion of the main contacts and insures equal pressure of the brush on each contact plate.

TANKS are approximately elliptical in cross section; are made from heavy sheet steel, acetylene welded, and lined with pressboard. They are supported from the cover by bolts, which hook under the bottom of the tank and pass through the cover where they are securely fastened.

Up to and including 1200 amp. capacity, round studs are screwed and sweated into the brush block; 1600- and 2000-amp. capacities have laminated studs.

MOUNTING. Each unit is supported on steel bed plates in a separable cell compartment and is leveled and bolted to these plates. Breaker is also arranged for open framework mounting when desired.

Provision is made for BUSHING TRANSFORMERS on the 25,000-volt breaker only, the transformers being located inside the tank.

INSULATION. Each breaker is given an insulation test at least equal to that prescribed in the Standardization Rules of the American Institute of Electrical Engineers.

HEATING. At normal rating no part of these breakers will exceed the heating limits specified in the standardization rules of the American Institute of Electrical Engineers, providing the connections to the breaker do not exceed this limit.

Switchboard Department, General Electric Company, Schenectady, N. Y.

67482

Class 221

10-1-18

GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES: SCHENECTADY, N. Y.

SALES OFFICES (Address nearest Office)

Atlanta, Ga.	Third National Bank Building
Baltimore, Md.	Lexington Street Building
Birmingham, Ala.	Brown-Marx Building
Boston, Mass.	84 State Street
Buffalo, N. Y.	Electric Building
Butte, Mont.	Electric Building
Charleston, W. Va.	Charleston National Bank Building
Charlotte, N. C.	Commercial National Bank Building
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Chicago, Ill.	Monadnock Building
Cincinnati, Ohio	Provident Bank Building
Cleveland, Ohio	Illuminating Building
Columbus, Ohio	The Hartman Building
Dayton, Ohio	Schwind Building
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Portland, Ore.	Electric Building
Providence, R. I.	Turks Head Building
Richmond, Va.	Virginia Railway & Power Building
Rochester, N. Y.	Granite Building
St. Louis, Mo.	Pierce Building
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San Francisco, Cal.	Rialto Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building
Springfield, Mass.	Massachusetts Mutual Building
Syracuse, N. Y.	Onondaga County Savings Bank Building
Toledo, Ohio	Spitzer Building
Washington, D. C.	Commercial National Bank Building
Worcester, Mass.	State Mutual Building
Youngstown, Ohio	Stambaugh Building

For TEXAS, OKLAHOMA and ARIZONA Business refer to
Southwest General Electric Co. (Formerly Hobson Electric Co.)

Dallas, Tex.	Interurban Building
El Paso, Tex.	500 San Francisco Street
Houston, Tex.	Third and Washington Streets
Oklahoma City, Okla.	1 West Grande Ave.

MOTOR AGENCIES in all large cities and towns

Partial List of FOREIGN Sales Offices

General Electric Co., Foreign Dept.	Schenectady, N. Y.
General Electric Co., Foreign Dept.	Equitable Bldg., 120 Broadway, New York City
General Electric Co. of N. Y.	83 Cannon St., London, E. C., England
Australian General Electric Co.	Melbourne and Sydney
Companhia General Electric do Brazil	Rio de Janeiro
Cia. General Electric Sudamericana	Buenos Aires
Mexican General Electric Co.	City of Mexico and Guadalajara
South African General Electric Co.	Johannesburg and Cape Town

Representatives and Agents in all countries
For all CANADIAN Business refer to Canadian General Electric Co., Ltd., Toronto, Ont.

CR 9510 Solenoid Brakes

for A-C. or D-C. Motors

1 to 300 Horse power

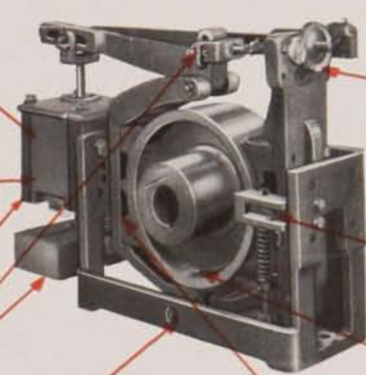
APPLICATION

Solenoid brakes are used extensively in connection with cranes, hoists, elevators, draw and lift bridges, turn tables, printing presses, line shafting, etc., to save time in stopping, to prevent over travel or to stop accurately at definite points, to hold loads without consumption of power by the motor and to make emergency stops.

All solenoids except 2200 volts a-c. are for direct connection to the line. A-c. solenoids may be used on single- two- or three-phase circuits without change.

All parts of a-c. and d-c. brakes of corresponding sizes are interchangeable except the solenoids, resulting in a minimum number of parts for renewal.

Jar and shock are eliminated, greatly adding to the life of the brake as well as rendering the operation noiseless.



The automatic air gap adjuster insures a constant air gap in the solenoid as the brake shoes wear, and eliminates the need of frequent inspection and attendant danger when inspection is neglected.

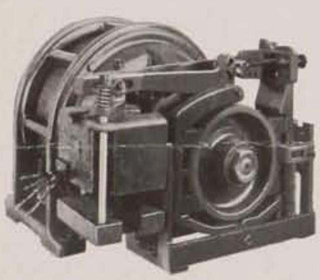
All brakes are automatically self-adjusting for shoe wear; no hand adjustment required.

From 3 to 15 different values of braking can be obtained by changing the pin as well as the weights on the short lever arm.

Seven sizes of standard brakes giving a range in braking torque from 5 pounds to 12,000 pounds at one foot radius.

All shoes easily removable. The wearing surface is a high grade compressed asbestos compound. Wears well, not affected by heat, gives smooth braking.

Wheels of small diameter finished all over give perfect balance and small flywheel effect.



Solenoid brake mounted on a G-E motor

All brakes are designed for floor mounting and are therefore applicable to any kind of motor or rotating shaft. Can be mounted directly on the frame of motors of General Electric or other manufacture.

All solenoids are enclosed, ventilated and rainproof and thoroughly protected from mechanical injury.

End view of brake with cover removed, showing solenoid coils and connections

Ask Our Nearest Office for Bulletin 48900

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.

Sales Offices in All Large Cities

CR 3202 DRUM CONTROLLERS

for Slip Ring Induction Motors

110 to 550 Volts—Two- or Three-phase

T-42 T-79 T-94 T-10 T-34 T-1 T-85 T-116

Standard Line of CR 3202 Controllers

G-E drum-type controllers provide the most efficient type of control where manual operation is desired. The present design, described in this leaflet, is the result of experience gained in the manufacture of more than 330,000 controllers of the drum type for every possible service. They are much stronger than the dial type, and totally enclosed, thus giving greater protection to the operator. In the design special attention has been given to their ability to open the circuit under all conditions without undue wear.

APPLICATION

The CR 3202 line will control both the primary and secondary of the motor and may be used for either reversing or non-reversing service. By using a properly designed resistor in the secondary circuit the controllers may be used for starting, crane and hoist, or speed-regulating duty. They are designed for two- and three-phase circuits and several forms of each are available.

For secondary control only, CR 3204 controllers are recommended.

A magnetic equipment is recommended for remote control or for use with motors beyond the capacity of the drum controller.

SAFETY

All live parts of every drum controller are enclosed, thus effectually protecting the operator, especially the unskilled, from shock and burn. The mechanism is also protected from dust, weather, and mechanical injury.

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

Sales Offices in all large cities

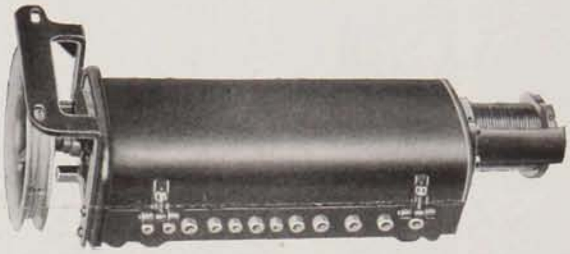
68200-A SUPERSEDES 68200

4-11-18

MAINTENANCE

In any type of controller the arcing points require the most frequent renewal. On drum-type controllers, the burning is kept down to a minimum by arc deflectors and by providing an ample number of points. Frequent renewals of fingers and arcing tips are therefore unnecessary. All wearing parts are accessible and easily and cheaply renewed.

Vertical handle used with CR 3202 controllers



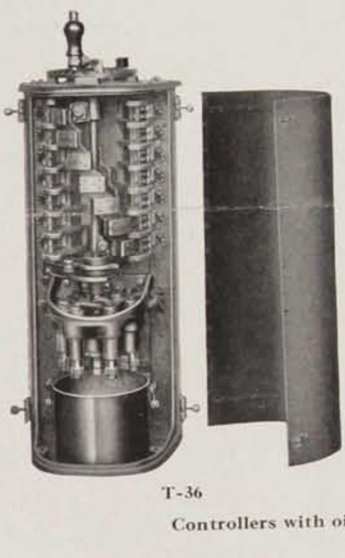
Controller complete with rope wheel and spring return

SMALL SIZE

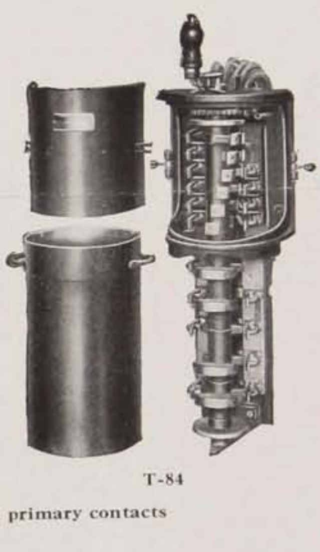
Drum controllers require less floor space than those of any other type. The operator can, therefore, have his controller in the most convenient location. The resistor, being separate, can be mounted out of the way.

HANDLES

While the standard controllers have the horizontal handles illustrated on page 1, various other styles can be furnished. With a few exceptions, vertical handles, handwheels for switchboard mounting, rope wheels, extended shafts for sprocket wheels, etc., all with or without spring return attachment, can be supplied. The common types of handles available are illustrated.

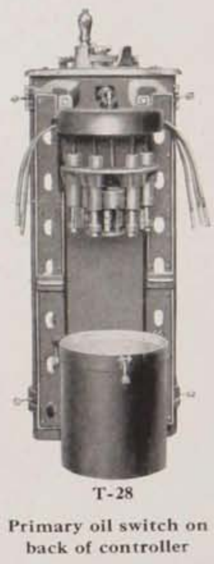


T-36



T-84

Controllers with oil immersed primary contacts



T-28

Primary oil switch on back of controller

INTERCHANGEABILITY

A careful record of the serial numbers of all drum controllers is kept. This, in conjunction with a strict avoidance of modification in design after standardization, insures the interchangeability of parts and greatly assists in ordering renewals.

DISTINCTIVE FEATURES

This type of rustproof handle is regularly supplied. The latch operated by button in handle prevents accidental reversal of the motor.

*Operating shaft hexagonal, positively preventing any turning of cylinder on shaft. Special composite fiber insulation between cylinder and shaft.

Starwheel and pawl or latch ring insure positive contact on each point.
Contacts have a sliding motion, giving running surfaces different from arcing tips, thus running surfaces are always clean.

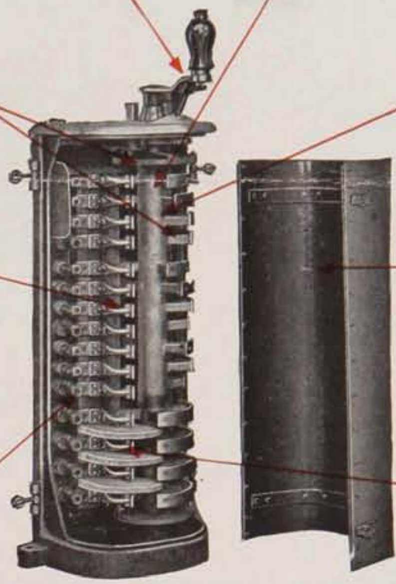
Cast-metal cylinder supports the contact segments, giving most rigid construction possible.

Forged copper fingers with phosphor bronze springs, and fitted copper segments are easily renewable. Finger pressure and alignment are adjustable.

Sheet-iron cover, asbestos lined, or oil tank protects controller parts from dust and mechanical injury and the operator from accidental contact with live parts. Easily removed for inspection.

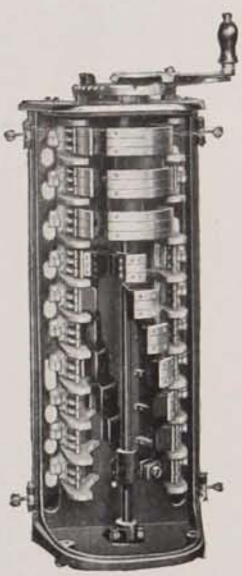
Each connection terminal is plainly marked.
A diagram of connections is pasted inside the cover to facilitate installation.

Moulded deflectors prevent arcing between primary contacts.
Controllers handling heavy currents have arc deflectors between secondary contacts as well.



T-10 Controller

*Exception:—Some of the larger sizes have body castings securely pinned to a round operating shaft.



T-42 Controller showing construction of fingers and segments to handle heavy currents

T-41 Controller with both primary and secondary contacts oil immersed

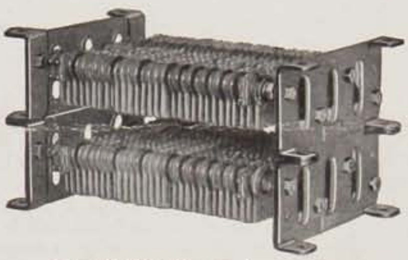
RESISTORS

The resistors recommended for use with these controllers consist of cast-iron grid units mounted on tie rods and assembled in pressed steel end frames. This construction permits of mounting individually or stacking one section on another in case form as desired.

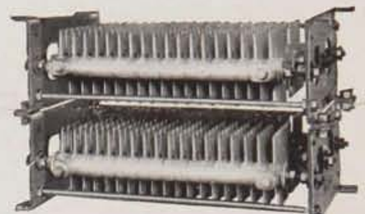
The resistor varies with the service and three standard lines have been laid out for use with CR 3202 controllers as follows:

(1) CR 3221 resistors (Type IG) for starting duty.
(2) CR 3222 resistors (Type SG) for crane and hoist duty.
(3) CR 3232 resistors (Type IG) for speed-regulating duty.

The resistance of each section is apportioned according to the service.

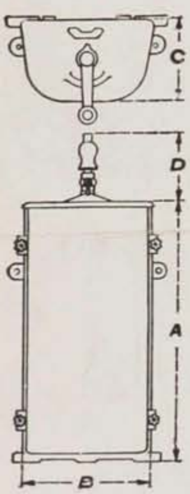


Type IG Resistor in two sections



Type SG Resistor in two sections

RATINGS AND DIMENSIONS



Type	Current per Phase		Maximum Voltage		Points		Wt. in Lb.		Dimensions in Inches			
	Primary	Secondary	Primary	Secondary	Forward	Reverse	Net	Ship.	A	B	C	D
THREE-PHASE The following controllers open two legs of the circuit in the "off" position, the third leg running direct to the motor. An additional switch should be installed which will entirely disconnect the motor from the line. If it is desired to have the controller open all three legs of the motor at the "off" position, a two-phase controller listed below should be used.												
T-116-A	40	40	550	550	12	12	65	100	$16\frac{3}{16}$	$8\frac{1}{8}$	$7\frac{7}{8}$	$3\frac{1}{4}$
T- 85-A	40	40	550	550	8	8	72	100	$18\frac{3}{4}$	$9\frac{1}{8}$	$7\frac{5}{8}$	$6\frac{7}{8}$
T- 85-C	40	40	550	550	8	..	72	100	$18\frac{3}{4}$	$9\frac{1}{8}$	$7\frac{5}{8}$	$6\frac{7}{8}$
T- 1-H	115	115	550	550	8	8	85	125	$22\frac{3}{4}$	$9\frac{3}{8}$	$7\frac{5}{8}$	$6\frac{1}{2}$
T- 1-T	115	115	550	550	8	..	85	125	$22\frac{3}{4}$	$9\frac{3}{8}$	$7\frac{5}{8}$	$6\frac{1}{2}$
T- 10-J	150	150	550	550	11	11	155	225	$32\frac{5}{8}$	$12\frac{3}{4}$	$8\frac{1}{2}$	$8\frac{3}{16}$
T- 10-N	150	150	550	550	11	..	155	225	$32\frac{5}{8}$	$12\frac{3}{4}$	$8\frac{1}{2}$	$8\frac{3}{16}$
T- 42-C	250	250	550	550	14	14	265	450	$40\frac{3}{8}$	$16\frac{3}{4}$	$12\frac{1}{16}$	$7\frac{1}{2}$
T- 42-P	300	300	550	550	12	12	265	450	$40\frac{3}{8}$	$16\frac{3}{4}$	$12\frac{1}{16}$	$7\frac{1}{2}$
The following controllers open all three legs of the circuit in the "off" position.												
T- 41-A	90	90	550	550	10	10	100	125	24	$9\frac{3}{8}$	$10\frac{3}{4}$	$7\frac{7}{8}$
T- 84-C	90	150	2200	550	10	10	185	230	$31\frac{1}{2}$	$11\frac{3}{4}$	$11\frac{3}{4}$	$6\frac{1}{2}$
T- 36-A	75	250	2200	550	14	14	260	300	$40\frac{3}{8}$	$17\frac{3}{4}$	$14\frac{1}{8}$	$7\frac{1}{2}$
T- 28-A	125	500	2200	550	14	14	376	530	$40\frac{3}{8}$	$17\frac{3}{4}$	$12\frac{1}{4}$	$7\frac{1}{2}$
TWO-PHASE The following controllers when used on a two-phase, four-wire circuit will open three legs of the circuit at the "off" position, the fourth running direct to the motor, in which case an additional line switch is required to entirely disconnect the motor from the line. When used on a three-phase or a two-phase, three-wire circuit, they will open all three legs at the "off" position.												
T- 34-E	115	115	550	550	8	8	95	125	$27\frac{1}{16}$	$10\frac{5}{8}$	$6\frac{7}{8}$	$7\frac{5}{16}$
T- 94-A	150	150	550	550	11	11	175	225	$37\frac{5}{16}$	$12\frac{1}{4}$	$9\frac{1}{4}$	$8\frac{3}{16}$
T- 79-D	250	250	550	550	13	13	295	450	$40\frac{3}{8}$	$16\frac{3}{4}$	$12\frac{1}{16}$	$7\frac{1}{2}$
T- 79-H	300	300	550	550	12	12	295	450	$40\frac{3}{8}$	$16\frac{3}{4}$	$12\frac{1}{16}$	$7\frac{1}{2}$
T- 84-C	90	150	2200	550	10	10	185	230	$31\frac{1}{2}$	$11\frac{3}{4}$	$11\frac{3}{4}$	$6\frac{1}{2}$
T- 36-A	75	250	2200	550	14	14	260	300	$40\frac{3}{8}$	$17\frac{3}{4}$	$14\frac{1}{8}$	$7\frac{1}{2}$
T- 28-A	125	500	2200	550	14	14	376	530	$40\frac{3}{8}$	$17\frac{3}{4}$	$12\frac{1}{4}$	$7\frac{1}{2}$

These dimensions are approximate and should not be used for construction.

Drum-type Switches

CR-3900

for throwing small alternating or direct current motors across the line

Reversing or Non-reversing

APPLICATION

Drum-type switches are designed for the control of small alternating current or direct current industrial motors which can be thrown directly across the line without the use of starting resistance. The size of the motor that can be so started depends upon its characteristics and the limitations set by the power company.

This leaflet describes several varieties of drum-type switches which the General Electric Company offers for this service.

RD-80 Switch with Horizontal Handle

RD-134 Switch with Horizontal Handle

RD-400 and 401 Switch with "T" Handle

CONSTRUCTION

The fundamental considerations involved in the design of each switch are durability, convenience and requirements of the service, and protection to the operator. All switches are enclosed in substantial cast-iron or sheet-steel cases, which exclude dust and dirt and prevent the operator from coming in contact with live parts. Either rubber-bushed holes for the connection leads, or knockout holes for conduit wiring are provided. Fingers and segments are readily renewable, and all arcing is confined at these points by means of fire-proof barriers shown in the illustrations following.

A table giving the ratings of these switches and also their uses will be found on page 2.

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.
Sales Offices in all large cities

68201 1-12-18

Classes 317 and 318

Ratings and Shipping Weights of Drum-type Switches

Type RD	Max. Ampere Capacity							* Max. Motor Capacity in H.P.				Approx. Ship. Wt. in lb.	Features
	Volts—A.C.				Volts—D.C.			Volts—A.C.					
	110	220	440	550	115	230	550	110	220	440	550		
402A	30	30	30	30	30	30	15	1½	3	5	7½	20	Triple-pole reversing
403A	30	30	30	30	30	30	15	1½	3	5	7½	20	Four-pole non-reversing
400A	30	30	30	30	30	30	15	1½	3	5	7½	20	Triple-pole reversing
401A	30	30	30	30	30	30	15	1½	3	5	7½	20	Four-pole non-reversing
134C	40	40	25	25	40	40	†	3	5	10	10	35	Triple-pole reversing
134E	40	40	25	25	40	40	†	3	5	10	10	35	Triple-pole reversing spring return
80A	100	100	100	75	100	100	†	5	7½	10	10	60	Triple-pole reversing
80F	100	100	100	75	100	100	†	5	7½	10	10	60	Triple-pole reversing spring return

* The size of the direct current motor that can be thrown directly on the line depends upon its characteristics and what the power company will permit.

† These switches should not be used on direct current circuits exceeding 250 volts.

Use of Drum-type Switches

For Direct Current Circuits

RD-80, RD-134, RD-400, RD-401, RD-402 and RD-403 open both sides of line in "OFF" position.

RD-80, RD-402-A and RD-400-A open one side of the shunt field and both lines to the motor.

RD-403-A and RD-401-A open both sides of the shunt field and both lines to the motor.

For Three- and Two-phase Three-wire Alternating Current Circuits

RD-134 opens two lines with the third running direct to the motor.

RD-80, RD-400, RD-401, RD-402 and RD-403 open all three lines.

For Two-phase Four-wire Alternating Current Circuits

The RD-134 switch should not be used.

RD-80, RD-402-A and RD-401-A open three lines with the fourth running direct to the motor.

RD-403-A and RD-400-A open all four lines.

Type RD-80

FORMS

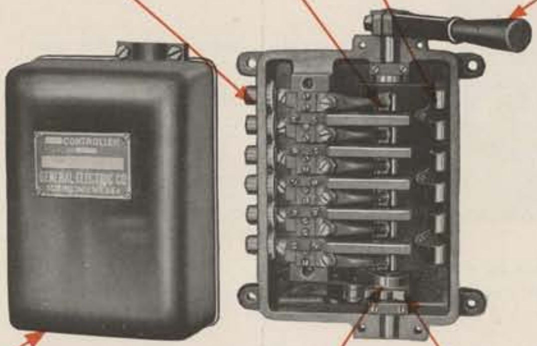
RD-80F is a triple-pole reversing switch which may be used with either direct current or alternating current motors. Particularly well suited for use on small overhead cranes operated by ropes from the floor. Has spring return which automatically brings handle to "off" position.

RD-80A differs from the Form F in the omission of the spring return feature.

The cast-iron case has rubber-bushed holes for the connection leads.

Contact fingers and segments easily renewable. Finger pressure adjustable.

Switch with horizontal handle. A lever for operation by ropes can be supplied if desired.



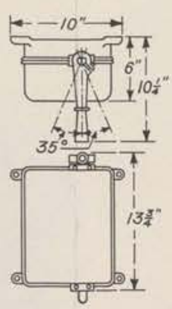
Switch with Horizontal Handle

The cast-iron cover protects the switch from dust and dirt and the operator from shock or burn.
Easily removed for inspection or repair.

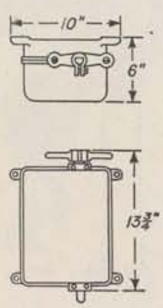
Supplied either with or without spring return attachment which automatically returns the switch to the "off" position when released.

Switches without spring return have a star wheel and pawl which hold the controller cylinder firmly either at the "off" or at the "running" positions.

Switch with Cover in place



Dimensions of Switch with Horizontal Handle



Dimensions of Switch with Rope Lever

A table showing the ratings and use of the RD-80 switch is given on page two

Type RD-134

FORMS

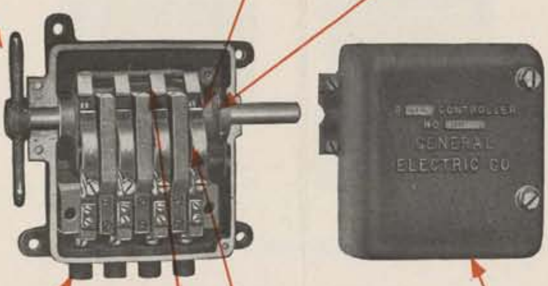
RD-134E is a triple-pole reversing switch which may be used with either direct current or alternating current motors. Particularly well suited for use on small overhead cranes operated by ropes from the floor. Has spring return which automatically brings the handle to "off" position when released.

RD-134C differs from E in the omission of the spring return feature. Well adapted for the control of motors operating cross rails, etc., on machine tools.

Switch with rope lever. A horizontal handle, illustrated below, can be supplied if desired.

Supplied either with or without spring return attachment which automatically returns the switch to the "off" position when released.

Switches without spring return have a star wheel and pawl which hold the controller cylinder firmly either at the "off" or at the "running" positions.



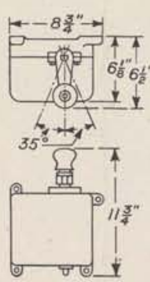
Switch with Rope Lever

The cast-iron case has rubber-bushed holes for the connection leads.

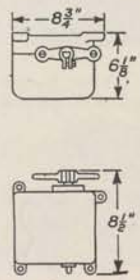
Contact fingers and segments renewable. Finger pressure adjustable.

Cast-iron cover protects the switch from dust and dirt and the operator from shock or burn.
Easily removed for inspection or repair.

Switch with Horizontal Handle



Dimensions of Switch with Horizontal Handle



Dimensions of Switch with Rope Lever

A table showing the ratings and use of the RD-134 switch is given on page two

Types RD-400, 401, 402 and 403

FORMS

RD-402A is a triple-pole, double-throw reversing switch with handle *for shipper rod operation.*

RD-403A is a four-pole, single-throw non-reversing switch with handle *for shipper rod operation.*

In both forms the pawl and spring are omitted and therefore the shipper rod with which they are to be used should have a spring or other centering device to insure that the handle is thrown to the "running" or to the "off" position.

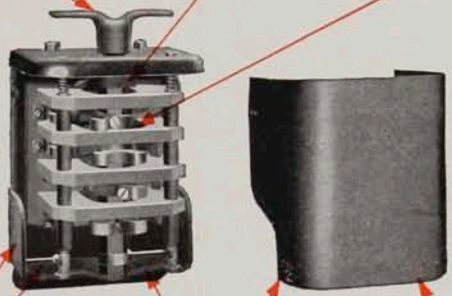
RD-400A is a triple-pole, double-throw reversing switch with either a T or horizontal handle.

RD-401A differs from the Form L in that it is a four-pole, single-throw non-reversing switch.

The T handle is regularly furnished. A horizontal handle, illustrated below, can be furnished if desired.

The star wheel and pawl give positive "on" and "off" positions.

The fingers are easily renewable. The contact segments are separated by fireproof barriers.



Switch with T Handle

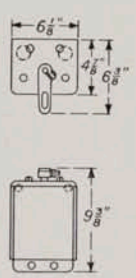
Knockout holes (1⅜ in.) are provided in the bottom and sides of the case for conduit connection.

The cap plate, frame and cover are sheet steel giving a light but strong and substantial case.

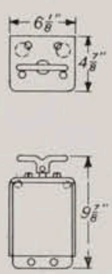
The front cover is easily removable for making connections, inspection of contacts, etc.

RD-400 and 401 Switch with Horizontal Handle

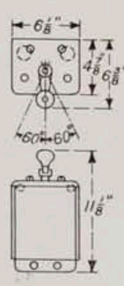
RD-402 and 403 Switch with Handle for Shipper Rod Operation



Dimensions of RD-402 and 403 Switch with Shipper Rod Handle



Dimensions of RD-400 and 401 Switch with T Handle



Dimensions of RD-400 and 401 Switch with Horizontal Handle

A table showing the ratings and use of these switches is given on page two

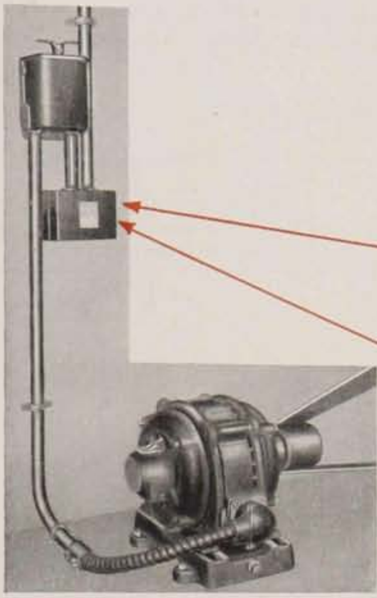
Overload Protection for A-C. Motors

CR-1920 Protective Cutout with Time-limit Protective Plugs

The CR-1920 Protective Cutout consists of two time-limit protective plugs with receptacle, enclosed in a sheet iron case.

Adapted for use with motor-starting devices where it is desired to obtain time-limit, overload protection.

Suitable for use with motors up to 3 h.p.—110 volts, and 5 h.p.—220, 440 and 550 volts.



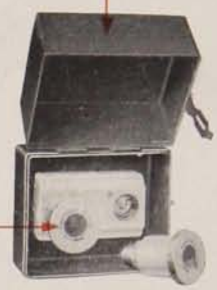
A CR-1920 Protective Cutout and an RD-400 Switch with conduit connections to the motor

CR-1920 Protective Cutout. No electrical parts exposed.

This method of motor protection is well adapted for use with drum type switches.

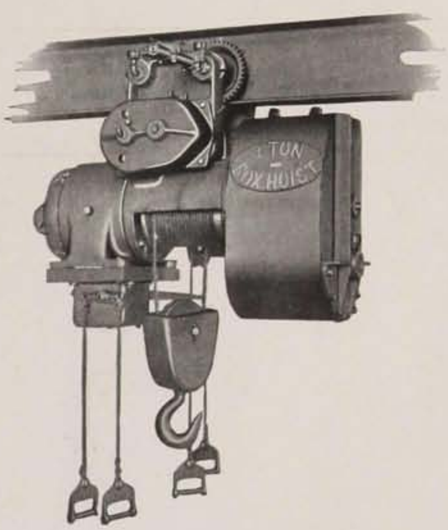
The sheet-iron case is hinged and can be locked. One-inch knockout holes are provided for conduit wiring.

These time-limit plugs protect motors from injurious single-phase running which is the cause of 90% of the burnouts.

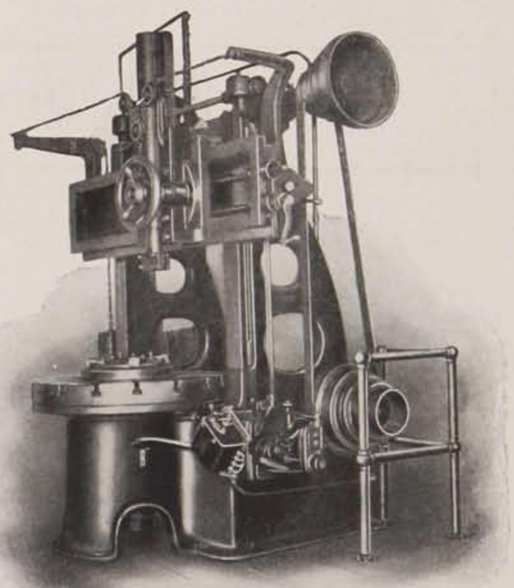


CR-1920 Cutout with time-limit protective plugs

Illustrations showing the application of Drum Type Switches



Three-ton two-motor Box Hoist with a RD-134 Drum Type Reversing Switch arranged for rope lever operation for use with the raising and lowering motor



42 in. Boring Mill operated by type KT-6-5-1200-220 volt motor controlled by a RD-134 Drum Type Switch

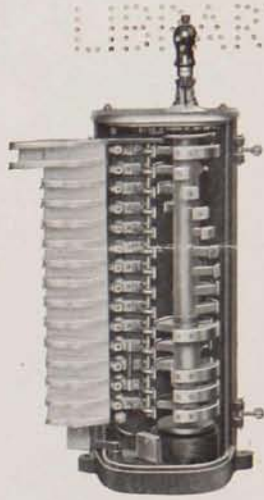
CR 3100 Drum Type Controllers
for Series, Shunt or Compound Wound Motors

Reversing or
Non-reversing

Starting or
Speed-regulating Duty

R-159

R-122



R-164

THREE SIZES OF THE STANDARD LINE OF CONTROLLERS

G-E Drum Type Controllers are designed to control motors operating machinery where frequent service is required. They have a distinct advantage over the dial type as they are of stronger construction and are totally enclosed, giving greater protection to the operator. In the design especial attention has been given to their ability to open the circuit under all conditions of load without undue wear.

APPLICATION

CR 3100 Controllers are recommended for use with either series, shunt or compound wound direct-current motors. They may be used for either starting or speed-regulating duty, reversing or non-reversing.

For adjustable speed motors use CR 3105 controllers.

A magnetic control equipment is recommended where remote control or automatic starting is desired.

SAFETY

All live parts of every drum controller are enclosed, thus effectually protecting the operator, who may be unskilled or inexperienced, from shock or burn. The mechanism is also protected from dust, weather, and mechanical injury.

Ask our nearest office for Complete Information

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

Sales Offices in all large cities.

68202
Class 317

4-16-18

MAINTENANCE

In any type of controller the arcing points require the most frequent renewal. On drum type controllers the burning is kept down to a minimum by magnetic blowout coils (except in the R-159), and by providing an ample number of points. Frequent renewals of fingers and arcing tips are, therefore, not necessary. All wearing parts are accessible and easily and cheaply renewed.

SMALL SIZE

Drum controllers require less floor space than any other type of controller. The operator can, therefore, have his controller in the most convenient location. The resistor, being separate, can be mounted out of the way.

R-115 Controller

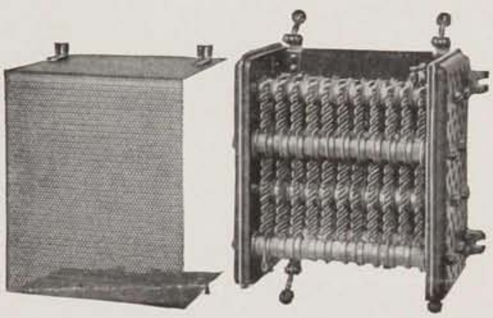
CR 3170 Protective Panel

HANDLES

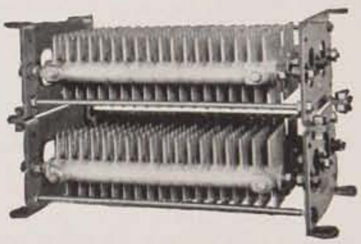
Standard controllers are furnished with a horizontal handle as illustrated. The handle is provided with a latch to prevent accidental reversal of the motor.

UNDER VOLTAGE AND OVERLOAD PROTECTION

Where it is desired to protect the operator and machinery against sudden starting after a failure of voltage, or against overloads which would injure the motor, a CR 3170 Protective Panel is recommended. A single-pole circuit breaker for overload protection and a single-pole contactor which opens on failure of voltage are mounted on a slate base. A sheet-iron case encloses all parts.



Enclosed Ventilated Resistor for Machine Shop Service



Open, Sectional Type Resistor for Crane and Hoist Service

RESISTORS

The resistors used with these controllers, with the exception of the R-159 controller, consist of two types:

For machine tool service the enclosed, ventilated type is recommended. Form R, wire-wound units are used on the smaller and cast grid units on the larger sizes. The terminals are placed inside the enclosing cover which is readily adapted for conduit wiring.

For crane and hoist service the open, sectional grid type resistor is used. It consists of cast-iron grid units mounted on tie rods and assembled in pressed steel end frames. The sections can be stacked one on the other, or individually mounted as space permits.

Three standard lines are available as follows:

For Machine Tool Service

CR 3130 for starting duty only.
CR 3131 for continuous regulating duty, giving 50 per cent speed reduction at three-quarter full load and 65 per cent speed reduction at full load.

For Crane and Hoist Service

CR 3132 for intermittent duty.

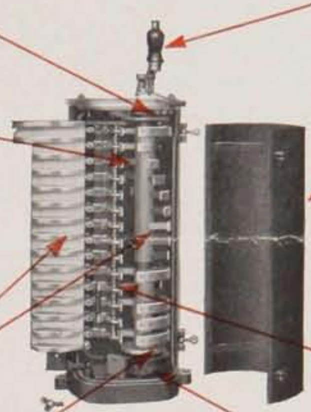
DISTINCTIVE FEATURES OF DRUM-TYPE CONTROLLERS

The star wheel and pawl insure positive contact on each point of the controller.

Malleable iron horizontal handles are made rustproof.
Latch operated by button in handle prevents accidental reversal of motor.

The contacts have a sliding motion, giving "make and break" points different from the "running" points, thereby insuring clean running contacts.

Sheet-iron cover, asbestos lined, protects controller parts from dust and mechanical injury and the operator from accidental contact with live parts.
Diagram of connections pasted inside cover to facilitate installation. Terminals are clearly marked.



Fireproof barriers prevent arcing between contacts.
Cast brass cylinder supports the contact segments. Cylinder held firmly in place by set screws.

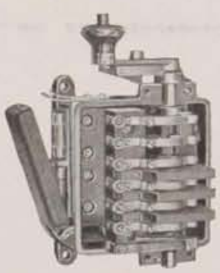
These Features are Typical of CR 3100 Controllers, Except the R-159

Forged copper fingers with phosphor bronze springs and fitted copper segments are easily renewable.
Finger pressure and alignment are adjustable.

Operating shaft, hexagonal, positively preventing any turning of cylinder on shaft. Special composite insulation between cylinder and shaft.

Magnetic blowout coils are moistureproof and will carry the full load current continuously. They effectively extinguish the arc at each finger and reduce the amount of burning to a minimum.

NOTE:—The photograph above illustrates the general appearance of the R-28, R-128 and R-156 Controllers.



R-159 Controller with Cover Removed

R-159 CONTROLLER

The design of this controller is radically different than the others and, therefore, requires special mention. It is used only on 110- and 220-volt circuits with small size, intermittent rated motors.

The starting resistor mounted on back of controller is rated 10 sec. starting 5 h.p., and 1 min. starting once every 4 min. for an hour on smaller sizes.

Enclosed line fuses are mounted on the side of the controller.

INTERCHANGEABILITY

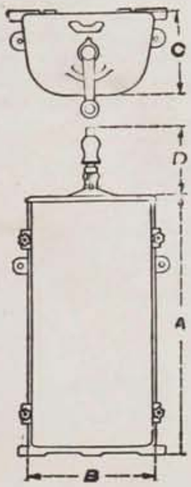
A careful record of the serial numbers of all drum controllers is kept. This, in conjunction with a strict avoidance of modification in design after standardization, insures the interchangeability of parts and greatly assists in ordering renewals.

CHARACTERISTICS OF CR 3100 CONTROLLERS

Type of Controller	HORSE-POWER RATING						Control Pts. Forward and Reverse	Remarks
	*Intermittent			†Continuous				
	115 Volts	230 Volts	550 Volts	115 Volts	230 Volts	550 Volts		
R-159-A	3	5	..	..	..	..	3	See note on page three.
R-122-A	8	12	20	5	12	20	5	Does not open shunt field in "off" position. This controller should not be used with motors having intermittent shunt fields. For these motors use R-28.
R-28-V	15	30	60	10	15	25	5	Holes through side for leads.
R-128-E	..	..	..	15	25	50	5	Use R-28-V or R-156-A for intermittent duty. Holes through side for leads.
R-156-A	20	35	70	..	..	..	8	Use R-128-E or R-164-A for continuous duty. Holes through back for leads.
R-164-A	30	50	100	20	35	75	8	Holes through back for leads.
R-115-L	50	100	200	35	75	150	10	Holes through back for leads.

*The intermittent rating should be used for crane and hoist work and other installations having short duty cycles where the running time is not over 50 per cent of the total and the maximum continuous running time is not over five minutes.

†The continuous rating should be used in all cases where any point on the controller will be used as a running point for a period exceeding five minutes.



‡DIMENSIONS AND WEIGHTS

Type	DIMENSIONS IN INCHES				WEIGHTS	
	A	B	C	D	Net	Shipping
R-159-A	9½	8	7⅞	3¼	35	50
R-122-A	14½	8⅝	7	4	60	75
R- 28-V	22¾	10½	7½	7¼	110	135
R-128-E	22¾	10½	7½	7¼	110	150
R-156-A	32⅝	13⅝	8½	8¼	200	240
R-164-A	32⅝	13⅝	8½	8¼	200	260
R-115-L	31½	16⅝	10½	8¼	280	350

‡These dimensions are approximate only and should not be used for construction.

May 6, 1918

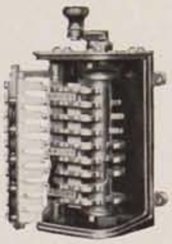
CR 3110 Drum-type Controllers

for Cranes, Hoists, and Similar Service

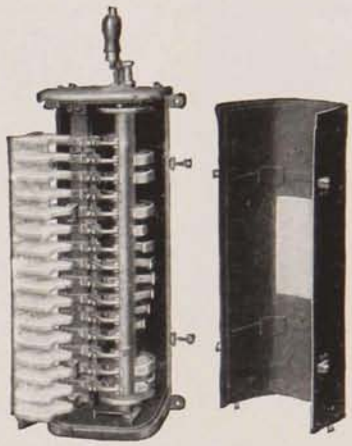
ARMATURE CONTROL POINTS

DYNAMIC BRAKING

G-E Drum-type controllers are designed to control motors operating machinery where frequent service is required. They have a distinct advantage over the dial type as they are of stronger construction and are totally enclosed, thus giving greater protection to the operator. In the design special attention has been given to their ability to open the circuit under all conditions of load without undue wear.



B-109 Controller



B-114-M Controller

APPLICATION

CR 3110 controllers are recommended for use with cranes, hoists, and similar machinery where the speed of the motor while lowering is to be controlled by dynamic or electric braking. When a direct-current motor is connected as a generator with resistance across its armature, and driven by the load which is being lowered, it delivers power to the line and holds back against the load. If there is not sufficient weight on the hook to overhaul the motor and drums, the controller is designed so that the motor will assist in driving the hoisting machinery in a downward direction. The speed of the motor can thus be accurately regulated. The controllers are for use with series-wound motors and, therefore, are provided with armature points only.

A magnetic control equipment is recommended for use with motors beyond the capacity of the drum type controller.

Ask our nearest office for complete information

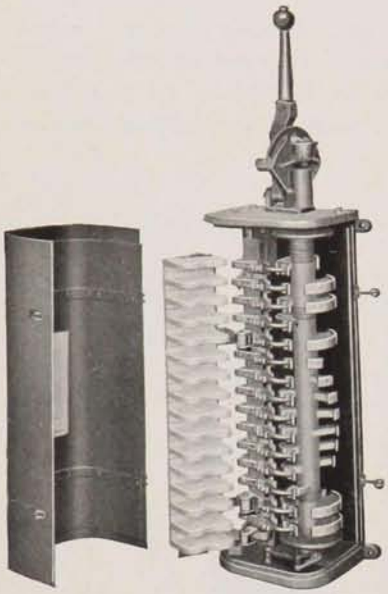
GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

Sales Offices in all large cities

SAFETY

All live parts of every drum controller are enclosed, thus effectually protecting the operator, especially the inexperienced, from shock or burn. The mechanism is also protected from dust, weather, and mechanical injury.



Controller equipped with vertical handle

MAINTENANCE

In any type of controller the arcing points require the most frequent renewal. On drum type controllers the burning is kept down to a minimum by magnetic blowouts and by providing an ample number of points. Frequent renewals of fingers and arcing tips are therefore not necessary. All wearing parts are accessible and easily and cheaply renewed.

SMALL SIZE

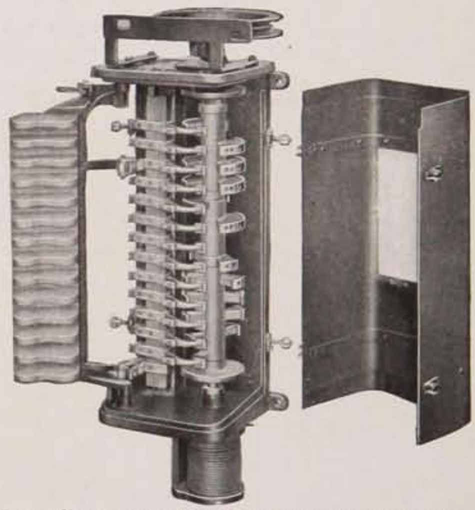
Drum controllers require less floor space than those of any other type. The operator can, therefore, have his controller in the most convenient location. The resistor, being separate, can be mounted out of the way.

HANDLES

Standard controllers as shown on pages 1 and 3 are furnished with a horizontal handle. Except on the B-109, the handle is provided with a latch to prevent accidental reversal of the motor. In most cases these controllers can be supplied with a vertical handle or a rope wheel with or without spring return attachment, as illustrated on this page.

AUXILIARY PANEL

An auxiliary magnetic switch panel containing two single-pole contactors is furnished with the B-112 controller to relieve the burning and wear on the controller fingers due to the large currents which must be handled. (See page 3.)



Controller equipped with rope wheel and spring—return attachment

Distinctive Features

This type of rustproof handle is regularly supplied. The latch operated by button in handle prevents accidental reversal of the motor.

Starwheel and pawl insure positive contact on each point.

Contacts have a sliding motion, giving running surfaces different from arcing tips, thus running surfaces are always clean.

Operating shaft hexagonal, positively preventing any turning of cylinder on shaft. Special composite fiber insulation between cylinder and shaft.

Each connection terminal plainly marked.

A diagram of connections is pasted inside the cover to facilitate installation.

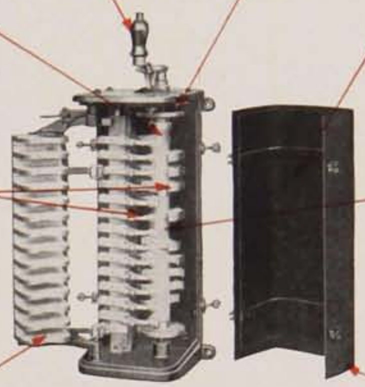
Forged copper fingers with phosphor bronze springs, and fitted copper segments are easily renewable. Finger pressure and alignment are adjustable.

Brass cylinders, being non-magnetic, do not distort or weaken the field produced by the magnetic blowout coils.

Magnetic blowout coils effectively extinguish the arc at each finger and will carry full load current continuously.

Moulded deflectors prevent cross arcing.

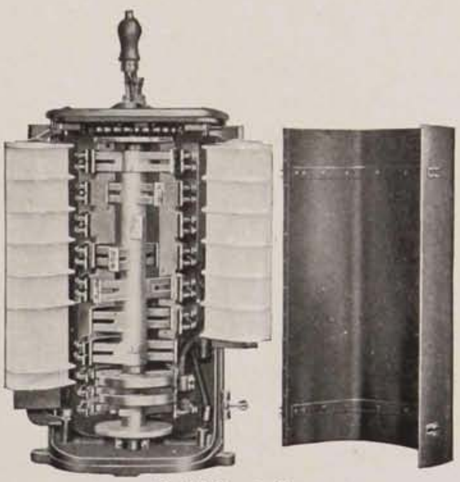
Sheet-iron cover, asbestos lined, protects parts from dust and mechanical injury and operator from accidental contact with live parts. Easily removed for inspection.



B-113 Controller

INTERCHANGEABILITY

A careful record of the serial numbers of all drum controllers is kept. This, in conjunction with a strict avoidance of modification in design after standardization, insures the interchangeability of parts and greatly assists in ordering renewals.



B-112 Controller

Magnetic Switch Panel

The B-112 controller requires a separately mounted magnetic switch to make and break the armature circuit.

RESISTORS

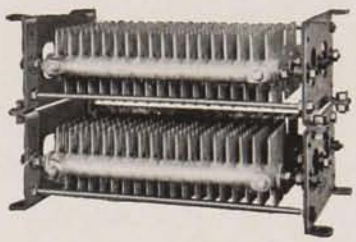
Type SG resistors are recommended for use with these controllers. They consist of cast-iron grid units mounted on tie-rods and assembled in pressed steel end frames.

Each grid is supported by three tie-rods and the design is such as to reduce to a minimum the danger of short circuits by vibration, or grounding or burning out by sudden changes in temperature or heavy current overloads.

All sections are of uniform dimensions so that they may be either bolted together and stacked one section on another, affording great economy in floor space, or mounted individually as desired.

There are four distinct lines of resistors required to meet the varied conditions of operation for different types of cranes and hoists as follows:

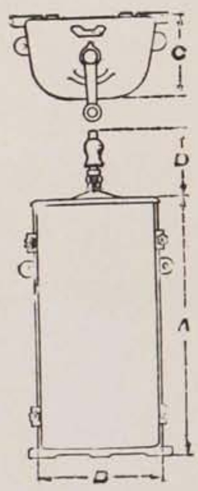
CR 3151 for high speed, light duty.
CR 3152 for high speed, heavy duty.
CR 3153 for slow speed, light duty.
CR 3154 for slow speed, heavy duty.



Type SG Resistor in Two Sections

RATINGS AND DIMENSIONS

Type of Controller	H.P. Rating Intermittent or Crane Duty			No. Control Points		Weights		φDimensions in Inches			
	115 Volts	230 Volts	550 Volts	Hoist	Lower	Net	Ship.	A	B	C	D
B-109A	5	5	‡	4	4	60	85	14½	8⅝	7½	3⅞
B-113P	15	30	40	5	6	140	200	27⅞	13	10⅛	8¼
B-114M	25	50	60	6	7	175	260	33⅝	13	10⅞	8¼
*B-112E	40	80	150	8	10	375	500	31½	16⅝	10⅝	8¼
†B-112E	50	100	150	8	10	375	500	31½	16⅝	10⅝	8¼



* Requires a 300-ampere magnetic switch panel to break the armature circuit.
† Requires a 500-ampere magnetic switch panel to break the armature circuit.
‡ Should not be used on 550 volts.
φ These dimensions are approximate only and should not be used for construction.

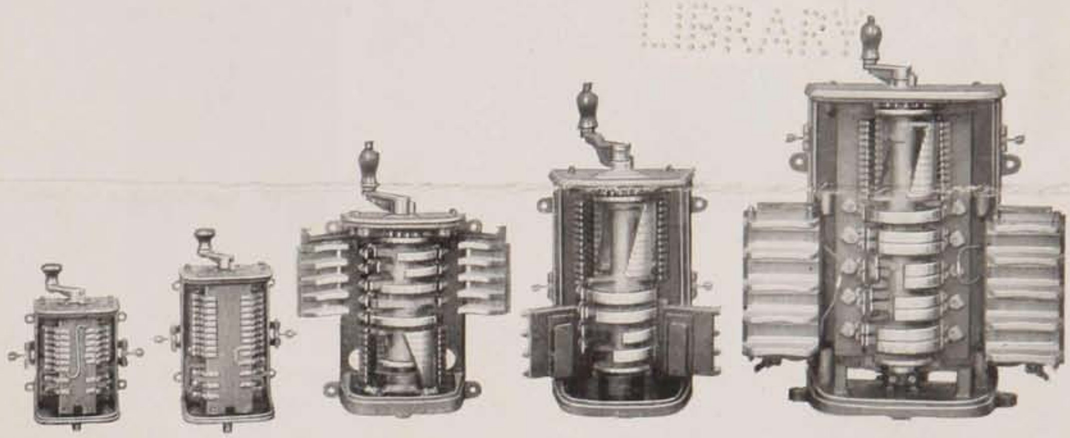
CR 3105 Drum-type Controllers

For Use with D-C. Adjustable-speed Motors

Machine Tool Service

Reversing or Non-reversing

Armature and Field Control Points



R-302 R-301 R-182 R-98 R-166

G-E drum-type controllers are designed to control motors operating machinery where frequent service is required. They have a distinct advantage over the dial type as they are of stronger construction and are totally enclosed, thus giving greater protection to the operator. In the design, special attention has been given to their ability to open the circuit under all conditions of load without undue wear.

APPLICATION

CR 3105 controllers are recommended for use with direct-current adjustable speed motors driving machine tools. They are provided with armature control points for starting and field control points capable of continuous duty for speed regulation. The controllers are supplied for either non-reversing or reversing service.

~~For constant speed motors use CR 3100~~ controllers.

A magnetic control equipment is recommended for remote control or for use with motors beyond the capacity of the drum controller.

SAFETY

All live parts of every drum controller are enclosed, thus effectually protecting the operator, especially the inexperienced, from shock or burn. The mechanism is also protected from dust, weather, and mechanical injury.

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

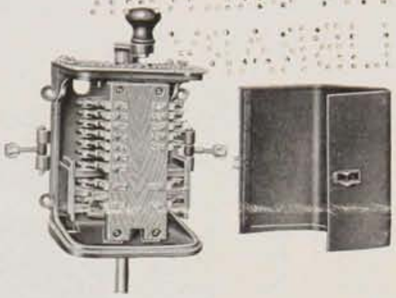
Sales Offices in all large cities

68204
Class 317

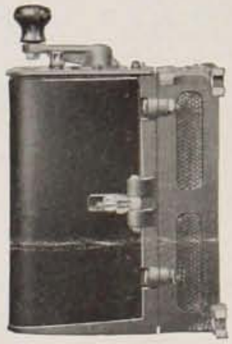
5-1-18

MAINTENANCE

In any type of controller, the arcing points require the most frequent renewal. On drum-type controllers the burning is kept down to a minimum by magnetic blowouts (except in the R-136), and by providing an ample number of points. Frequent renewals of fingers and arcing tips are therefore not necessary. All wearing parts are accessible and easily and cheaply renewed.



R-302 Controller With Cover Removed



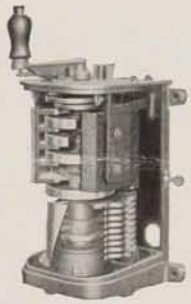
R-301 Controller Showing Armature and Field Resistance Mounted on Back of Controller

SMALL SIZE

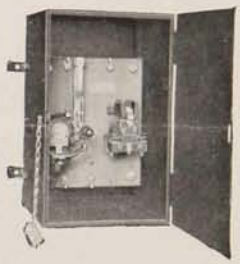
Drum controllers require less floor space than those of any other type. The operator can, therefore, have his controller in the most convenient location. The resistor, being separate, can be mounted out of the way.

HANDLES

Standard controllers are furnished with a horizontal handle as illustrated. The handle, except on the R-301 and R-302, is provided with a latch to prevent accidental reversal of the motor.



R-182 Controller



CR 3170 Under-voltage and Overload Protective Panel

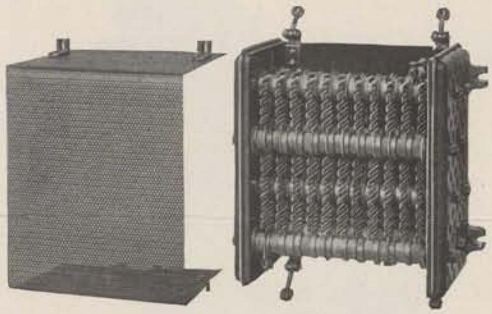
UNDER-VOLTAGE AND OVERLOAD PROTECTION

Where it is desired to protect the operator and machinery against sudden starting after a failure of voltage, or against overloads which would injure the motor, a CR 3170 protective panel is recommended. A single-pole circuit breaker for overload protection and a single-pole contactor which opens on failure of voltage are mounted on a slate base. The contactor is reset at the "off" position of the controller. A sheet-iron case encloses all parts.

GEAR DRIVE

On lathes where it is desired to operate from the apron through a splined shaft and gearing or on other machine tools where the controller is operated through gears or sprockets, the handles may be removed and a pinion readily attached, as the shafts are accurately finished. The shafts of the R-301 and R-302 controllers are extended through the bottom to facilitate operating them either by handle or through gearing as desired.

CR 3134 Resistor Showing Ventilated Case and Conduit Wiring Connection

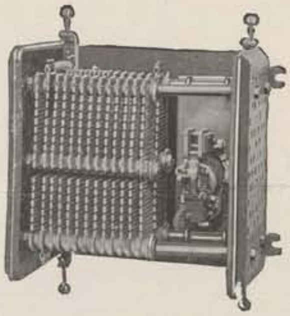


CR 3134 Resistor Showing How Cast-iron Grids are Anchored to Prevent Breakage from Vibration

RESISTORS

The armature and field resistors for motors 3 h.p. and below are mounted on the back of the controller as illustrated on page 2. Above 3 h.p. the field resistor is mounted on the back of the controller, but the armature resistor is arranged for mounting separately and is enclosed in a ventilated box which prevents chips or metallic substances from short circuiting the resistance units.

The resistors are liberally designed and while the armature resistor cannot be used for regulating duty continuously, it may be left in the circuit for short periods when "setting up" a tool.



CR 3137 Resistor with Contactor for Use Above 15-h.p., 230 volts, 25-h.p., 230 volts, and all 550-volt Motors

In many installations it is desirable to bring the motor to rest quickly and this is accomplished by the effective application of the dynamic braking principle. A separate resistor, CR 3137, is required in addition to the regulating resistor, CR 3134, the former being connected across the motor armature when the controller handle is thrown to the "off" position. Above 15 h.p., 115 volts, 25 h.p., 230 volts, and for all 550-volt motors, a contactor is required in addition to the resistor; both are mounted in the same box as illustrated above. Below these sizes CR 3134 and CR 3137 are similar in construction and appearance.

DISTINCTIVE FEATURES

The various features described below are characteristic of the complete line of CR 3105 controllers, except as noted.

Star wheel and pawl insure positive contact on each point.
Contacts have a sliding motion, giving running surfaces different from arcing tips, thus running surfaces are always clean.

This type of rustproof handle is regularly supplied on the R-98, R-166, and R-182. The latch operated by button in handle prevents accidental reversal of the motor.

Operating shaft hexagonal, positively preventing any turning of cylinder on shaft. Special composite fiber insulation between cylinder and shaft.

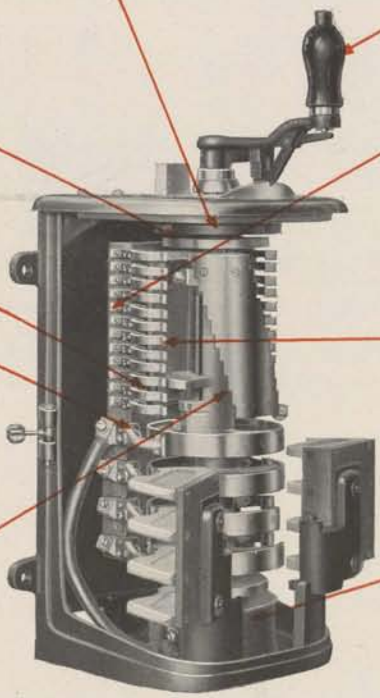
Finger board for stationary contacts is kiln dried hard wood, impregnated for moisture-proofing.

Motor field circuits (D_1) controlled by fingers and segments same as for armature circuits (D_2). No dial switch used.
Relation of fingers and segments such that fingers cannot stub.

Forged copper fingers with phosphor bronze springs and fitted copper segments are easily renewable. Finger pressure and alignment are adjustable.

Brass cylinders, being non-magnetic, do not distort or weaken the field produced by the magnetic blowout coils.

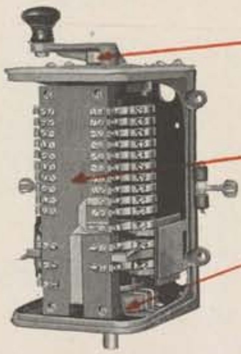
Magnetic blowout coils (except on R-302), effectively extinguish the arc at each finger and will carry full load current continuously.



R-98 Controller Typical of the Three Larger Sizes

Sheet-iron cover, asbestos lined, protects controller parts from dust and mechanical injury and the operator from accidental contact with live parts.

Each controller has a diagram of connections, pasted inside the cover, to facilitate installation. All terminals are clearly marked.


R-301 Controller Typical of Two Smallest Sizes

Removal of stop in cap plate, makes these controllers reversible.
This type of handle supplied with R-301 and R-302.

This form of finger board supplied on R-301 and R-302 controllers only, making small terminals very accessible.

Magnetic blowout coils furnished on all controllers except the R-302.

Shaft extension at bottom of R-301 and R-302 permits splined shaft connection at this point.


R-301 Controller with Name Plate Explaining Removal of Stop in Cap Plate

INTERCHANGEABILITY

A careful record of the serial numbers of all drum controllers is kept. This, in conjunction with a strict avoidance of modification in design after standardization, insures the interchangeability of parts and greatly assists in ordering renewals.

CHARACTERISTICS OF CR 3105 CONTROLLERS

Type	Maximum Horse-power Capacity			*Points Forward and Reverse		REMARKS
	115 Volts	230 Volts	550 Volts	Arma-ture	Field	
†R-302-B	3	3	..	2	10	Segment at "off" position giving dynamic brake.
π‡R-301-A	5	10	15	3	18	
πR-301-B	5	10	15	3	18	
πR-182-A	12	20	40	4	18	
φR- 98-B	20	35	70	4	22	
φR-166-A	35	65	100	4	22	

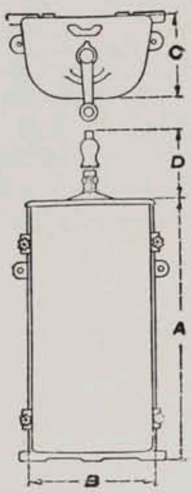
* Number of resistance steps is one less than the number of controller points.

† No magnetic blowout furnished. This controller is not satisfactory for use on 550-volt circuits and has only 10 field points; if more are required use R-301-B Controller.

‡ The R-301-B controller can be used with 115- and 230-volt motors for dynamic braking. For 550 volts use the R-301-A controller.

π With these controllers a contactor is required in the dynamic braking circuit for 550 volts.

φ With these controllers a contactor is required in the dynamic braking circuit for all voltages.

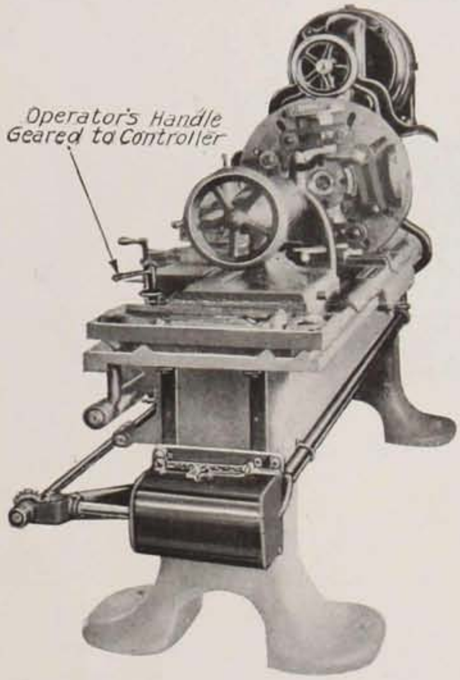


§ DIMENSIONS OF CONTROLLERS

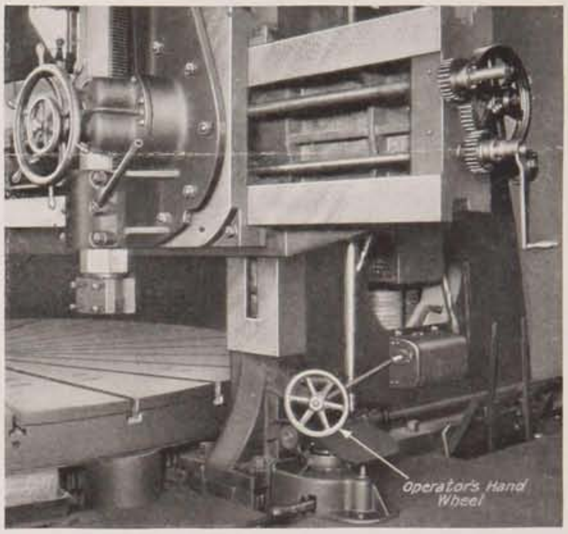
Type	DIMENSIONS IN INCHES				WEIGHTS	
	A	B	C	D	Net	Shipping
R-302-B	10⅛	7½	7⅜	3⅜	40	75
R-301-B	13⅛	8⅛	7⅞	3⅜	60	85
R-182-A	17¾	11¼	9⅞	6½	98	140
R- 98-B	21½	12¾	10¾	8¼	135	200
R-166-A	29¼	17½	11⅜	6½	265	400

§ These dimensions are approximate only and should not be used for construction.

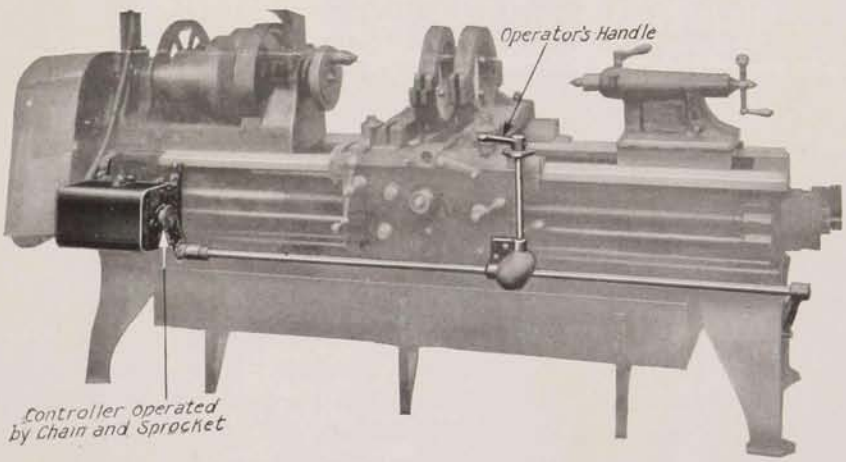
TYPICAL APPLICATIONS OF CR 3105 CONTROLLERS



Controller Operated by Splined Shaft and Gearing from Apron of Lathe



The Extended Shaft and Hand Wheel Make it Possible to Mount the Controller out of the Way and Still Place the Hand Wheel at a Point Most Convenient for the Operator



Controller Operated by Splined Shaft, and Chain and Sprocket from Apron of Lathe

Self Starters for Single-Phase Induction Motor

Types CR-2372, 2373 and 2375

Suitable for use with single-phase repulsion motors, Type RI. Particularly applicable to motor-driven pumps when it is desired to automatically start and stop motors depending upon a predetermined change in fluid level, fluid pressure or air pressure.

These starters limit the initial starting current by means of resistance in series with the motor which, after a certain time interval, is automatically short circuited, permitting the motor to come up to speed.

Type	Features	Remarks
CR-2372	Accelerating Contactor only.	Motor circuit closed and opened by separate switch, such as a knife switch, float switch, pressure switch, etc.
CR-2373	Accelerating Contactor and line contactor.	For remote control by float switch, pressure governor, pressure switch or other types of master switches.
CR-2375	Accelerating Contactor, line contactor and overload relay.	For remote control similar to CR-2373. Has in addition an overload relay of the time element type.

Perforated metal box back of panel containing the resistor.

Accelerating contactor which short circuits the starting resistance.

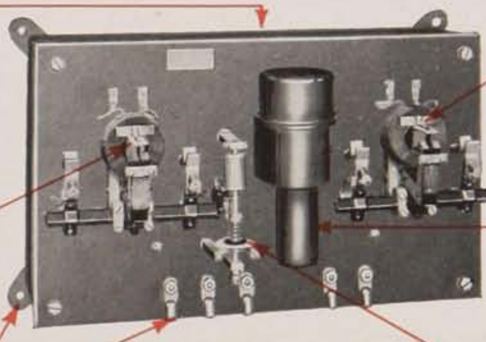
Line contactor with solid copper self-cleaning contacts. All wearing parts of substantial construction and renewable.

Adjustable time element, hand-reset overload relay. All parts enclosed.

All types arranged with feet for wall mounting.

Terminals for front connection to line and motor.

Adjustable time element interlock which provides the motor accelerating period. Larger sizes employ a time-limit shunt relay.



CR-2375

Rating

All types of starters are furnished in sizes from 1 to 15 h.p. for 110 and 220 volts, 60, 40 or 25 cycles.

Low-Voltage Release—The standard lines of starters provide "low-voltage release" only, i. e., upon failure of voltage; the motor will automatically start upon return of voltage to the line.

Low-Voltage Protection—Can be furnished if specified, so that after failure of voltage, the motor will start only at the will of the operator.

Detailed information will be supplied upon request to our nearest office

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

68408

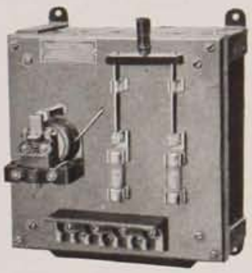
Automatic Control
for Small Direct Current Motors

The counter e.m.f. self-starter is recommended for use with shunt or compound wound motors.

Particularly adapted for use with motor-operated pumps where it is desired to maintain a predetermined pressure or fluid level in a tank.

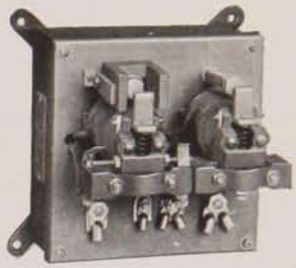
CR-2301

Accelerating contactor only. Motor started by closing external line switch.



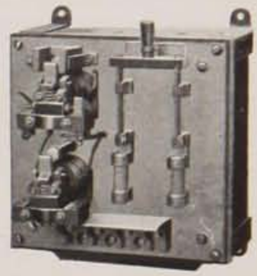
CR-2302

Similar to CR-2301 but with line switch and fuses. Motor started by closing line switch.



CR-2303 CR-2304

Accelerating contactors and line contactor for remote control by float switch, pressure switch, etc. CR-2304 same but arranged for push-button control.



CR-2305 CR-2306

Modification of the CR-2303 and CR-2304 starters by the addition of line switch and fuses. Remote control by float switch, pressure switch, push-buttons, etc.

These starters provide the simplest and most inexpensive method of automatically controlling small D-C. Motors.

Resister mounted on back of starter and enclosed in ventilated case.

Low-Voltage Release—CR-2301, CR-2302, CR-2303 and CR-2305 Starters provide "low-voltage release" only, i.e., upon failure of voltage; the motor will automatically start upon return of voltage to the line.

Low-Voltage Protection—CR-2304 and CR-2306 with a "start and stop" push-button station provide "low-voltage" protection; that is, upon failure of voltage, the motor will not start when the voltage returns to the line until the "start" button is pressed.

Capacity—up to 5 h.p., 115 volts.
up to 10 h.p., 230 volts.

Other types of automatic control are available for larger motors and higher voltages.

Dimensions—Smaller sizes, 6 in. square.
Larger sizes, 9 in. square.

Weight—ready to ship, 40 lb.

Ask Our Nearest Office for Complete Information.

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

Sales Offices in all Large Cities

68409

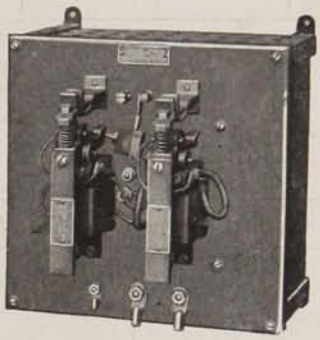
AUTOMATIC STARTERS

For Direct Current Motors—Current-Limit Acceleration

For the Automatic Starting and Stopping of Series, Shunt or Compound-wound Motors

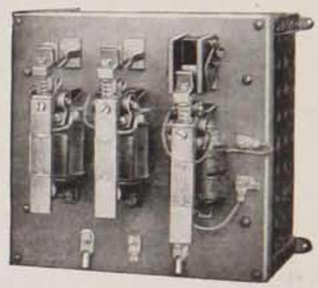
G-E automatic starters provide a simple and reliable means of controlling direct current motors from remote points, and are particularly advantageous when used with motors which are required to start and stop frequently.

This leaflet describes the application and construction of the standard lines built by the General Electric Company.



CR 2201
Motor Started by Closing Separately Mounted Line Switch

CR 2202 Starter similar to CR 2201 with d.p. line switch and fuses mounted on Panel.



CR 2203 AND CR 2204
For Remote Control by Float Switch, Pressure Governor, Push-Button Station, etc.

APPLICATION

Recommended for the control of industrial motors driving centrifugal or reciprocating pumps, air compressors, blowers, fans, belt conveyors, line shafting, or any machinery where automatic starting and stopping is desired.

The remote-control starters may be operated either by a float switch, pressure governor, pressure switch, single-pole knife, snap switch, or push-button station.

Ask Our Nearest Office for Complete Information

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

Sales Offices in all large cities

68410
Class 317

1-16-18

CONSTRUCTION

The accelerating units or contactors with the line switch and overload relay (when furnished) are mounted on a slate base and the resistor, enclosed in a ventilated case, is mounted on the back.

The following tables give the various forms of the standard line and the sizes and voltages of each which are available.

Characteristics	FORMS—ALL FORMS HAVE SERIES ACCELERATING CONTACTORS					
	MOTOR CONTROLLED BY LINE SWITCH		FOR REMOTE CONTROL BY FLOAT SWITCH, PRESSURE GOVERNOR, ETC.		FOR REMOTE CONTROL BY PUSH-BUTTON STATION	
	Separately Mounted Line Switch	Line Switch and Fuses on Starter	With Line Contactor	With Line Contactor and Line Switch and Fuses	With Line Contactor	With Line Contactor and Line Switch and Fuses
Without overload relay......	CR 2201 *CR 2201-1	CR 2202	CR 2203 *CR 2203-1	CR 2205	CR 2204	CR 2206
With overload relay.........	....	....	CR 2213	CR 2215	CR 2214	CR 2216

* Oil-immersed.

SIZES AND VOLTAGES OF STANDARD STARTERS

Forms	H-P. SIZES		
	115 Volt	230 Volt	550 Volt
CR 2201 and CR 2202...........	1–20	1–25	1–25
*CR 2201-1 and *CR 2203-1.......	....	1–25	....
CR 2203 to CR 2206........... CR 2213 to CR 2216...........	1–40	1–85	1–200

* Oil-immersed.

PROTECTION FOR THE MOTOR

All starters provide either under-voltage release or under-voltage protection. Overload protection may be obtained if desired.

Under-Voltage Release provides that in case of failure of voltage the motor will automatically re-start on return of voltage.

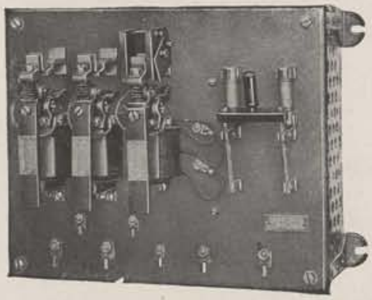
Starters providing "under-voltage release,"—CR 2201, 2202, 2203, 2205, 2213, 2215.

Under-Voltage Protection provides that in case of failure of voltage the motor will not start upon return of voltage to the line until the "start" button is pressed.

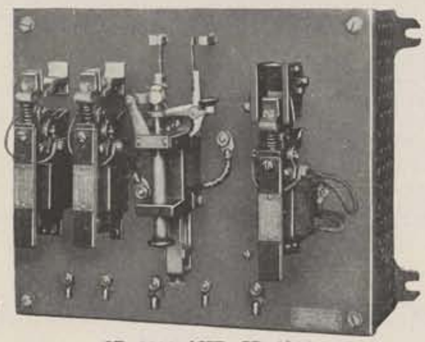
Starters providing "under-voltage protection,"—CR 2204, 2206, 2214, 2216.

Overload Protection is supplied by an instantaneous hand reset overload relay which opens the control circuit on overload. An electrically reset relay can be supplied if desired.

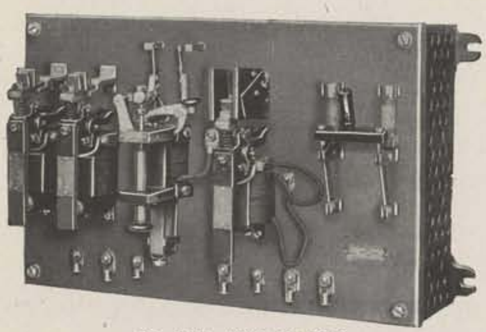
Starters providing "overload protection,"—CR 2213, 2214, 2215, 2216.



CR 2205 AND CR 2206
The Line Switch Mounted on the Starter is Recommended as it Adds to the Economy of Space, Ease of Wiring, and Compactness of the Complete Equipment



CR 2213 AND CR 2214
The Overload Relay Protects the Motor from Injurious Overloads



CR 2215 AND CR 2216
Another Modification of the Standard Remote-Control Starter Having the Line Switch and Fuses and Overload Relay Mounted on the Panel

DISTINCTIVE FEATURES

All contactors are designed for heavy duty. The operating coils of the line contactors, as well as the coils of the smaller accelerating contactors, are wound with enamel covered wire and impregnated for moisture proofing. On larger sizes, coils are edgewise-wound with heavy copper ribbon.

The main circuit is made and broken on solid copper contacts provided with magnetic blowout and arc chutes.

The starters provide current-limit acceleration which always starts the motor right, quickly on light loads, slowly on heavy loads.

Wearing parts all replaced from front, without disturbing panel mounting or connections.

Starters have long life, renewal parts are inexpensive, therefore low maintenance.

Terminals are plainly marked and line, motor, and control circuit connections are made on front of panel, facilitating installation.

What Automatic Control will do in Your Plant

Will automatically maintain any predetermined fluid level or pressure in a tank.

Will start the motor by means of a push-button placed at any point.

Will, as desired, either automatically restart the motor when voltage returns to the line after failure, or prevent unexpected starting after shutdowns.

Will protect the motor from injurious overloads.

Will protect the operator from shock or burn, thereby making starting and stopping safe.

Will eliminate the personal factor at just the time human service is apt to fail.

Will save time and increase the output because of greater speed and accuracy for each operation.

Will save power on account of ease of starting and stopping.

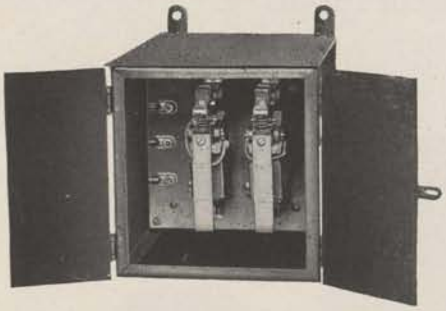
Will save expense and require only occasional attention.

Can be operated by unskilled labor.

"Emergency stop" push-buttons can be located at convenient points.

Will work perfectly day or night.

ENCLOSING CASES FOR AUTOMATIC STARTERS



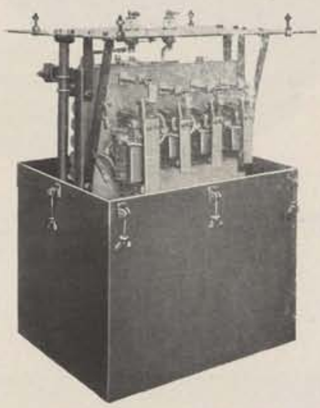
Automatic Starter with Sheet Metal Enclosing Case

The General Electric Company is prepared to furnish dustproof sheet iron enclosing cases (CR 2200-1) for the automatic starters described in this leaflet. The hinged doors can be locked shut to prevent any unauthorized person from making adjustments or tampering with the equipment.

Enclosing cases protect the control equipment from dust and dirt and prevent accidental contact with live parts.

AUTOMATIC STARTERS IMMERSED IN OIL

Oil-immersed automatic starters (CR 2201-1 and CR 2203-1) not only eliminate fire risk in mines and similar places, but they are particularly adapted for use where unprotected devices would be disastrously affected if a great amount of moisture or acid were present.



The Oil Tank Can be Easily and Quickly Removed to Facilitate Inspection and Repairs

After the Cover is in Place it is Securely Fastened, Making the Starter Proof Against Explosive Gases as Well as Against Corrosion

ACCESSORIES FOR REMOTE CONTROL

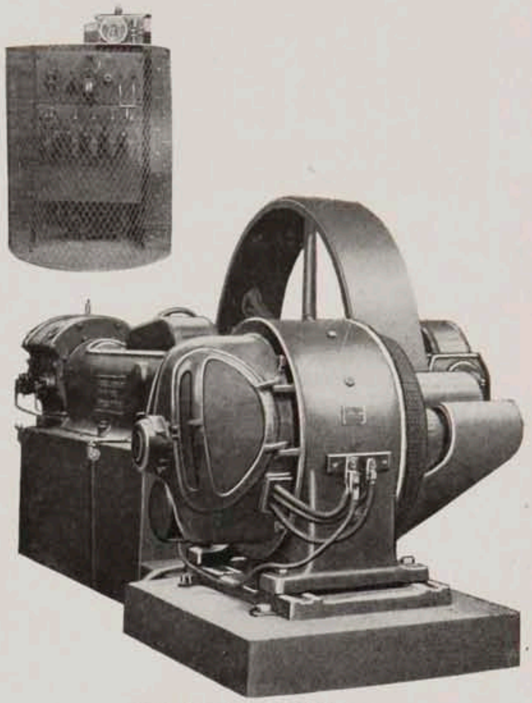
To automatically maintain a predetermined fluid level in a tank—use a CR 2931 Float Switch.

To automatically maintain a predetermined air or water pressure on a tank—use a CR 2922 Pressure Governor or a CR 2925 Pressure Switch.

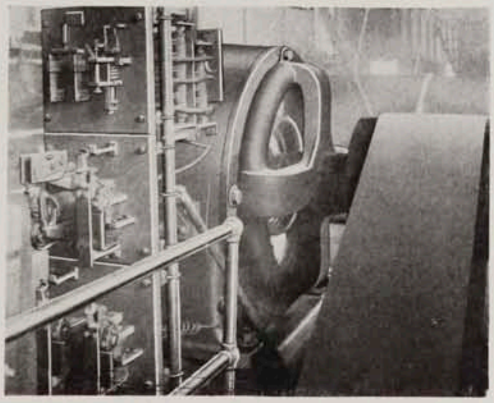
To control motors by hand from remote points—use a CR 2940-BS-7J or BS-12A push-button station.

TYPICAL EXAMPLES OF THE APPLICATION OF AUTOMATIC CONTROL

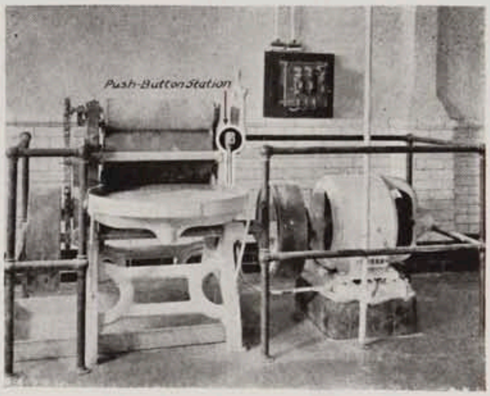
FOR MACHINERY IN GENERAL
Mount the Starter on a Wall or Post, the Push Button on the Machine. Convenience of Control Increases Production



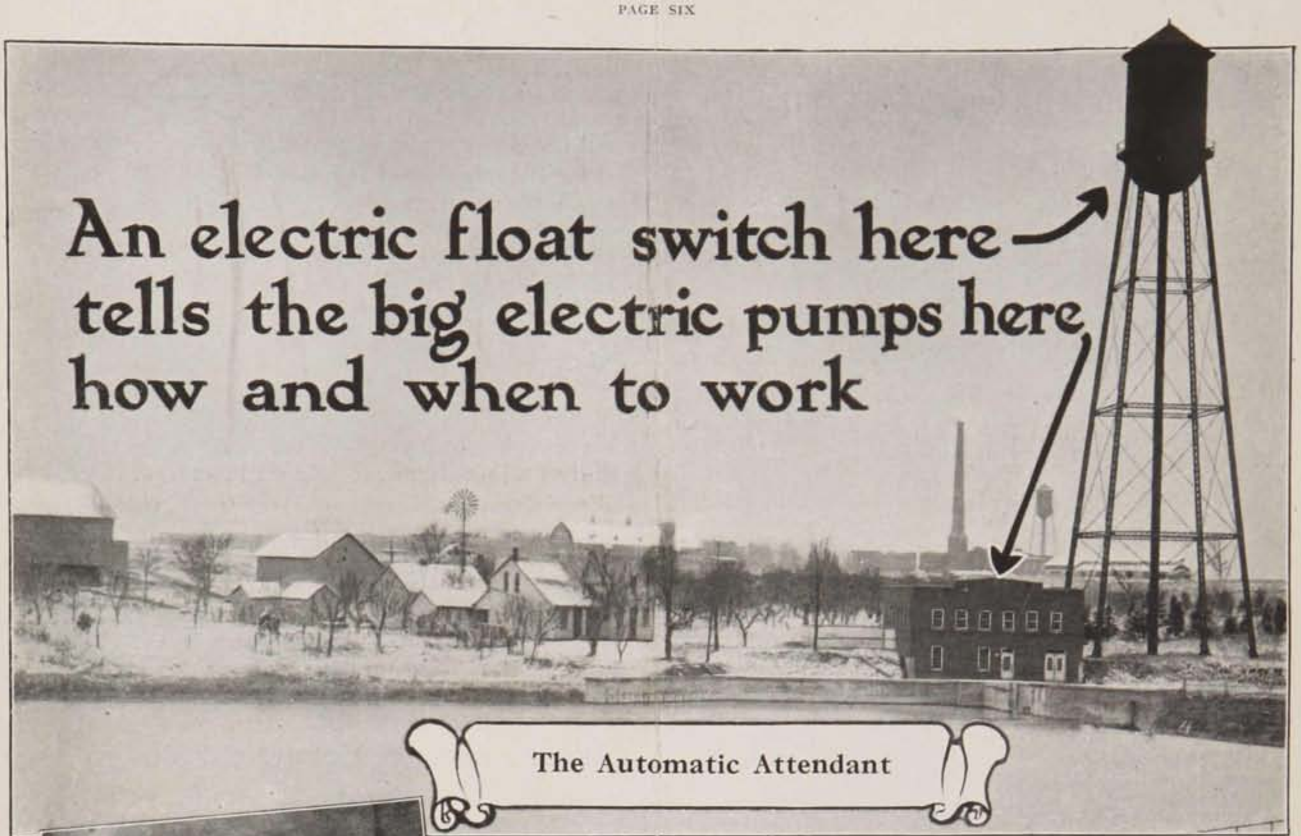
FOR AIR COMPRESSORS
A Constant Pressure Can be Maintained in a Tank Without any Attention by Means of a G-E Pressure Governor and Automatic Starter



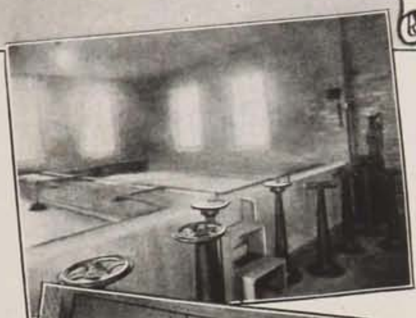
FOR LINE SHAFTING
Arranged to Start Simply by Pushing a Button. Power Can be Shut Off Instantly by Emergency Stations Located at Convenient Points



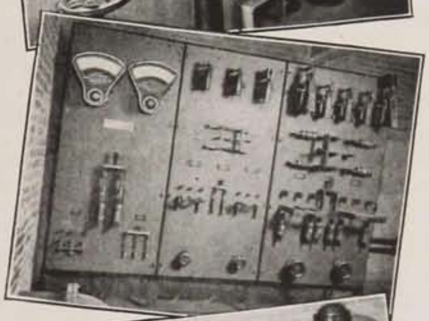
FOR BAKING MACHNIERY
Push-button Control Will Aid You in Maintaining a Neat, Clean, and Attractive Plant



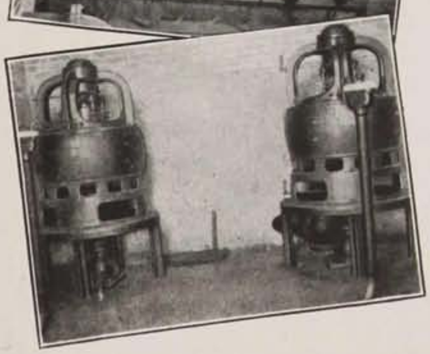
The Automatic Attendant



Float and switch at settling tanks.



Control panels actuated by above switch.



50 h.p. vertical type pump motors.

AN INTERESTING INSTALLATION

Water is lifted from a nearby storage basin to settling tanks, the level of which is automatically maintained by the float switch and 10-h.p. electrically operated pumps.

The water is then raised from these tanks to a tower 195 feet above. A constant level in the tower is maintained by another float switch connected to a 50-h.p. motor-operated pump.

All electrical equipment is automatic and located in the pump house.

Continuity of service at minimum cost can be secured at any water pumping, sewage disposal, drainage, or reclamation plant by the use of G-E motors and automatic control.

May 14, 1918

Magnetic Control for Machine Tools for D-C. Motors

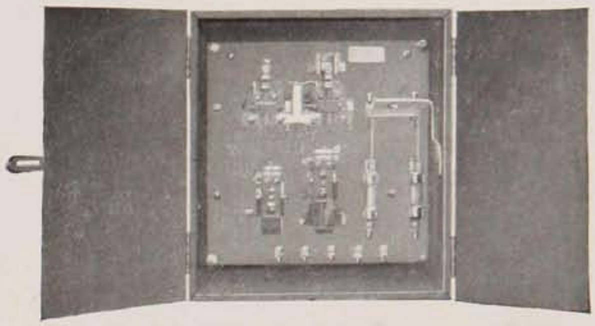
Constant or Adjustable Speed | **Wall or Floor Mounting** | **Reversing or Non-reversing**

CONSTANT SPEED EQUIPMENTS

NON-REVERSING TYPE CR 4051 REVERSING TYPE CR 4059

Form A1, sizes 1 to 5 h.p., 115 volts; 1 to 10 h.p., 230 volts, with self-contained line switch and fuses.
Form B1, sizes 7½ to 25 h.p., 115 volts; 15 to 50 h.p., 230 volts, with overload relay—line switch separate.

Enclosing Case for Wall Mounting Showing Operating Handle for Line Switch



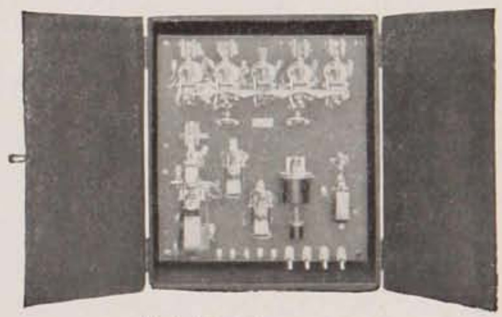
Typical Panel for Constant Speed Motors with Case Open

ADJUSTABLE SPEED EQUIPMENTS

NON-REVERSING TYPE CR 4151 REVERSING TYPE CR 4159

Form A1, sizes 1 to 5 h.p., 115 volts; 1 to 10 h.p., 230 volts, with self-contained line switch and fuses.
Form B1, sizes 1 to 5 h.p., 115 volts; 1 to 10 h.p., 230 volts, with self-contained line switch and fuses and field accelerating relay.
Form C1, sizes 7½ to 25 h.p., 115 volts; 15 to 50 h.p., 230 volts, with overload relay and field accelerating relay—line switch separate.

Enclosing Case for Floor Mounting on Pipe Supports



Typical Panel for Adjustable Speed Motors with Case Open

For Combinations with Auxiliaries see page 4

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

DISTINCTIVE FEATURES

Letters in Red Ink Refer to Corresponding Features on Opposite Page

Protection of Motor and Machine

A Under-voltage protection insures proper starting of motor at all times and prevents unexpected starting.

Elimination of Hazard to Life and Limb "Safety First"

B Overload protection safeguards motor and machine. The fuses and relays possess a time element preventing momentary overload from stopping machinery.

C On all reversing equipments the reversing contactors are mechanically interlocked to prevent "plugging" of motor.

D All live parts enclosed
Doors of all panels may be locked to prevent adjustments or repairs being made by unauthorized persons.

E Current-limit acceleration by series contactors and by field relay brings the motor to speed evenly and rapidly without exceeding safe limits or wasting time.

F Terminals at bottom of panel. Wall or pipe supports as desired. Starting and brake resistors enclosed and connected.

G Adjustable speed equipments always start motor on full field insuring rapid acceleration.
Separate field rheostat permits setting of ultimate speed.

H Dynamic braking standard on all sizes.
Provides quick stop in emergency and saves considerable time when stopping and starting frequently.

J Conduit plates on enclosing case (top and bottom) and conduit fittings on auxiliary devices simplify wiring and add to neatness of the installation.

Convenience of Control Increases Production

K Place the push-button or master switch where the operator wants it. The panel and field rheostat may be readily installed in available locations.

Ease of Installing a Finished Job

TYPICAL ARRANGEMENT OF PANELS

Letters in Red Ink Refer to Corresponding Features
on Opposite Page

H Dynamic braking contactor mechanically interlocked with line contactor.

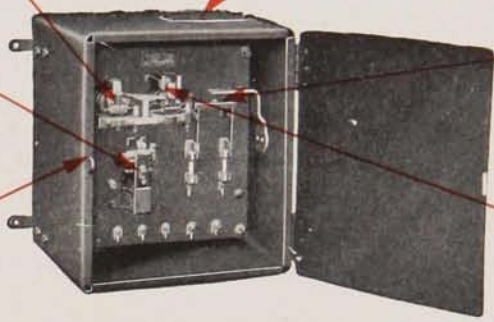
J Conduit plate at top and bottom of case.

E Series contactors for current-limit acceleration.

B Line switch with fuses, externally operated as furnished on panels, 5 h.p. or less, 115 volts: 10 h.p. or less, 230 volts.

D Enclosing case can be locked shut.

A Line contactor with magnetic blowout. With push-button station it provides under-voltage protection.



CR 4051A1 Non-reversing Panel

F Resistors assembled in enclosing case on back of panel.

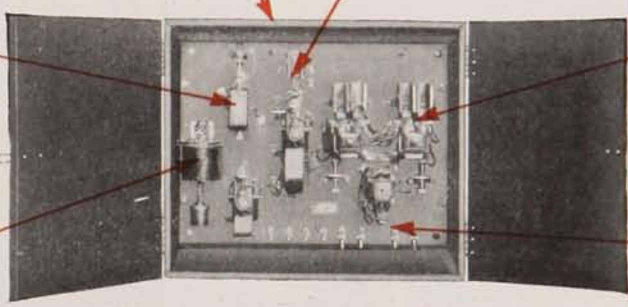
G Contact retaining full field during acceleration.

E Field accelerating relay.

C Reversing Contactors mechanically interlocked with each other and with dynamic braking contactor.

B Inverse time-limit overload relay as furnished on panels $7\frac{1}{2}$ h.p. and above, 115 volts; 15 h.p. and above, 230 volts.

F Terminals provided for all panel connections.



CR 4159C1 Reversing Pane

SUGGESTIONS FOR ORDERING MACHINE TOOL CONTROL EQUIPMENTS

(1) Specify the horse power and voltage of the motor with which the panel is to be used.
(2) If for use with adjustable speed motor, the following information is required to select the proper field rheostat:
When the motor is already installed, give serial number, if General Electric, or serial number and maker's name if of other manufacture.
As an alternative, give the shunt field current both at full field and at high speed at which it is desired to run the motor.
(3) Specify type of machine which motor will drive.
(4) How often will motor be started?
(5) Is the panel to be furnished with pipe supports for floor mounting?
(6) Specify type of accessory switch required. (See page four.)
(7) Is there anything unusual about the installation; e.g., acid fumes, dirt, long supply mains of small capacity, small generator capacity, etc.

AUXILIARY DEVICES

Use with Constant and Adjustable Speed Equipments

Conduit Fixture
Cat. No. 197484
with Conductor

Pendant Switch

For Rigid Mounting

BS-7 "Start and Stop" Push Button Station

BS-13C "Forward Reverse and Stop" P. B. Station

Station Complete

Cover Removed

BS-11N Under Voltage or Field Protective Push-button Station

SY-58 Master Switch for Control by Lever on Splined Shaft

For push-button control select the type or types of stations best suited. For control by lever on a splined shaft, or a similar mechanical arrangement, use instead the SY-58 master switch and the BS-11N under-voltage, protective, push-button station. With the panels which are not equipped with the line switch and fuses, the safety-first enclosed lever switch becomes a part of the complete equipment.

Use with Adjustable Speed Equipments Only

Any of the auxiliaries described above can be used, and in addition some means must be provided to vary the shunt field of the motor.

Enclosed Field Rheostat for Mounting Separate from Panel

Alternative No. 1. Employing a separate field rheostat which is furnished with a sheet metal cover and an insulated handwheel. This rheostat can be mounted directly on the machine if desired.

Alternative No. 2. Employing a drum type-master switch which is complete with field control points and also contains an under-voltage protective relay. Its use eliminates the separate field rheostat and push-button stations. The separate lever switch is required with the Form C1 panels. The drum-type master switch will provide any speed increase up to 4:1 and contains 18 field control points. It may be controlled either by an operating handle or remotely by mechanical means.

C-339 Drum Type Master Switch with Self-contained Field Points. Recommended for use with Type RF motors or motors having similar characteristics.

"Safety First" Enclosed Lever Switch

Features of Enclosed Lever Switches

1. Current-carrying parts are completely enclosed and inaccessible while alive.

2. Fuses are accessible only when they are "dead" and when the switch is in the "off" position.

3. Switches can be locked in the "off" position.

4. The fuse chamber can be locked to prevent access by unauthorized persons, without interfering with the operation of the switch.

CR 2940 Push-button Stations

For use in the Control Circuits of all Types of Magnetic Control

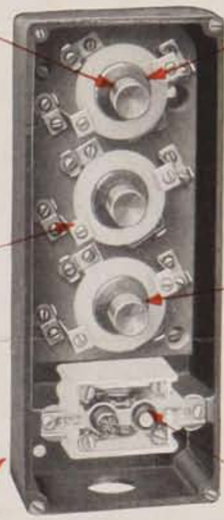
The advantages of controlling industrial motors from remote points are well known. One of the simplest methods is by push-button control which is adapted to practically every application of the electric motor. The General Electric Company has developed and is prepared to furnish practical devices by means of which you may start, stop, and control the speed of your motors by simply pushing a button.

This leaflet illustrates and describes the standard line of push-button stations available for this service.

DISTINCTIVE FEATURES

All buttons (except BS-7 and snap switch) are steel with natural finish. The "Stop" button is readily distinguished by red enamel marking. Each button is thoroughly insulated from the contact disk.

Buttons concave to form convenient recess for thumb.
Button plates individual etched brass, making them interchangeable.



BS-33 STATION
with cover removed

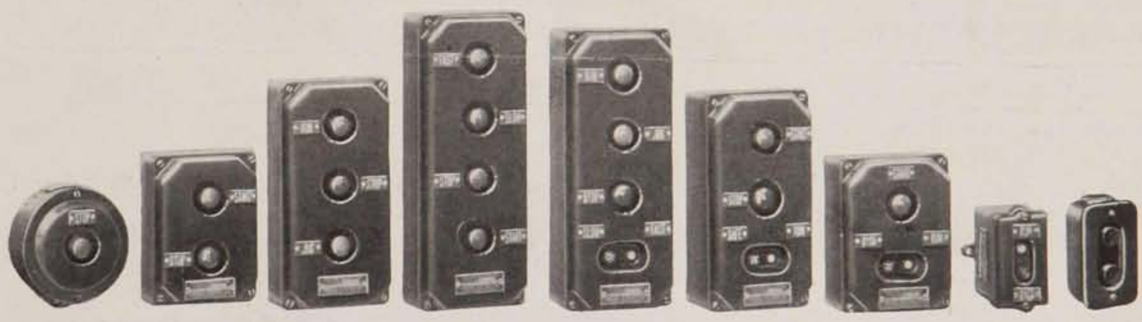
Contacts interchangeable—disks (except BS-7) reversible.

Universal design of contacts and disks makes it possible to use them either normally open or normally closed, or both.

Non-corrodible phosphor bronze springs and silver-plated copper contact disks permit the use of station in the weather or damp places.

Cast-iron box and cover (except BS-7 which is pressed steel) finished in hard-baked japan.
Arranged for conduit wiring for either top or bottom connection, ½-in. or ¾-in. conduit for BS-7, 11, 12, 13, 31, 32; ¾-in. conduit for BS-14, 33; ½-in. conduit for BS-30.

Standard flush type snap switch with hard rubber buttons used where "Safe" or "On and Off" features are required.



BS-11 BS-12 BS-13 BS-14 BS-33 BS-32 BS-31 BS-30 BS-7

Standard Line of Push-button Stations.

(See reverse side for special features)

Push-button Stations Providing Special Features

Conduit Fixture
Cat. No.
197434
with Conductor

BS-7

The BS-7 Station can be used either as a wall or pendent switch by the addition of a conduit fixture of standard design.

Pendent switches are used as portable push buttons on planers, boring mills, miscellaneous tools, etc.

BS-11B

The BS-11B is a foot-operated, single-button station which may be used either as a "start," "stop," or "slow" station.

Convenient on drilling and tapping machines where the operator requires both hands to guide the work.

BS-11N

The BS-11N is a single-button station used on direct-current circuits to obtain under voltage or field protection. A coil connected across the line or in series with the shunt field will hold the contact disk closed across the lower contacts. When a master switch is used with a magnetic control panel a BS-11N station should be used to obtain under-voltage protection, thus preventing the motor, after a failure of voltage, from automatically restarting on return of voltage. It may also be used as a shunt field protective relay providing protection to the motor against accidental opening of the shunt field circuit.

Shutter Set for "jog"

Shutter Set for "run"

The BS-33 illustrates a station provided with a "jog" feature. When the shutter is pulled down and set for "jog," the contact disk cannot touch the top connection studs, thereby allowing ample time for the line contactor on the self starter to close and open when it is desired to "jog" the motor. When the shutter is set for "run," the contact disk establishes a holding circuit for the line contactor. All stations but the BS-7, BS-11 and BS-30 can be equipped with this feature.

LIST OF STANDARD STATIONS

PUSH BUTTONS ONLY

BS-7 One- or two-button, either wall or pendent.
BS-11 One-button.
BS-11B One-button, foot operated.
BS-11N One-button, under-voltage and field protection.
BS-12 Two-button.
BS-13 Three-button.
BS-14 Four-button.

PUSH-BUTTON AND TWO-BUTTON SNAP SWITCH

BS-12M Snap switch only. For 600 volts or less.
BS-30 Snap switch only. For 230 volts or less.
BS-31 One-button and snap switch.
BS-32 Two-button and snap switch.
BS-33 Three-button and snap switch.

NOTE—Name plates with any desired marking can be supplied if specified on the order.

CAPACITY OF CONTACTS AND CONTACT DISKS

The rupturing capacity of contacts in the BS-7 and BS-30 stations and the contact disks of the other stations depend upon the inductance of the circuit.

On inductive circuits the following are the limiting values:

	D-C Circuit	A-C Circuit
BS-7 STATION	115 volts, 0.75 amp. 230 volts, 0.4 amp.	110/220 volts, 2 amp. 440/550 volts, 0.75 amp.
BS-30 STATION (Snap Switch)	115 volts, 2 amp. 230 volts, 1 amp.	110/220 volts, 5 amp. 110/220 volts, 5 amp.
All other stations except the snap switch part where used.	115 volts, 2 amp. 230 volts, 1 amp. 600 volts, 0.4 amp.	110/220 volts, 8 amp. 440/550 volts, 4 amp.

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.
Sales Offices in all large cities

CR 7006 Remote Control Starters

For Small Alternating-current Motors

*Under-voltage Protection †Overload Protection

CR 7006 Starters provide maximum protection, as well as a simple and reliable means of controlling small alternating-current motors, which can be started by throwing them directly across the line. The motor may be started and stopped from remote points by means of a BS-7 push button station or equivalent single-pole switch.

DISTINCTIVE FEATURES

Enclosing case to be drilled for conduit connection by customer to suit individual requirements. Terminals provided for connection to line, motor and control circuits.

The contacts are easily renewable. They have a sliding motion which keeps the contact surfaces clean and bright. Contacts are held together, when the contactor is closed, by firm spring pressure.

The magnetic blowout coil instantly extinguishes the arc at point of rupture, reducing any burning of the contacts to a minimum.
The asbestos barriers prevent cross arcing.

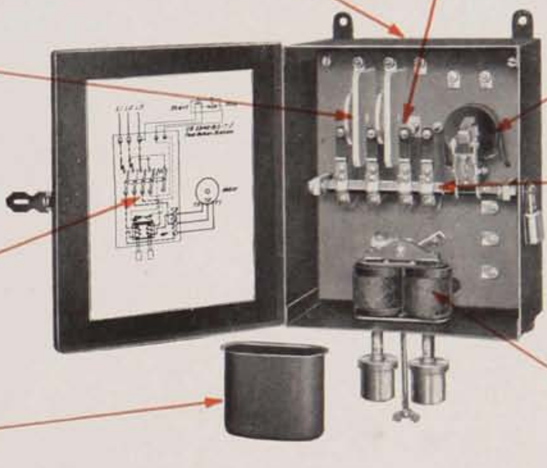
The operating magnet is wound for full line potential and is moisture-proof.

The cover of the sheet steel enclosing case can be locked to prevent tampering or adjustments by unauthorized persons. Connection diagram pasted inside cover.

The square operating shaft is insulated with mica which prevents grounding of any of the contact supports.

Cover of relays easily removable, permitting adjustment without uncovering any live parts.

Overload protection provided by gravity reset time limit overload relays. Time element obtained by an oil dashpot which has a wide range of adjustment, each point being clearly marked on calibrating scale.



Form A1 Starter

Form A1 Starter and BS-7J "Start" and "Stop" Push-button Station

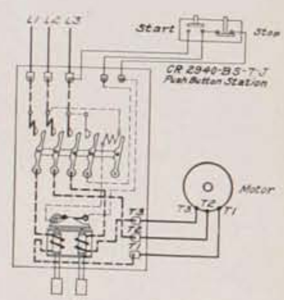
**Under-voltage Protection* provides that in case of failure of voltage the motor will not start upon return of voltage until the "start" button is pressed.

†Overload Protection is supplied by the time limit overload relay which opens the control circuit on overload. The relay resets by gravity.

Capacity—5 h.p., 110 volts, 7½ h.p., 220, 440, and 550 volts.

Dimensions—18 in. high, 11⅝ in. wide, 7½ in. front to back.

Weight—ready to ship, 70 lb.



Connections of the Form A1 Starter

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY
Schenectady, N. Y.
Sales Offices in all large cities

CR 4015 ENCLOSED AUTOMATIC STARTERS

FOR SMALL DIRECT-CURRENT MOTORS

1 to 3 H.P., 115 Volts **1 to 5 H.P., 230 Volts**

Recommended for machine tool or any other similar constant speed service. Can be used with a field rheostat separately mounted for adjustable speed motors having a speed range not greater than 2:1.

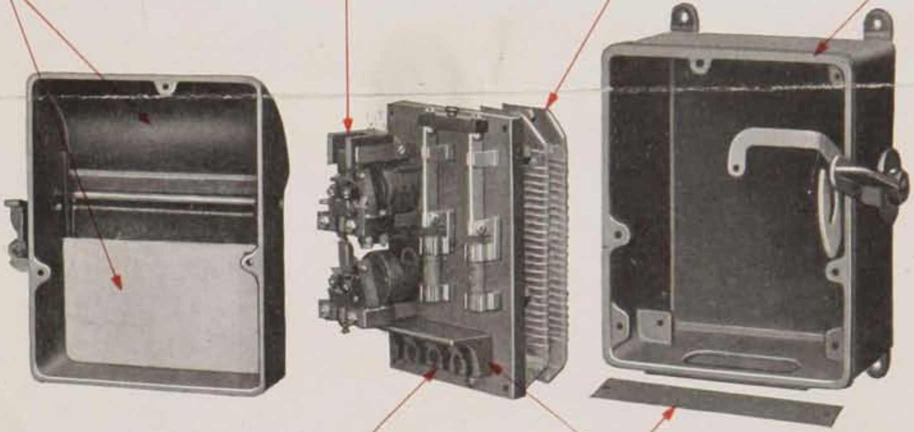
For remote control they are well adapted for use with either a "Start and Stop" push button station or single-pole knife switch or its equivalent.

COVER is easily removed for inspection or repairs.
DIAGRAM showing all standard connections is pasted inside the cover.

LINE CONTACTOR has substantial arc chute and blow out coil.

RESISTOR is wound on a metal body and covered with a fireproof insulating compound baked on.

HEAVY CAST IRON ENCLOSING CASE protects the starter, and prevents accidental contacts with live parts.

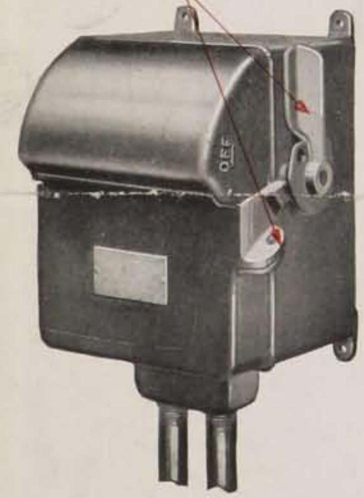


LINE SWITCH is operated by a lever outside the case. Padlock may be used to lock cover shut or switch open.

REMOVAL OF FOUR SCREWS and connections permits removal of complete unit.

TERMINAL BOARD is covered by a plate to prevent accidental contact when cover is open.

COVER OPEN, showing the accessibility of the line fuses and also how the terminals are protected.



SAFETY FEATURES

Enclosing case and terminal plate protect operator from accidental contact with live parts.

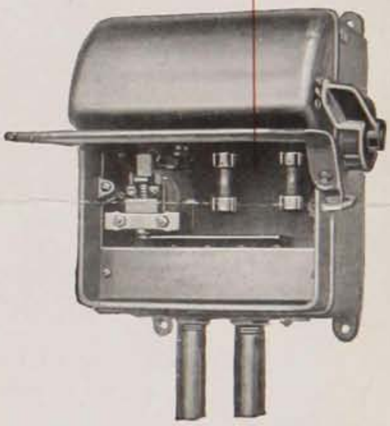
The line switch is operated by a lever outside the case.

Either the cover can be locked shut or the switch locked open.

The cover cannot be lifted when the line switch is closed.

The switch cannot be closed when the cover is open.

Push button control protects the operator and the machine by preventing unexpected starting on return of voltage.



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GENERAL ELECTRIC COMPANY, Schenectady, N. Y.

Sales Offices in all Large Cities

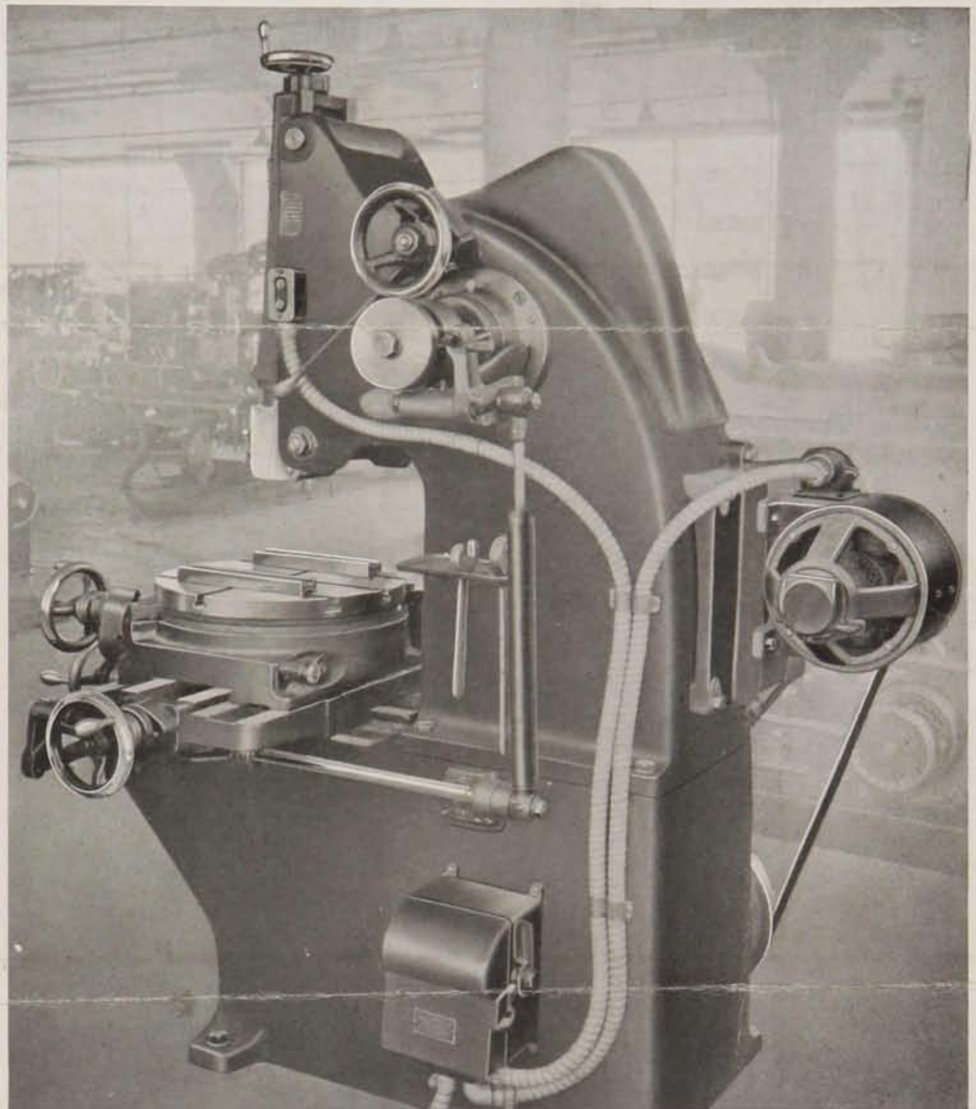
(OVER)

68420
Supersedes 68402-2 and 68405
Class 317

4-28-19

A "SAFETY" INSTALLATION

"Start" and "stop" push button station within easy reach of the operator, starter conveniently placed for opening the line switch at night, and conduit wiring, make an excellent installation to facilitate production and prevent accidents.



A CR 4015 Enclosed Automatic Starter operating a Type RC, 2 H.P., 230 Volts Motor driving a Vertical Shaper.

CR4031 Series Contactor Type Automatic Starters

For Series-, Shunt-, or Compound-wound Direct-current Motors

CR4031-A1 Open Type *CR4031-A2 Enclosed Type*
CR4031-A3 Oil Immersed Type

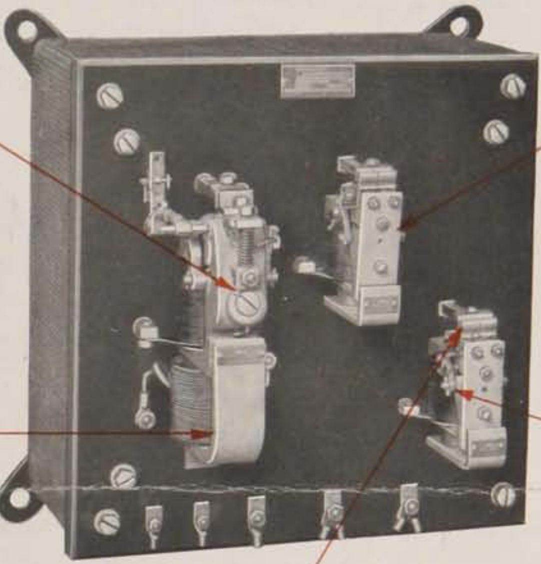
RECOMMENDED for starting series-, shunt-, or compound-wound direct-current motors which drive line shafts, pumps, compressors, blowers, conveyors, etc., where automatic starting is desired upon closing a line switch at some remote point.

STANDARD CAPACITIES: CR4031-A1 and CR4031-A2, 1 to 25 h.p., 115, 230 and 550 volts; CR4031-A3, 5 to 25 h.p., 115 volts, 7½ to 25 h.p., 230 volts, and 10 to 25 h.p., 550 volts.

Common Features

Current limit setting of contactors may be adjusted by means of a screw, if conditions of operation are such that higher or lower accelerating torques are desirable.

Starters have one to three accelerating contactors giving two to four starting points, depending upon the horse power rating. Two points, 1 to 3 h.p., three points, 5 to 10 h.p., and four points, 15 to 25 h.p.



CR4031-A1 15-h.p., 230-volt Automatic Starter

Last accelerating contactor to close, short circuits all starting resistance and series operating coils of all contactors. It is held closed by a shunt wound coil which prevents it from opening upon light loads.

Contactor operating coils are connected in series with motor armature. Contacts automatically short-circuit steps of the starting resistor as the motor accelerates.

Vertical solid copper contact tips close with a rolling and wiping motion. This construction insures long life and permits easy replacement at minimum expense.

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

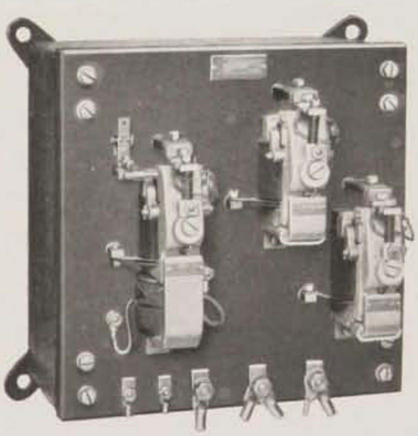
1-6 20

68433
Class 317

CR4031-A1 Starter Showing Construction of 1- to 5-h.p., 115-, 230- and 550-volt Sizes

CR4031-A1 Starter Showing Construction of 5- to 7½-h.p., 230-volt and 10-h.p., 550-volt Sizes

CR4031-A1 Starter Showing Construction of 5-h.p., 115-volt and 10-h.p., 230-volt Sizes



CR4031-A1 Starter Showing Construction of 25-h.p., 230-volt Size

Upon closing a main line switch or some equivalent device, CR4031 automatic starters automatically accelerate motors to full speed in the minimum time consistent with values of current which are safe for the motors, and which do not cause undue line disturbances or subject driven apparatus to objectionable mechanical shocks.

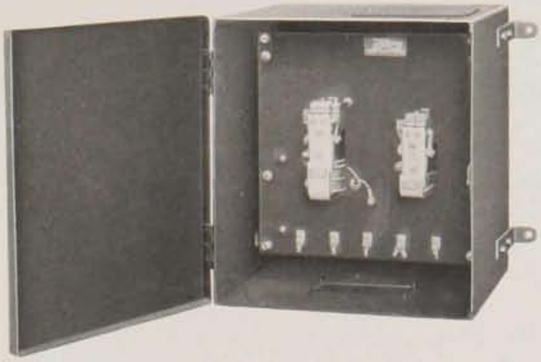
They insure proper acceleration at all times, independently of the experience of the operator. It is merely necessary for him to close a switch to start a motor and open the switch to stop it. In the case of persons who are entirely unfamiliar with electrical equipment, or where for any reason a safety installation is desired, such a switch may be entirely enclosed so that no live part will be exposed.

When for any reason it is desirable to start a group of motors simultaneously, two or more starters may be controlled from the same switch or a suitable circuit-breaker.

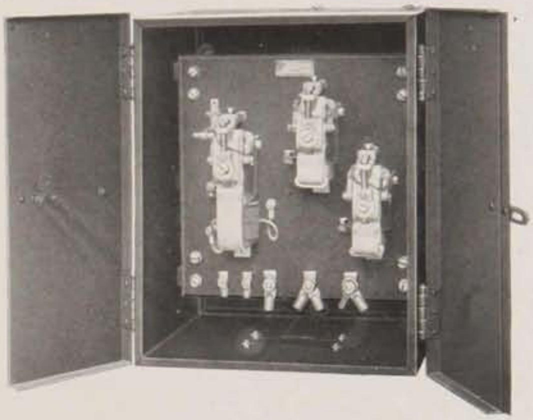
CR4031 starters are also suitable for automatically starting small motors which maintain fluid pressures or liquid levels in tanks when used in connection with pressure switches or float switches. Such applications are generally limited to the smaller motors on account of the usual small current carrying capacity of automatically operated line switches. Similar types of starters can, however, be furnished for use in connection with such automatically operated switches for starting large motors.

All parts of CR4031 automatic starters are simply constructed of substantial parts so they may be installed easily and operated with minimum attendance. There are no complicated connections to be made or delicate adjustments to be maintained.

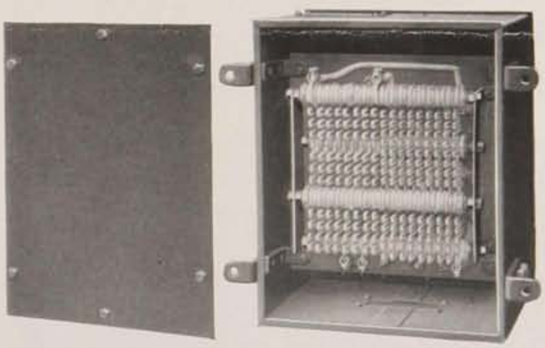
Clearly marked terminals are provided on the front of the slate base for making the necessary connections to the line and motor.



CR4031-A2 Starter Showing Construction of 5-h.p., 115-volt and 10-h.p., 230-volt Sizes



CR4031-A2 Starter Showing Construction of 25-h.p., 230-volt Size



CR4031-A2 Starter Showing Type of Grid Resistor Used in 3- to 25-h.p., 115-volt and 10- to 25-h.p., 230-volt Sizes

Contactors

Series type contactors automatically short-circuit steps of a starting resistor as the motor accelerates. They are operated directly by the motor current in such a way that they remain open on high values of current and close at pre-determined adjusted values, which occur upon sufficient acceleration of the motor.

The contacts of these contactors consist of solid copper tips that close with a combined rolling and wiping motion which keeps their surfaces clean and in good current carrying condition with minimum wear. This type of tip has a very long life and may be easily and inexpensively renewed.

The contactor tips, and in the case of the CR4031-A3 oil-immersed starter the oil, are the only parts which will ordinarily have to be renewed under average operating conditions. All other parts, however, are designed so they can be replaced easily and with minimum expense in case an accident or unusually severe operating conditions make it necessary.

Resistors

The resistors consist of CR9010 "Form R" or CR9042 "Form IG" resistor units, depending upon the value of motor current. The CR9010 units consist of resistance wire of low temperature coefficient wound on grooved porcelain insulating supports which are separated by sherardized metal punchings. The CR9042 units are of the familiar cast-grid type. Both types of units are moisture-resisting and are mounted in such a way that they have very high insulation factors.

CR4031-A1 Automatic Starters

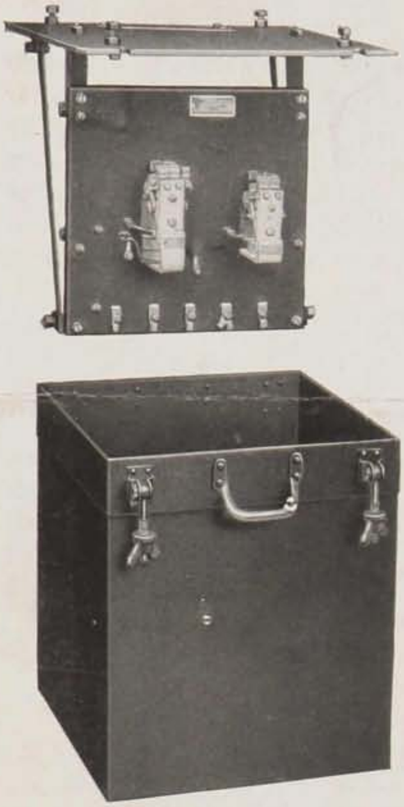
CR4031-A1 automatic starters are of the open type. They are suitable for most industrial applications where they can be mounted on a wall or column out of the reach of persons liable to come into contact with live parts.

CR4031-A2 Automatic Starters

CR4031-A2 automatic starters are provided with sheet metal enclosing cases which are suitable for wall mounting. This type is recommended for general industrial applications where it is desirable to mount it on some part of a driven machine or where persons working nearby may be in danger of coming into contact with some live part. The construction is in keeping with modern safety installations. The enclosing case may be locked shut with a padlock if desired.

CR4031-A3 Automatic Starters

CR4031-A3 automatic starters are oil-immersed. They are especially suitable for use in mines and similar places when explosive or inflammable gases are present and where dripping water or acid fumes are encountered.



CR4031-A3 Starter Showing Construction of 5-h.p., 115-volt and 10-h.p., 230-volt Starters

CR4031 Automatic Starters start motors in the minimum safe time.

The most desirable rate of acceleration is scientifically secured independently of the operator's judgment.

The simplicity and convenience of starting save power because motors may be stopped when not needed and started again without loss of time.

CR4031 Automatic Starters are easy to install and economical to operate.

Ask our nearest office for complete information

GENERAL ELECTRIC COMPANY, Schenectady, N. Y.

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CR4033 SERIES CONTACTOR TYPE AUTOMATIC STARTERS

For Series-, Shunt-, or Compound-wound Direct-current Motors

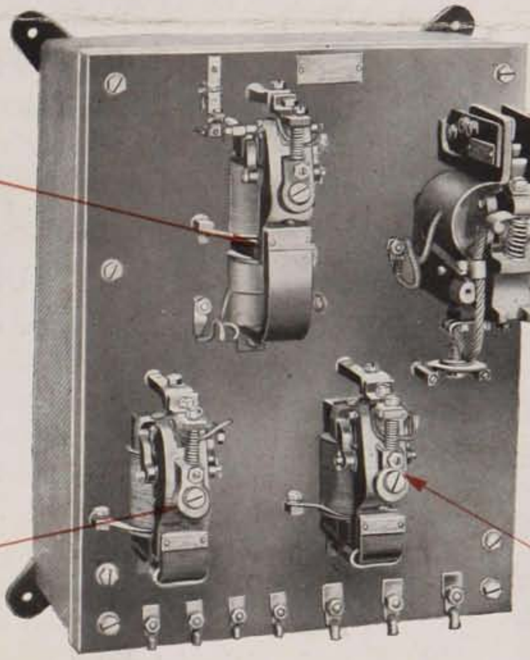
Under-voltage Release *Under-voltage Protection*

Overload Protection

Recommended for automatically starting series-, shunt- or compound-wound, direct-current motors driving line shafts, pumps, compressors, blowers, conveyors, etc. This is readily accomplished by a push button, or by the operation of a float switch, pressure governor, or similar accessory.

Last accelerating contactor to close short-circuits all starting resistance and series operating coils of all series contactors. It is held closed by a shunt-wound coil which prevents it from opening on light loads.

Line contactor has magnetic blowout which instantly extinguishes operating arcs. All contactors have solid copper tips. Their construction insures maximum life and permits easy replacement of wearing parts.



Current limit setting of series contactors may be adjusted to produce most desirable values of accelerating torques.

Starters have 1 to 6 accelerating contactors giving 2 to 7 starting points, depending on the h.p. rating.

25-h.p., 230-volt CR4033-A1 Automatic Starter

STANDARD FORMS

Type	Description	STANDARD H.P. CAPACITIES		
		115-volt	230-volt	550-volt
CR4033-A1	Open type without overload relay or line switch	1 to 60	1 to 150	1 to 300
CR4033-A2	Enclosed type without overload relay or line switch	1 to 60	1 to 150	1 to 300
CR4033-A3	Oil-immersed type without overload relay or line switch	1 to 20	1 to 25	1 to 25
CR4033-B1	Open type without overload relay with line switch	1 to 5	1 to 10	1 to 30
CR4033-B2	Enclosed type without overload relay with line switch	1 to 5	1 to 10	1 to 30
CR4033-C1	Open type with overload relay and line switch	7½ to 60	15 to 150	35 to 300
CR4033-C2	Enclosed type with overload relay and line switch	7½ to 60	15 to 150	35 to 300
CR4033-D1	Open type with overload relay without line switch	1 to 60	1 to 150	1 to 300
CR4033-D2	Enclosed type with overload relay without line switch	1 to 60	1 to 150	1 to 300

GENERAL ELECTRIC COMPANY, Schenectady, N. Y.

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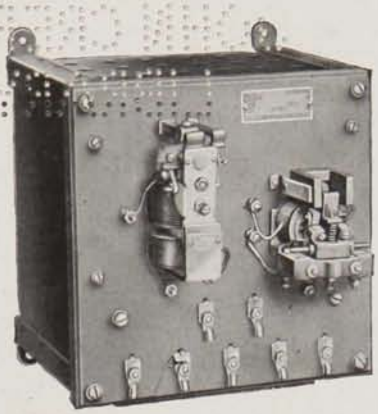
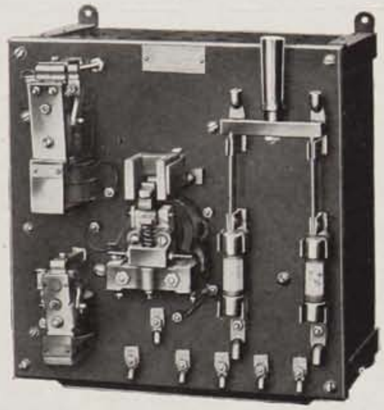
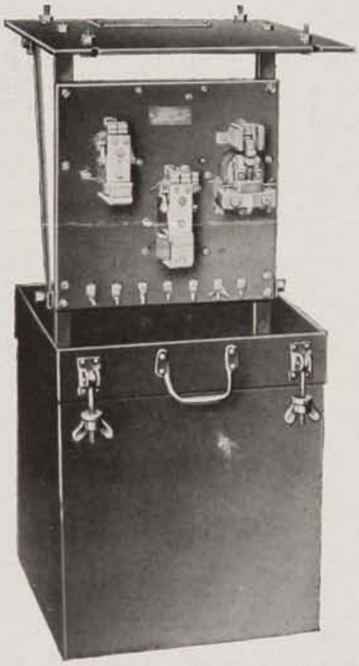


CR4033-A1 Starter, Showing Construction of 1- to 3-h.p., 115- and 230-volt Sizes



CR4033-B1 Starter, Showing Construction of 7 1/2-h.p., 230-volt Size



CR4033-A3 Starter, Showing Construction of 5-h.p., 115-volt, and 10-h.p., 230-volt Sizes

OPERATION

CR4033 automatic starters are suitable for starting series-, shunt- or compound-wound direct-current motors in the minimum time which is safe for the motors and which does not cause undue line disturbance or subject driven apparatus to objectionable mechanical shocks.

They are designed for pilot circuit control and may be used interchangeably with momentary contact push buttons or snap switches for manual operation, or with float switches, pressure governors, etc., for operation independently of an attendant.

Upon pushing a button or the operation of an automatic master switch, a line contactor connects the motor to the line with its armature in series with a starting resistor. As the motor accelerates, series contactors short-circuit the starting resistor step by step until full speed is attained.

CONSTRUCTION

Open and enclosed types of CR4033 starters are constructed for wall or floor mounting depending upon the capacity. Oil-immersed types have heavy sheet metal tops with supporting bolts so that they may be hung from wall brackets or other easily constructed suspension supports.

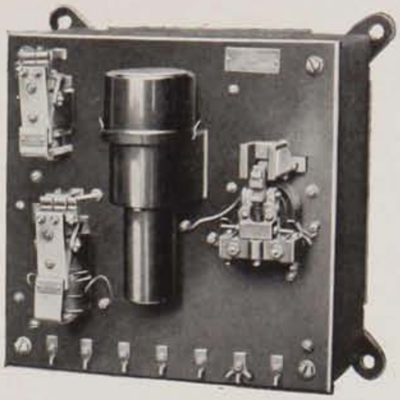
All contactors, relays, and switches are assembled on slate bases and are completely wired to the starting resistors. The resistors are mounted directly on the backs of the slate bases.

Clearly marked terminals are provided to facilitate making all line, motor and control connections.

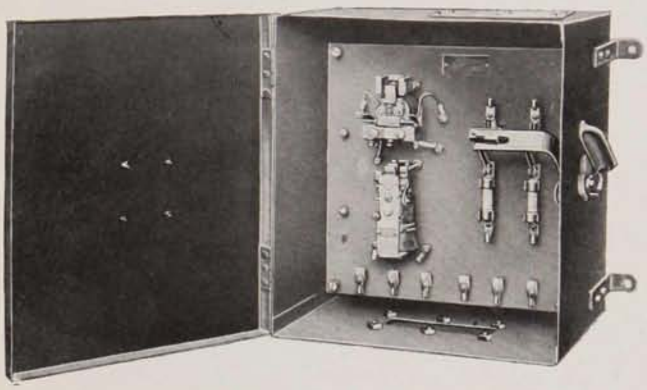
RESISTORS

The resistors consist of CR9010 Form R or CR 9042 Form IG resistor units depending upon the value of motor current. CR9010 units consist of resistance wire of low temperature coefficient wound on grooved porcelain insulating supports which are separated by sheradized metal punchings. CR9042 units are of the familiar cast grid type.

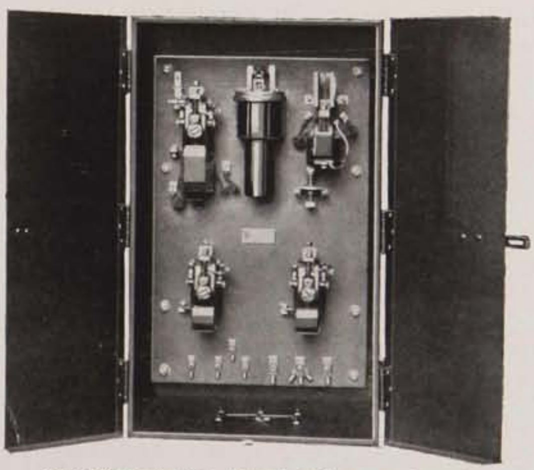
Both types of units are moisture-resisting and are mounted in such a manner that they have very high insulation factors.



CR4033-D1 Starter, Showing Construction of 5-h.p., 115-volt, and 10-h.p., 230-volt Sizes



CR4033-B2 Starter, Showing Construction of 1- to 3-h.p., 115- and 230-volt Sizes



CR4033-D2 Starter, Showing Construction of 20-h.p., 230-volt Size

CONTACTORS

Particular consideration has been given to the construction of the contactors so that they will operate with minimum attendance.

Their contacts consist of two solid copper tips that close with a combined rolling and sliding motion which keeps their surfaces clean and in good current carrying condition with minimum wear. This type of tip has a long life and may be easily and inexpensively renewed.

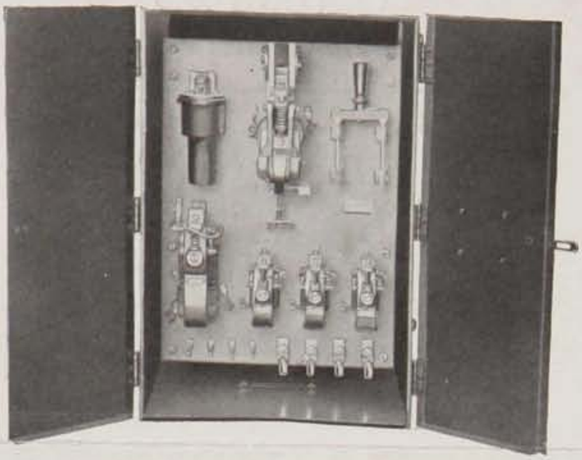
All coils which operate on voltage are wound in two sections with enameled wire, and are impregnated to exclude moisture. This method of winding results in low voltage strains between conductors and in bringing both ends out at the surface of the coil where they can be most effectively insulated. It also permits replacing a broken lead without rewinding a coil.

OPEN STARTERS

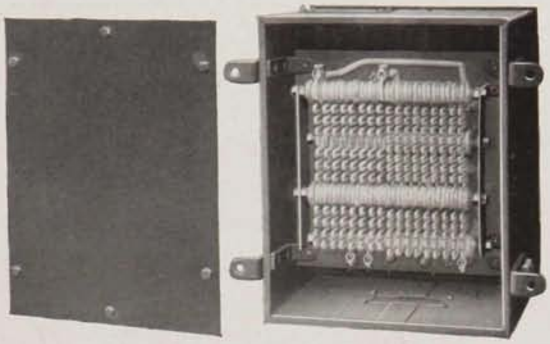
Open starters are suitable for industrial applications where they can be mounted on a wall or column or otherwise out of the reach of persons liable to come into contact with live parts.

ENCLOSED STARTERS

Starters with sheet metal enclosing cases are recommended for most industrial applications where they are to be mounted on machines or where persons working nearby may be in danger of coming into contact with live parts. Their construction is in keeping with modern safety installations. The enclosing cases shield the starters from dirt and safeguard persons working nearby. They may be locked with padlocks when desired.



CR4033-C2 Starter, Showing Construction of 50-h.p., 230-volt Size



CR4033 Starter, Showing Type of Grid Resistor Used in 3- to 25-h.p., 115-volt and 10- to 25-h.p., 230-volt Sizes

OIL-IMMERSED STARTERS

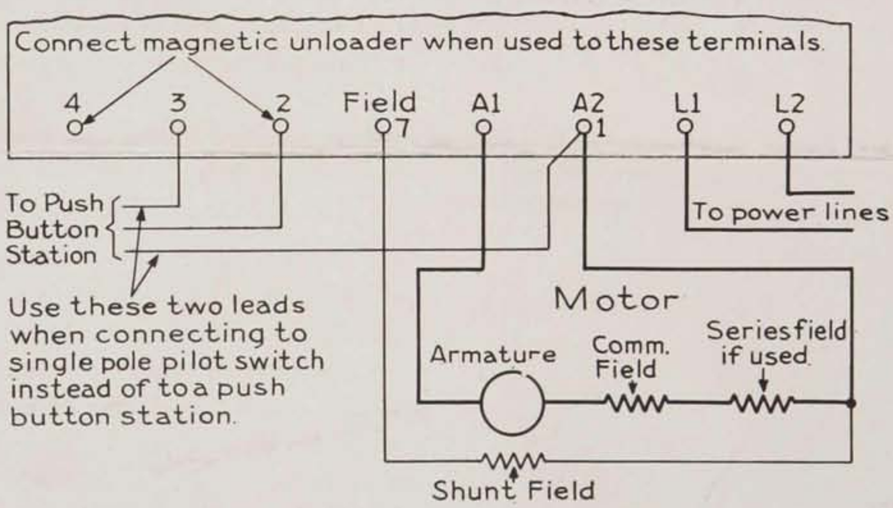
Oil-immersed starters are suitable for use in mines and similar places where explosives, inflammable gases, or destructive chemical fumes are present.

STARTERS WITH LINE SWITCHES

Starters with line switches are desirable when there is no other disconnecting switch near the motor. When the line switch of a CR4033 starter is open, all potential is removed from the motor, control wiring and all parts of the starter except the incoming line terminals and top clips of the switch.

STARTERS WITH OVERLOAD RELAYS

Starters with overload relays are preferable for most applications. The overload relay used on CR4033 starters is of the inverse time element type. It protects the motor against all overloads liable to cause overheating, but does not operate to stop the motor upon the appearance of peak overloads of short duration which are necessary for many production operations.



Typical CR4033 Wiring Diagram Which Indicates External Connections

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G-E Portable Oil Tester

Oil-testing Transformer

The proper care and routine testing of insulating oils is now recognized as imperative for the protection of oil-insulated equipment. It has been demonstrated that the only sure test of the dielectric strength of oil is the direct high voltage test. The General Electric Company has developed the G-E Portable Oil Tester for this work only. It is a small, compact, portable set, providing a reasonably priced equipment which can be afforded by users of oil-filled transformers even for small and remote stations.

The G-E Portable Oil Tester consists of a high tension transformer, an auto transformer control, and an oil receptacle and gap with suitable gauge for setting.

Transformer

The main transformer which has one end of its high tension winding grounded, has a ratio of 110 to 25,000 volts. It is contained in a sheet steel tank with a composition cover bolted at frequent intervals on a gasket making an oil-tight joint. The total weight, filled with oil, is about 75 lb., thus making it easy to lift or carry by the handles provided. Lugs are welded on the base of the tank so that it may be bolted to a bench or the floor of a truck.

Oil-testing Receptacle and Gap

Oil-testing Receptacle and Gap

The-oil testing receptacle and gap consists of a moulded hard rubber cup, holding 135 c.c. One-inch-diameter disk electrodes are supported in the cup in a horizontal position on two shafts shrunk into the moulded part. The spacing can be varied by rotating one of the shafts and a gauge is provided for adjusting the gap to $\frac{1}{10}$ in. A set screw locks the gap at the proper setting. The high tension terminal supports one end of the receptacle while the other rests on a cast-iron post attached to the tank.

Control Box

The Auto Transformer Control

The control consists of an air-cooled auto transformer with taps connected to a dial selector switch, and a suitable knife switch for making connection to the supply circuit.

By means of the selector switch such voltages are applied to the main transformer as to give 15, 17.5, 20, 22.5 and 25 kv. on the high tension side of the main transformer. The double-pole knife switch is arranged so that in closing or opening, a suitable resistance is inserted in the circuit thus preventing wave distortion. A composition panel is provided on the control box, mounting the selector and knife switches. An attachment plug and cord are supplied for connecting to the supply circuit.

General Electric Company, Schenectady, N. Y.

(OVER)

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Class 215

G-E Portable Oil Tester

OPERATION

This testing set is intended for service testing in the field and determines whether the oil has sufficient dielectric strength to be classified as serviceable or whether it should be immediately filtered or replaced. The operation then, briefly, is to determine the classification of the oil according to classes which have been selected in accordance with good operating practice.

The receptacle is first lifted from its supports, filled with oil to overflowing, and then replaced. The operator next steps to the control, which should be placed as far from the transformer as the leads furnished will permit. The dial switch is placed on the first point corresponding to 15 kv. on the high tension side, and the double-pole line switch is closed, impressing voltage on the oil sample. This voltage is kept on about five seconds (long enough to count five slowly). If the sample does not fail, the knife switch is opened and the dial moved to the second point corresponding to 17.5 kv. and the voltage is again impressed for five seconds. This process is repeated, increasing the voltage each time until the sample breaks down. The average breakdown of at least (5) samples should be considered as the value of the insulating quality of the oil. Oil testing above 25 kv. is in excellent condition. Oil which does not fail at 22.5 kv. is satisfactory for transformers of any voltage. Oil failing between 17.5 kv. and 22.5 kv. is to be considered as in fair condition only, while oil breaking down below 17.5 kv. should be immediately filtered or replaced.

This set has been designed so that with exactly 110 (or 220) volts supply, the test voltage, when testing oil, will correspond with the figures on the dial. For routine oil testing, it is not necessary to correct the voltages for variations in supply voltage. If, however, very exact test voltages are required, a voltmeter suitable for reading 110 volts may be connected across the low tension terminals of the testing transformer and will give a very close indication of the test voltage.

COMPLETE OIL-TESTING SETS, INCLUDING MAIN TRANSFORMER, CONTROL BOX, AND OIL SPARK GAP

Cat. No.	Cycles	Voltage of Supply Circuit	List Prices
221442	60	110	$250.00
223728	60	220	260.00
223729	25	110	310.00
223730	25	220	320.00

General Electric Company

General Office: Schenectady, N.Y.

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*Southwest General Electric Company

INTERNATIONAL GENERAL ELECTRIC CO., INC.
120 Broadway, New York City, and Schenectady, N. Y.
REPRESENTATIVES AND AGENTS IN ALL COUNTRIES

D&W OIL FUSE CUTOUTS

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

D & W

OIL FUSE CUTOUTS

FOR EVERY SERVICE

"We regard these Fuses as the best on the market. * * have thirty in use and are now installing twenty-four additional."

—*Duluth Edison Electric Company*

"We have had D & W Oil Fuse Cutouts in service for several years, on aerial and on underground circuits. They are all in use at the present time and have given excellent satisfaction."

—*City of Detroit, Public Lighting Commission*

"Oil Fuse Cutouts have filled a long felt want in our underground construction work."

—*The Flatbush Gas Company*

With the recent improvements described herein, these cutouts, which for years have been the recognized standard, may be applied universally

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

CATALOGUE 6004

JANUARY, 1922

Supersedes Bulletin No. 45114 and D & W Fuse Co's Catalogue No. 2

D & W OIL FUSE CUTOUTS

ORDERING INSTRUCTIONS

When ordering, specify catalogue number and in addition—the type, rated ampere capacity and voltage. For example, if ordering two (2) Cat. No. 230014 cutouts, the order should read:

2—Cat. No. 230014—Type D-1C-50-ampere—2500-volt standard pole type—D & W Oil Fuse Cutouts.

Sufficient oil is shipped with the cutouts in all cases and should not be specified as a separate item on the order.

Particular attention is directed to the fact that fuse links are not included with cutouts and must be ordered as a separate item. The factory will question all orders for cutouts which do not also call for fuse links or specify distinctly that they are not wanted. Ordinary fuse wire or fuse links for other kinds of cutouts will not operate satisfactorily and only the special links designed for these cutouts should be used.

In ordering fuse links specify the catalogue number and in addition the ampere rating, type, and mention the ampere rating of the cutout for which they are intended. If possible, also mention the catalogue number of the cutout. For example, if you are ordering ten (10) Cat. No. 230555 fuse links the order should read:

10—Cat. No. 230555—10-ampere standard fuse links. For use in 50-ampere D & W Oil Fuse Cutout—Cat. No. 230014.

Care should be taken in ordering fuse links, since a fuse link for a 50-ampere cutout will not fit in a 100-ampere cutout.

Orders for fuse links should be confined to standard packages wherever possible.

Supply parts should be positively identified on the order by description and type (complete with letter, if any) of the cutout as well as the Cat. No. of the cutout.

D & W OIL FUSE CUTOUTS

The protection of distribution transformers in service begins with an adequate means of breaking the high tension supply under abnormal load conditions. D & W Oil Fuse Cutouts have accurately and reliably met these conditions in several thousand installations. Seven years of successful operation have proven the absolute dependability and thorough satisfaction resulting from such protection. In addition to this service record exhaustive tests have been made under extremely exacting conditions of large generator capacity and low power-factor.

CAT. NO. 230014—50-AMP. STD. SERVICE
POLE TYPE D & W OIL FUSE
CUTOUT IN SECTION

This simple but effective device embodies features of both the plug cutout and the oil circuit breaker. The action is positive and a rapid break is made under oil. The unreliability of the enclosed fuse for high tension service of 2000 volts and above is eliminated.

POLE TYPE—STANDARD SERVICE

POLE TYPE, 50-200 AMPERES

D & W Oil Fuse Cutouts for standard service are contained in a cast iron box provided with suitable lugs for mounting, openings for re-fusing, and entrance leads through bushings. The cover and tank are separable and are solidly bolted together on an oil tight gasket.

D & W OIL FUSE CUTOUTS

The standard line of pole type oil fuse cutouts are made in three sizes ranging from 50 to 200 amperes. The principle of operation is the same for all sizes.

A

B

Phantom view of D & W Oil Fuse Cutout showing principal safety feature
(A) Carrier unlocked, circuit open, (B) Carrier is locked before circuit is closed

In the D & W cutout, the fusible element is placed under a heavy body of special oil. On the blowing of the fuse, the terminals are so arranged that they are forcibly thrown apart by combined spring and magnetic action and the circuit is interrupted practically instantaneously.

METHOD OF INSERTING THE FUSE CARRIER INTO THE CUTOUT

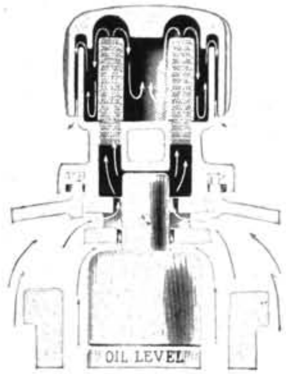
Particular attention has been given to design the device so as to render the operation of re-fusing safe for the lineman. A new fuse can be inserted with practically no risk, even when the line is short circuited, since the whole device is effectually locked against the blowing out of the carrier in case the fuse blows during the process of its renewal. This is accomplished by an automatic locking of the carrier before contact is made with the fuse terminals.

The cutout is provided with an effective venting system which prevents accumulation of pressure within the casing, as well as the blowing out of any considerable quantity of oil.

D & W OIL FUSE CUTOUTS

The gas formed from the blowing of the link travels upward around the carrier, taking with it a certain amount of oil. As this froth enters the tubes located under the cap it encounters a series of screen baffle plates. The contact with these screens, together with the impact of the foam against the rounded deflectors of the cap, sets free the gas which passes out from under the base of the cap by an indirect path. The oil being unable to follow the circuitous route is deflected into the reservoir from which it drains back into the tank by means of the capillary holes drilled into the base of the brass tubes.

In draining back to the tank a permanent film of oil is left in the holes which forms an effective seal against the entrance of water or moisture which might condense within the reservoir.



METHOD OF VENTING POLE TYPE CUTOUTS

The oil used is especially prepared for this service. It will not thicken unduly in zero weather, nor does it evaporate materially at the full load operating temperature. Other oils, such as those used in transformers, should be used with caution as they may not have the proper characteristics. The use of the oil (G-E No. 21 Oil) supplied with this device is strongly recommended as its effectiveness is assured. The height of the oil should be inspected once a year, to keep it up to the proper level.

It is occasionally necessary to draw off the oil for purification. By the use of a simple filter (or the G-E Oil Dryer and Filter Press) carbon or other similar impurities can be removed from the oil and its use prolonged indefinitely. Under ordinary conditions of service such a cleansing is not required oftener than once in a year or two.

A few prospective buyers have raised the question as to the effect of a possible admission of rain during the operation of re-fusing in a heavy storm. This is most conclusively answered in the record of performance of thousands of these cutouts during seven years of commercial operation under all kinds of weather conditions. Not one failure has occurred from this source notwithstanding the fact that it has frequently been necessary to re-fuse them during a heavy downpour. Despite this record, we can furnish, if desired, small covers which can be placed over the opening in the cutouts during re-fusing. These are light, and can be readily carried in the lineman's pocket.

In recent years it has become common practice to make the size and kind of oil circuit breaker bear a definite relation to the amount of energy to be handled on short circuits. The same is true of oil fuse cutouts. It is, therefore, urged when purchasing these devices for a new installation that accurate information be given as to the greatest amount of energy to be handled on short circuit,

D & W OIL FUSE CUTOUTS

the size of the generating system and the distance between the oil cutouts and the source of energy, as well as the continuous carrying capacity, in order that we may recommend the style and size best suited to the conditions.

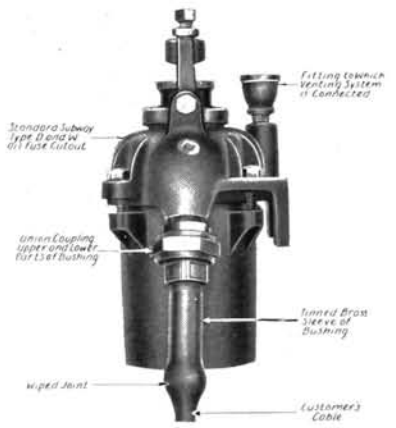
In the design of these cutouts the safe operative point has been limited to ten times maximum rated capacity in amperes, thus on short circuits the 50-ampere cutout will safely handle 500 amperes, the 100-ampere, 1000 amperes, and so on. Beyond this is an ample safety factor, so that these devices are suitable for all ordinary conditions of commercial service. Where conditions of service are extraordinary the use of the heavy service cutout is recommended. The description of this line is treated on pages 9 and 10.

D & W Oil Fuse Cutouts are not intended for use as switching devices. However, it is common practice to use ordinary cutouts for sectionalizing purposes, and the D & W Oil Fuse Cutout will be found exceptionally well adapted for this service.

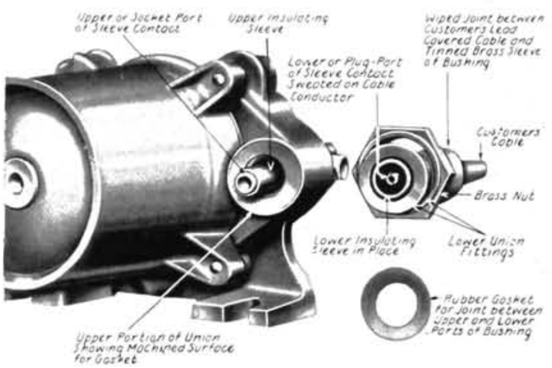
The cutouts are equipped with flexible terminals to which the feeder wires may be soldered, thus eliminating the necessity of making complicated connections within the device itself.

SUBWAY TYPE

The most commonly used forms of underground primary protective devices present at least two inherent weaknesses that have been successfully overcome in the design of the Subway Type of D & W Oil Fuse Cutouts. The un-



D & W, 2500-volt, Subway Type, Oil Fuse Cutout, Showing Details of Sleeve Bushing Construction



D & W, Subway Type, Oil Fuse Cutout with Bushing Separated to Show Sleeve Contacts, Insulating Sleeve, Union and Gasket

reliability of enclosed fuses frequently result in the destruction of the box in which they are installed. In underground work, this is costly, both from interruptions to service and in the expense of repairing the damage. The D & W Oil Fuse Cutout is positive in its operation, and has appreciably reduced repair and shutdown costs of the numerous utilities who have installed them.

A second cause of dissatisfaction with the ordinary type of underground box is the length of time necessary for the re-fusing. The removal of numerous cover bolts which are usually small and corroded or rusted occasions delay in restoring service which works a hardship on the consumer, as well as the utility. The simplicity and rapidity with which the D & W Oil Fuse Cutout may be re-fused reduces the period of interrupted service to a minimum. It is necessary to loosen but one large screw and lock nut in order to have access to the fusible element.

D & W OIL FUSE CUTOUTS

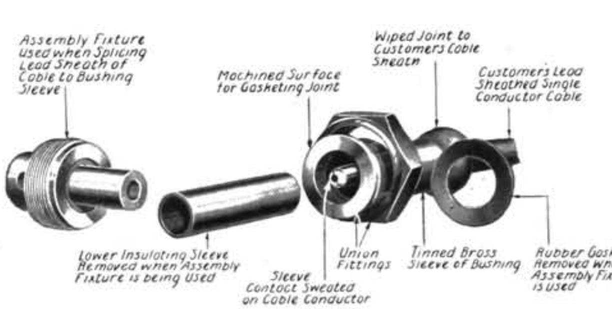
In underground service the frequent presence of gas in the manhole, which may be ignited during the operation of and re-fusing of cutouts having exposed contacts, introduces risks of no small moment. By the method of arranging for the making and breaking of contacts under oil, as is effected in the oil fuse cutout, the danger from such explosions is eliminated.

The subway type oil fuse cutout is identical with the pole type in essential operating principles. Slight modifications in construction have been made to adapt it to underground service, and to prevent moisture from entering the cable system.

Principal among these differences is the cable lead construction which has recently been further improved. The former design required that the cutout be permanently coupled by wiped joints to the cables. This often necessitated sharply bending the cable leads and the splicing most always had to be done in the manhole.

The new design has reduced the difficulty of installing to a minimum. The customer's cable leads are now brought directly into the sleeve bushing and in practically all instances it is no longer necessary to make two of the cable splices formerly required. In addition much of the work can now be done in the workshop.

SUBWAY TYPE, 50-200 AMPERES FOR STANDARD SERVICE



ASSEMBLY FIXTURES AND CABLE. END OF SPECIAL SLEEVE BUSHING FOR 50 AND 100-AMP. 2500-V. SUBWAY TYPE

Bushings for the 50- and 100- ampere standard service and 100- ampere heavy service cutouts are all similar and interchangeable. This allows an exchange of cutouts without any change in the cables. It is possible to replace a 50 ampere device with a 100-ampere cutout when additional transformer capacity has been in stalled.

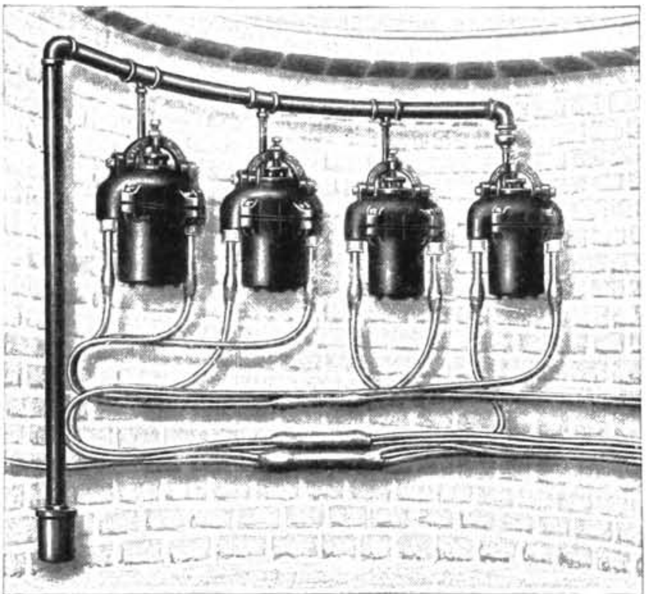
The bushing is made in two separate parts. The lower part is a brass sleeve threaded to take a standard union fitting with a brass coupling nut. Inside the sleeve is an insulating tube of high dielectric strength and a plug contact into which the conductor of the customer's lead sheathed single conductor cable is sweated. The upper part of the bushing completes the union fitting and contains the socket part of the sliding contact which is permanently connected to the leads inside the cutout. Here an insulating tube also separates the live parts from the walls of the bushing. Ample creepage distances are obtained by having these insulating tubes telescope each other. The lower tube when in place projects out of the bushing beyond the plug contact acting as a shield in case the joint is separated when the circuit is alive.

The end of the customer's cable entering the cutout is prepared in the following manner: The lead sheath is stripped back and a portion of the cable insulation removed. A gauge, giving the proper dimensions, is supplied for this

D & W OIL FUSE CUTOUTS

purpose. The split plug part of the sliding contact is then sweated to the bare end of the cable conductor. The next operation is the assembling of the lower bushing sleeve.

An assembly fixture which is in reality a dummy of the upper part of the bushing is supplied. The tinned brass sleeve with the lower part of the union in place is clamped to the assembly fixture by threading with the union nut. The joint is drawn down tight without a gasket. The end of the customer's cable with the split plug in place is then inserted in the sleeve with the contact plug firmly seated in the assembly fixture. The insulating sleeve is not put in at this time. The lead cable is then wiped fast to brass sleeve. The assembly fixture is then removed and the lower insulating sleeve is inserted from the open end. The bushing is then ready for coupling with the cutout.



INSTALLATION SHOWING METHOD OF VENTING SUBWAY TYPE

Cutouts of the existing design cannot be economically changed to the new design.

The remaining differences between the subway and pole type cutouts are necessitated to prevent moisture entering the cutout or cable system. A lead gasket is inserted between the tank and the fuse carrier.

In order to compress the lead gasket against the V-shaped ring on which it rests, a swivel yoke is employed. This carries at its center a powerful compression screw provided with a lock nut. A quarter or half turn of this brings the gasket against the V ring with such force as to insure absolute tightness of the joint, even when the cutout is entirely submerged.

The gasket in the carrier head, which might become unduly distorted owing to the repeated openings of the cutout, is so arranged as to be readily repaired by heating the lead with a blow torch, thus insuring continued tightness of the cutout under service conditions.

A similar form of lead gasket is used between the oil container and the top of the cutout. In this case a suitable number of clamping bolts provide the

D & W OIL FUSE CUTOUTS

necessary compression to draw the oil container into position and to insure tightness of the gasket.

The venting arrangement is necessarily modified for subway service and provision is made for connecting the cutouts either to separate vent pipes, or, preferably, to a common pipe. In either case the piping should be run from the vent openings in the cutouts up as high as possible in the manhole and from there dropped to within a few inches of the floor and the joints made up with shellac. For all 2500- and 4400-volt subway cutouts, pipe not smaller than 1 inch should be used. When a number of cutouts are grouped to a single pipe, the size should be increased proportionately.

The lower end of each vent pipe should be fitted with an air bell made by screwing a short piece of larger pipe into a reducing cap attached to the end of the vent pipe. The lower end of the larger pipe is to be left open, but great care must be used to have all of the joints in the venting system absolutely tight. In case the manhole becomes flooded with water, the air in the enlarged lower end of each vent pipe is compressed in the cutout, thus resisting the rise of water in the pipe. If the piping is tight and the proper size of air bell is used at the bottom, no water can enter the cutout even though the manhole be completely filled. This venting arrangement insures watertightness and yet provides an open passage for the escape of gas at all times.

Air bells should be at least as large as given in the table:

Voltage Rating	Ampere Capacity	Box Designation		Volume of Air Bell
2500	50	D-10	D-20	1 pint
2500	100	D-11	D-21	1 quart
2500	200	D-12	D-22	2 quarts
4400	150	D-22		2 quarts

NOTE.—When several oil fuse cutouts are attached to a common vent pipe the air bell should have a capacity equal to the sum of those required for the separate boxes.

The general design of the fuse carrier is similar to that used in the pole cutout. It has the same safety locking arrangement whereby the carrier is made fast in position before contact with the terminals is effected.

FOR HEAVY SERVICE

POLE TYPE, HEAVY SERVICE CUTOUT

SUBWAY TYPE, HEAVY SERVICE CUTOUT

The heavy service type has been developed for use where the conditions are excessively severe, or where, with a very large generator capacity connected,

D & W OIL FUSE CUTOUTS

it is necessary or desirable to install these cutouts for junction or primary protection within a short distance of the source of current.

These cutouts are identical in principle and interior construction with the standard type. Some modifications have, however, been made in the materials used. A pressed steel oil tank, threaded into the upper portion of the cutout, is substituted for the cast iron one. By this change the mechanical strength is greatly increased, since pressed steel possesses nearly twice the tensile strength of cast iron. The insulation resistance has also been greatly increased, and an improved type of bushing introduced, so that certain sizes of the cutout may be used on potentials as high as 15,000 volts.

The heavy service oil fuse cutouts fused with reactive type links will rupture on short circuits 25 times the maximum current they are rated to carry continuously.

Before these cutouts were placed on the market conclusive tests were conducted in order to demonstrate their ability to handle the most severe conditions which could be met in commercial service. Probably the most exacting short circuit tests ever conducted on any fuse device were made at the Ontario Hydroelectric Station at Toronto, Canada. Lines which supplied energy through a 5000-kv-a. bank of transformers from generators aggregating 100,000 horse power were short circuited through one oil fuse cutout. Currents of 5000 amperes at 2500 volts were repeatedly opened quietly, which verified our earlier conclusions that this cutout is the most effective piece of apparatus yet devised for high tension service.

FUSE LINKS

Two kinds of fuse links are furnished for D & W Oil Fuse Cutouts and either kind may be used. The standard type of fuse link is the plain link and is made in sizes suitable for all of the cutouts. The reactive type fuse link is made for cutouts of 100 amperes capacity and larger.

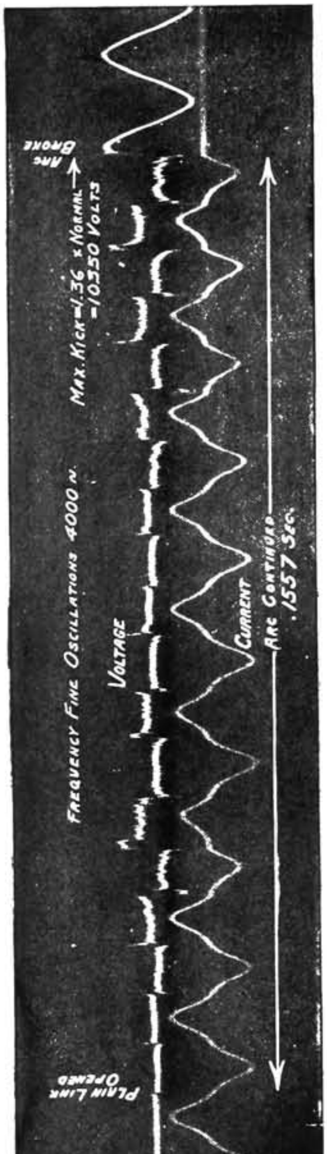
STANDARD TYPE FUSE LINK

HEAVY SERVICE REACTIVE TYPE FUSE LINK

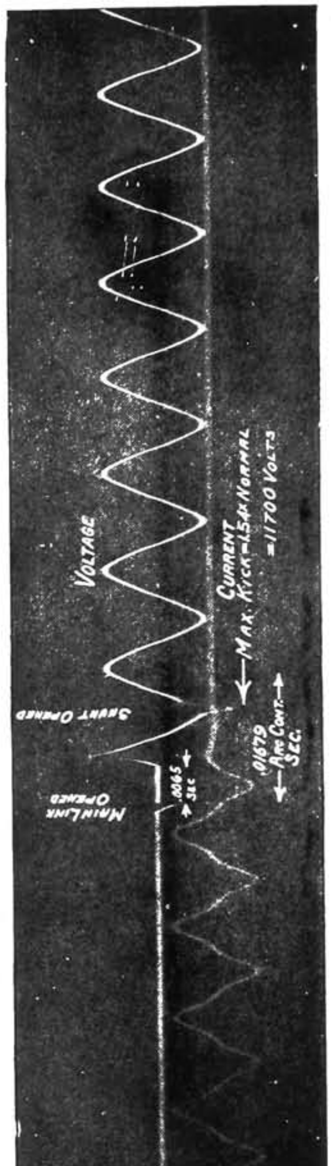
It is of utmost importance that only fuse links designed and furnished especially for these cutouts be used. Fuse links made of ordinary fuse wire should never be employed, as they have a tendency to cause an abnormal rise in temperature of the oil, with a resultant carbonization which rapidly destroys its effectiveness.

D & W OIL FUSE CUTOUTS

OSCILLOGRAMS



OSCILLOGRAM SHOWING STANDARD FUSE LINK OPENING A 7600-VOLT, 60-CYCLE LINE SHORT-CIRCUITED THROUGH D & W OIL FUSE CUTOUT. MAXIMUM CURRENT, 770 AMPERES



OSCILLOGRAM SHOWING REACTIVE FUSE LINK OPENING A 7600-VOLT, 60-CYCLE LINE SHORT-CIRCUITED THROUGH D & W OIL FUSE CUTOUT. MAXIMUM CURRENT, 1040 AMPERES

D & W OIL FUSE CUTOUTS

STANDARD TYPE FUSE LINKS

These fuse links have laminated metal terminals supporting between them a small section of special fusible alloy of low melting point and high conductivity. They are attached under tension to the carrier by means of star thumb nuts, so that the lineman can quickly replace a blown fuse without tools. The links are inexpensive, and are boxed so compactly that a number of them may be readily carried in the trouble-man's kit without inconvenience.

This type of fuse link is most commonly used and will meet all ordinary requirements. The reactive type fuse link described below is useful on systems of large generating capacity where it is desirable to open the circuit in minimum time and with minimum disturbance.

REACTIVE TYPE FUSE LINK

In connection with the development of the heavy service cutout, there has been designed a new form of fusible element where the conditions are exceptionally severe. This has been termed the "Reactive Link" and it is found to possess marked advantages over the plain link for the conditions cited.

In the reactive link the main fusible strip is shunted by means of two inductively wound, enclosed helixes of high resistance. By this construction the final rupture of the circuit occurs within these enclosures. When the main link melts, only a small arc results, because the current is shunted through the enclosed helixes. The current passing through these is quickly cut down in volume due to the rapid increase in resistance before the melting point is reached. The coils of the secondary links are surrounded by porous material thoroughly saturated with oil. This structure has the peculiar advantage that it causes the final interruption of the current to take place simultaneously at a number of points within the enclosures. In this way very quiet operation is secured under the most severe conditions.

By means of the reactive type link, the period of arcing is materially reduced. Oscillographic records of the operation of the Oil Fuse Cutout employing two types of links are shown on page 11. Although the reactive type fuse links are generally used in the heavy service type cutouts, they may, however, be used in the standard types with the same beneficial results.

APPLICATION

D & W Oil Fuse Cutouts may be applied in many places on primary circuits. While their principal function is the protection of transformers, they are now frequently used for fusing tapoffs, sectionalizing feeders and even as protection for feeders at substations.

They are very effective for fusing important transformer substations, even of small capacity, where service is of importance. Their high rupturing capacity permits their use near stations where large amounts of power may require interrupting.

These cutouts are suitable for overload protection and the uniformity and accuracy of the blowing of the fuse is exceptional. In this cutout is combined the ability to fuse against overloads, and at the same time the rupturing capacity of the cutout is very high, as indicated in the tables.

The selection of the correct cutout for a given location must depend upon the consideration of local conditions, taking into account the rated rupturing capacity, as well as the normal rated capacity in amperes. In order to promote standardization, it is advisable to keep the number of sizes of cutouts on a system to a minimum. Standardization of the 100-amp. and 200-amp. sizes can be strongly recommended.

D & W OIL FUSE CUTOUTS

SUMMARY OF DESIRABLE FEATURES

1. Safety First feature. Fuse carrier locked in place before circuit is closed.
2. No deterioration of fuse under normal operating conditions due to oxidation or electrolysis.
3. Fuses quickly and easily replaced.
4. Circuit broken under oil.
5. Breaks arc as fast as any device ever placed on the market.
6. Same characteristics as oil circuit breaker with inverse time overload relay, but does not have relays or tripping mechanism.
7. Inspection and care reduced to a minimum.
8. Never fails to operate.
9. The arc is under oil when the fuse blows and there is no danger of igniting any inflammable gases in the manhole.
10. Thoroughly tried in service and universally approved.

Cat. No.	Type	Rated Capacity Amp.	Interrupting Amp.	Volts	Oil Required	Net Wt. Each	List Price Each
STANDARD POLE TYPE							
230014	D-1C	5– 50	500	2500	2 qts.	30 lbs.	**$30.00**
230000	D-2C	5–100	1000	2500	3 qts.	35 lbs.	**45.00**
230001	D-3C	10–200	2000	2500	6 qts.	53 lbs.	**60.00**
STANDARD SUBWAY TYPE							
246103	D-10B	5– 50	500	2500	2 qts.	35 lbs.	**$60.00**
246104	D-11B	5–100	1000	2500	3 qts.	45 lbs.	**70.00**
246105	D-12B	10-200	2000	2500	6 qts.	62 lbs.	**95.00**
HEAVY SERVICE POLE TYPE							
230006	D-8C	5–100	2500	2500	5 pts.	40 lbs.	**$51.00**
230007	D-4C	10– 200 / 150	5000 / 3750	2500 / 4400	7 qts.	68 lbs.	**75.00**
230008	D-5C	100–300	7500	2500	3 gals.	133 lbs.	*
230009	D-6C	10–150	3750	6600	3 gals.	133 lbs.	*
230010	D-9C	10–100	2500	13000	3 gals.	200 lbs.	*
HEAVY SERVICE SUBWAY TYPE							
246107	D-21B	5–100	2500	2500	5 pts.	50 lbs.	**$79.00**
246108	D-22B	10– 200 / 150	5000 / 3750	2500 / 4400	7 qts.	70 lbs.	**119.00**

* Price quoted on application.

Prices are f.o.b. Pittsfield, Mass., and include oil and boxing but no fuse links.

Prices and data subject to change without notice.

D & W OIL FUSE CUTOUTS

SUBWAY AND POLE TYPES

STANDARD PLAIN FUSE LINKS

For Use with Oil Fuse Cutouts

Rated Capacity in Amp.	*235587	230014 230002 230005 230011 246103	230000 230003 230006 230012 246104 246107	230009 230010	230001 230004 230007 230013 246105 246108	230008 For 2500 or 4400 Volts
	CAT. NOS. OF FUSE LINKS					
5	235673	230553				
10	235675	230555	230566	230608	230581	
15	235676	230556	230567	230609	230582	
20	235677	230557	230568	230610	230583	
25	235678	230558	230569	230611	230584	
30	No larger fuse links made for these cutouts	230559	230570	230612	230585	
35		230560				
40		230561	230571	230613	230586	
45		230562				
50		230563	230572	230614	230587	
60		No larger fuse links made for these cutouts	230573	230615	230588	
70			230574	230616	230589	
75			230575	230617	230590	
80			230576	230618	230591	No smaller fuse links made for these cutouts
90			230577	230619	230592	
100			230578	230620	230593	230620
110			No larger fuse links made for these cutouts	†230621	230594	
120				†230622	230595	
125				†230623	230596	230623
130				†230624	230597	
140				†230625	230598	
150				†230626	230599	230626
160				No larger fuse links made for these cutouts	230600	
170					230601	
175					230602	235605
180					230603	
190					230604	
200					230605	235606
225					No larger fuse links made for these cutouts	235607
250						235608
275						235609
300						235610
List Price Std. Pkg. of 10 Links	**$4.50**	**$4.50**	**$7.50**	**$18.00**	**$18.00**	**$18.00**
Ship. Wt. of Std. Pkg.	½ lb.	½ lb.	1 lb.	2¼ lb.	2¼ lb.	2¼ lb.

* Cat. No. 235587, Type D Oil Fuse Cutout for 25-amp., 2500-volt service is no longer manufactured, but links for same can be furnished.

† For use in Cat. No. 230009 cutout only.

Prices are f.o.b. Pittsfield, Mass., and include boxing.

Prices and data subject to change without notice.

D & W OIL FUSE CUTOUTS

SUBWAY AND POLE TYPE

REACTIVE TYPE FUSE LINKS

For Use with Oil Fuse Cutouts

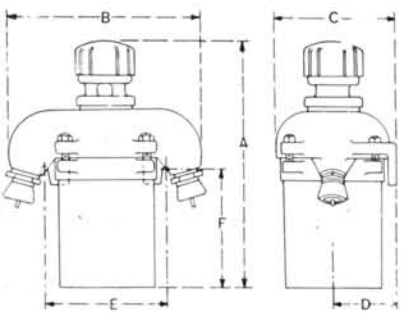
Rated Capacity in Amp.	230000 230003 230006 230012 246104 246107	230009	230010	230001 230004 230007 230013 246105 246108	230007 230013 246108 For use on 4400 volts	**230008 For 2500 volts only
	CAT. NOS. OF FUSE LINKS					
10	230664	230681	235613	230704	235636	
15	230665	230682	235614	230705	235637	
20	230666	230683	235615	230706	235638	
25	230667	230684	235616	230707	235639	
30	230668	230685	235617	230708	235640	
35	230669	230686	235618	230709	235641	
40	230670	230687	235619	230710	235642	
45	230671	230688	235620	230711	235643	
50	230672	230689	235621	230712	235644	
60	230673	230690	235622	230713	235645	
70	230674	230691	235623	230714	235646	
75	230675	230692	235624	230715	235647	
80	230676	230693	235625	230716	235648	No smaller fuse links made for these cutouts
90	230677	230694	235626	230717	235649	
100	230678	230695	235627	230718	235650	235663
110	No larger fuse links made for these cutouts	230696	No larger fuse links made for these cutouts	230719	235651	
120		230697		230720	235652	
125		230698		230721	235653	235664
130		230699		230722	235654	
140		230700		230723	235655	
150		230701		230724	235656	235665
160		No larger fuse links made for these cutouts		230725	No larger fuse links made for these cutouts	
170				230726		
175				230727		235666
180				230728		
190				230729		
200				230730		235667
225				No larger fuse links made for these cutouts		235668
250						235669
275						235670
300						235671
List Price Std. Pkg. of 10 Links	**$37.50**	**$37.50**	**$37.50**	**$37.50**	**$37.50**	**$37.50**
Ship Wgt. of Std. Pkg.	3 lb.	4 lb.	4 lb.	4 lb.	4 lb.	4 lb.

** Cat. No. 230008 when used on 4400-volt circuits will require special reactive type links. Full data on request.

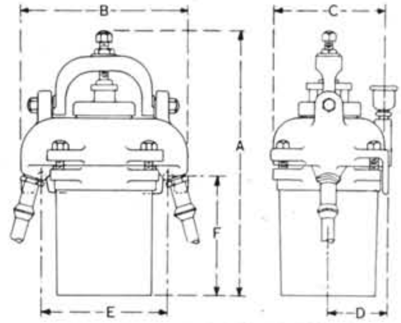
Prices are f.o.b. Pittsfield, Mass., and include boxing.

Prices and data subject to change without notice.

D & W OIL FUSE CUTOUTS
DIMENSIONS

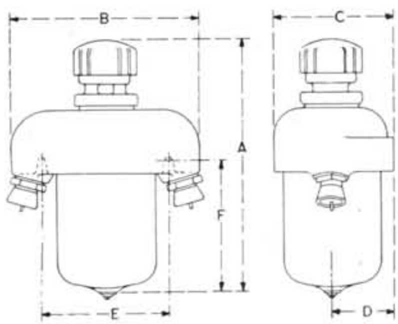


STANDARD POLE TYPE

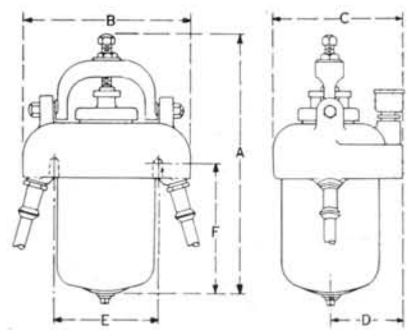


STANDARD SUBWAY TYPE

Amp.	Volts	DIMENSIONS IN INCHES A	B	C	D	E	F
		STANDARD POLE TYPE					
5– 50	2500	14	$11\frac{1}{2}$	$6\frac{3}{4}$	$3\frac{1}{2}$	7	6
10–100	2500	$15\frac{1}{4}$	$12\frac{1}{2}$	$7\frac{9}{16}$	4	$7\frac{3}{4}$	$7\frac{3}{8}$
10–200	2500	$17\frac{3}{4}$	$15\frac{1}{2}$	$9\frac{1}{4}$	$4\frac{3}{4}$	9	$8\frac{3}{4}$
		STANDARD SUBWAY TYPE					
5– 50	2500	$15\frac{1}{16}$	$10\frac{1}{8}$	$7\frac{1}{4}$	4	$7\frac{1}{2}$	$6\frac{1}{16}$
10–100	2500	$16\frac{5}{8}$	$10\frac{3}{4}$	$7\frac{15}{16}$	$4\frac{3}{8}$	$8\frac{1}{4}$	$7\frac{7}{16}$
10–200	2500	$19\frac{13}{16}$	14	$9\frac{3}{4}$	$5\frac{1}{4}$	$9\frac{1}{2}$	$8\frac{7}{8}$



HEAVY SERVICE POLE TYPE



HEAVY SERVICE SUBWAY TYPE

Amp.	Volts	DIMENSIONS IN INCHES A	B	C	D	E	F
		HEAVY SERVICE POLE TYPE					
10–100	2500	$15\frac{1}{4}$	12	$7\frac{9}{16}$	$3\frac{15}{16}$	8	$7\frac{7}{8}$
10–200 10–150	2500 4400	$18\frac{3}{8}$	16	$9\frac{3}{4}$	5	10	$9\frac{1}{2}$
100–300	2500 4400	$23\frac{5}{8}$	$19\frac{3}{8}$	$12\frac{3}{16}$	$6\frac{1}{4}$	$12\frac{3}{4}$	$11\frac{7}{8}$
10–150	6600	$23\frac{5}{8}$	$19\frac{3}{8}$	$12\frac{3}{16}$	$6\frac{1}{4}$	$12\frac{3}{4}$	$11\frac{7}{8}$
10–100	13000	$25\frac{1}{8}$	$23\frac{3}{8}$	$13\frac{1}{2}$	7	$16\frac{1}{2}$	$13\frac{1}{8}$
		HEAVY SERVICE SUBWAY TYPE					
10–100	2500	$16\frac{3}{8}$	$10\frac{3}{4}$	$8\frac{3}{8}$	$4\frac{3}{4}$	$6\frac{3}{4}$	$8\frac{3}{8}$
10–200 10–150	2500 4400	$20\frac{1}{4}$	$13\frac{3}{4}$	$10\frac{9}{16}$	$5\frac{13}{16}$	$8\frac{1}{4}$	$9\frac{15}{16}$

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D&W OIL FUSE CUTOUTS

GENERAL ELECTRIC COMPANY
SCHENECTADY, N.Y.

D & W
OIL FUSE CUTOUTS

FOR EVERY SERVICE

"We regard these fuses as the best on the market. * * have * * (many) * * in use and are now installing * * additional."

—*Duluth Edison Electric Company*

"We have had D & W Oil Fuse Cutouts in service for several years, on aerial and on underground circuits. They are all in use at the present time and have given excellent satisfaction."

—*City of Detroit, Public Lighting Commission*

"Oil Fuse Cutouts have filled a long felt want in our underground construction work"

—*The Flatbush Gas Company*

With the recent improvements described herein, these cutouts, which for years have been the recognized standard, may be applied universally

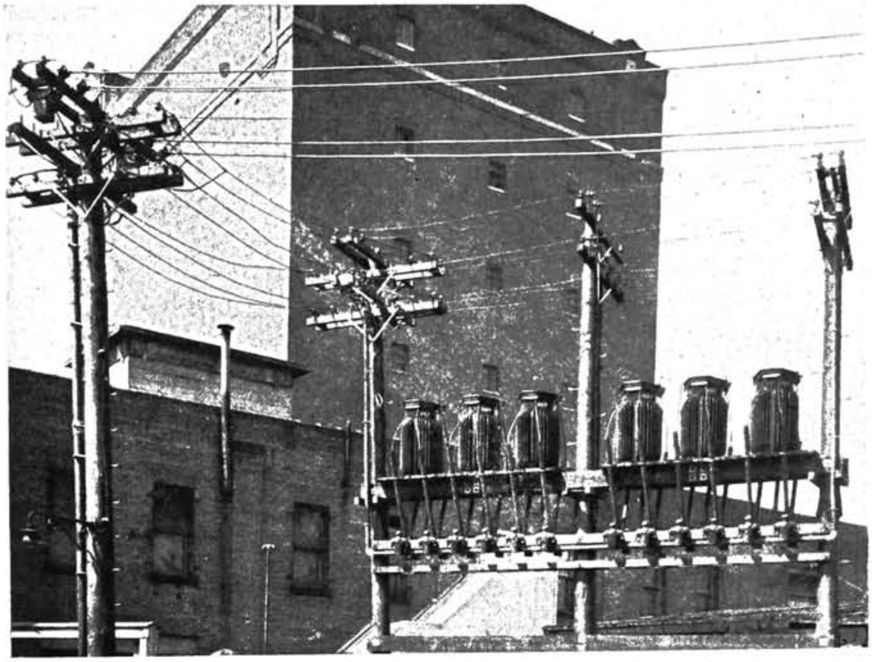
GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

CATALOGUE 6004-A

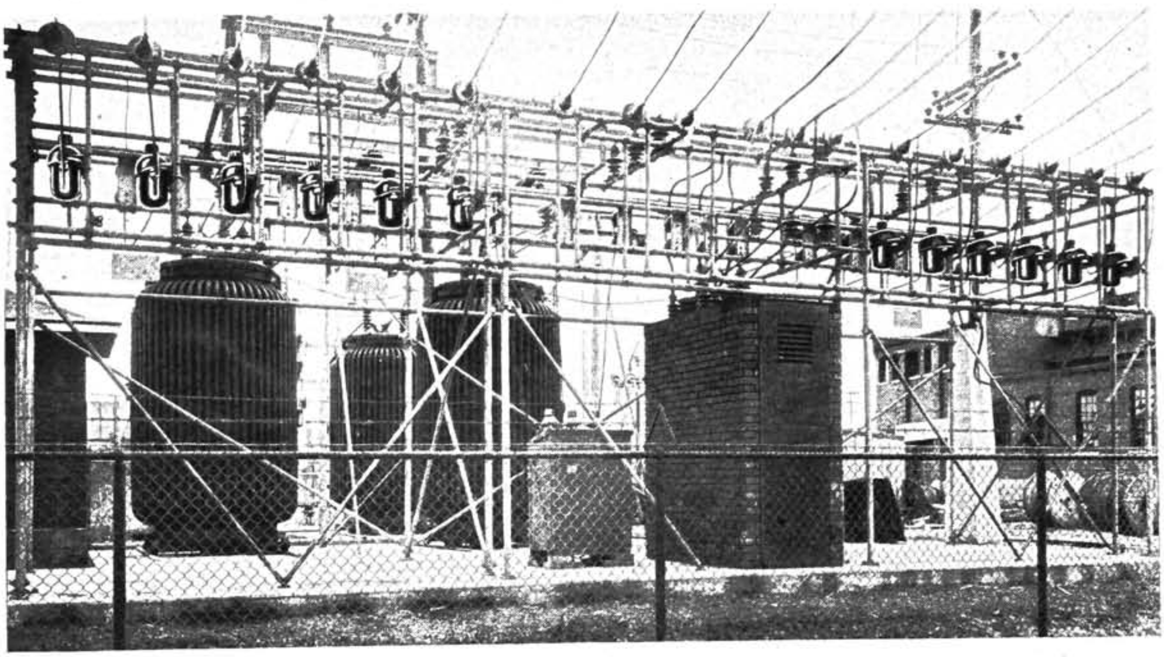
AUGUST, 1923

Supersedes Catalogue No. 6004

D & W OIL FUSE CUTOUTS IN SERVICE



INSTALLATION AT BROOKLYN, NEW YORK. D & W OIL FUSE CUTOUTS IN BOTH INCOMING AND OUTGOING 2400/4156Y 3-PHASE TO 2400-VOLT, 2-PHASE LINES OF TRANSFORMER SUBSTATION



INSTALLATION AT INDIANAPOLIS, INDIANA. D & W OIL FUSE CUTOUTS PROTECTING 2300/4000Y-VOLT SECONDARY FEEDERS AT 33,000Y-VOLT OUTDOOR SUBSTATION

D & W OIL FUSE CUTOUTS

GENERAL

The protection of distribution and small power transformers in service begins with an adequate means of breaking the high tension supply under abnormal load conditions. On systems where service is not severe the ordinary expulsion type cutout is satisfactory, but on large systems or where transformers are located close to the source of supply, a stronger protective device is desirable. This is especially true where continuity of service is essential.

In many cases where service conditions are such that the reliability of the expulsion type cutout may be questioned, it is uneconomical to install protective equipment of the more expensive designs. D & W oil fuse cutouts, being moderate in price, meet the demand. They have proved themselves accurate and reliable in thousands of installations in many parts of the world where they are used not only for protecting transformers but also for fusing outgoing substation lines and for sectionalizing purposes. Ten years of successful operation have demonstrated the absolute dependability and thorough satisfaction resulting from such installations. In addition to this service record, exhaustive tests have been made on these cutouts under extremely exacting conditions of large generator capacity and low power-factor.

This simple but effective device embodies features of both the plug cutout and the oil circuit breaker. The fuse link is retained yet a positive and rapid break is made under oil. The fusible element is placed under a heavy body of oil and the terminals are so arranged that on the blowing of the fuse they are forcibly thrown apart by combined spring and magnetic action. The circuit is interrupted practically instantaneously.

Particular attention has been given to design the device so as to render the operation of re-fusing safe for the lineman.

A new fuse can be inserted with practically no risk, even when the line is short circuited, since the whole device is effectually locked against the blowing out of the carrier in case the fuse blows during the process of its renewal. This is accomplished by an automatic locking of the carrier before contact is made with the fuse terminals.

POLE TYPE CUTOUT, SECTIONAL VIEW

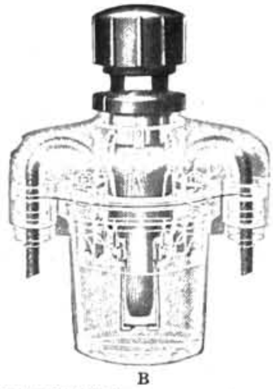
The cutout is also provided with an effective venting system which prevents accumulation of pressure within the casing, as well as the blowing out of any considerable quantity of oil.

The oil used is especially refined for this service. It does not thicken in zero weather, nor is there appreciable evaporation at operating temperatures. Other oils, such as those used in transformers, should not be used, as they may not have the proper characteristics. The use of the oil (G-E No. 21 Oil) supplied with this device is strongly recommended as its effectiveness is assured.

D & W OIL FUSE CUTOUTS

The oil level should be checked at least once a year, and the oil should be kept at the proper level.

A

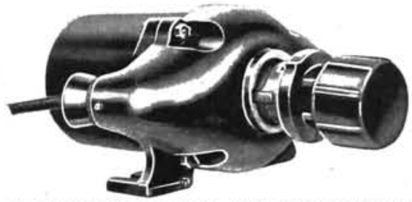


B

Phantom view of D & W Oil Fuse Cutout showing principal safety feature
(A) Carrier unlocked, circuit open (B) Carrier is locked before circuit is closed

It is occasionally necessary to draw off the oil for purification. By the use of a simple filter (or the G-E Oil Dryer and Filter Press) carbon or other similar impurities can be removed from the oil and its use prolonged indefinitely. Under ordinary conditions of service such a cleansing is not required oftener than once in a year or two.

A few prospective buyers have raised the question as to the effect of a possible admis-



VIEW SHOWING KEY AND KEYWAY FOR LINING UP FUSE CARRIER TO INSURE SAFETY IN FUSING

sion of rain during the operation of re-fusing in a heavy storm. This is most conclusively answered in the record of performance of thousands of these cutouts during ten years of commercial operation under all kinds of weather conditions. Not one failure has occurred from this source notwithstanding the fact that it has frequently been necessary to re-fuse them during a heavy downpour. Despite this record, we can furnish, if desired, small covers which can be placed over the opening in the cutouts during re-fusing. These are light, and can be readily carried in the lineman's pocket.

In recent years, it has become common practice to make the size and kind of oil circuit breaker bear a definite relation to the

INSERTING THE FUSE CARRIER. A SLIGHT TURN LOCKS IT, AND A 90 DEG. TURN CLOSES THE CIRCUIT UNDER OIL

amount of energy to be handled on short circuits. The same is true of oil fuse cutouts. It is, therefore, urged when purchasing these devices for a new installation that accurate information be given as to the greatest amount of energy to be handled on short circuit, the size of the generating system and the distance from the oil cutouts to the source of energy, as well as the continuous carrying capacity, in order that we may recommend the style and size best suited to the conditions.

D & W OIL FUSE CUTOUTS

D & W Oil Fuse Cutouts are not intended for use as switching devices under load. However, it is common practice to use ordinary cutouts for sectionalizing purposes, and the D & W Oil Fuse Cutout will be found exceptionally well adapted for this service.

POLE TYPE STANDARD SERVICE

D & W Oil Fuse Cutouts for standard service are contained in a cast iron box provided with suitable lugs for mounting, openings for re-fusing, and entrance leads through

POLE TYPE, 50-200 AMPERES

bushings. The cover and tank are separable and are solidly bolted together on an oil tight gasket.

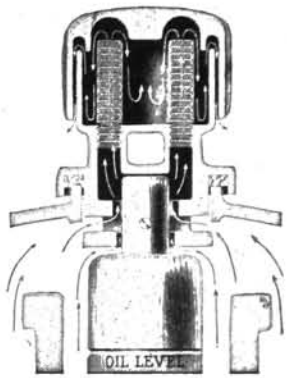
The standard line of pole type oil fuse cutouts are made in three sizes ranging from 50 to 200 amperes at 2500 volts. The principle of operation is the same for all sizes.

These cutouts will interrupt ten times their maximum rated capacity in amperes, on short circuits, i.e., the 50-ampere cutout will safely handle 500 amperes; the 100-ampere, 1000 amperes, and so on.

Beyond this is an ample safety factor, so that these devices are suitable for all ordinary conditions of commercial service. Where conditions of service are extraordinary the use of the heavy service cutout is recommended. The description of this line is given below.

The cutout is so constructed that when the fuse link blows the gas formed travels upward around the carrier, and escapes through the venting system.

The venting system is so arranged that as any oil or froth enters the tubes located under the hood, it encounters a series of screen baffle plates. The contact with these screens, together with the impact of the foam against the rounded deflectors of the hood, sets free the gas which passes out from under the base of the hood by an indirect path. The oil being unable to follow the circuitous route is deflected into the reservoir from which it drains back into the tank by means of the



METHOD OF VENTING POLE TYPE CUTOUTS

capillary holes drilled into the base of the brass tubes.

In draining back to the tank a film of oil is left in the holes which forms an effective seal against the entrance of water or moisture which might condense within the reservoir.

The cutouts are equipped with heavily insulated flexible leads to which the feeder wires may be soldered, thus eliminating the necessity of making complicated connections within the device itself.

FOR HEAVY SERVICE

The heavy service type has been developed for use where the conditions are excessively severe, or where, with a very large generator capacity connected, it is necessary or desirable to install these cutouts for junction or primary protection within a short distance of the source of current.

These cutouts are identical in principle and interior construction with the standard type. Some modifications have, however, been made in the materials used. A pressed

D & W OIL FUSE CUTOUTS

steel oil tank, threaded into the upper portion of the cutout, is substituted for the cast iron one. By this change the mechanical strength is greatly increased, since pressed steel possesses nearly twice the tensile strength of cast iron. The insulation resistance has also been greatly increased, and an improved type of bushing introduced, so that certain sizes of the cutout may be used on potentials as high as 15,000 volts.

The heavy service oil fuse cutouts fused with reactive type links will rupture on short circuits 25 times the maximum current they are rated to carry continuously.

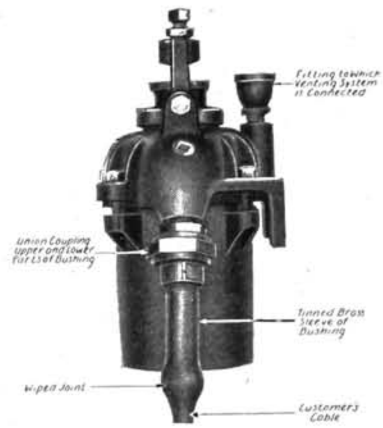
POLE TYPE, HEAVY SERVICE CUTOUT

Before these cutouts were placed on the market conclusive tests were conducted in order to demonstrate their ability to handle the most severe conditions which could be met in commercial service. Probably the most exacting short circuit tests ever conducted on any fuse device were made at the Ontario Hydroelectric Station at Toronto, Canada. Lines which supplied energy through a 5000-kv-a. bank of transformers from generators aggregating 100,000 horse power were short circuited through one oil fuse cutout. Currents of 5000 amperes at 2500 volts were repeatedly opened quietly, which verified earlier conclusions that this cutout is the most effective piece of apparatus yet devised for high tension service.

SUBWAY TYPE

The subway type of oil fuse cutouts is identical with the pole type in essential operating principles and the same safety locking arrangement which locks the carrier into the cutout before contact with the terminals is made. However, slight modifications in construction are made to adapt it to underground service.

The types of underground primary protective devices most commonly used before the D & W oil fuse cutout was developed



D & W 2500-VOLT SUBWAY TYPE, OIL FUSE CUTOUT, SHOWING DETAILS OF SLEEVE BUSHING CONSTRUCTION

presented inherent weaknesses that have been successfully overcome by the D & W design.

One weakness was the unreliability of the enclosed fuses which frequently resulted in the destruction of the box in which they were installed. In underground work, this was costly, both from interruptions to service and in the expense of repairing the damage. The D & W oil fuse cutout is positive in its operation, and has appreciably reduced the repair and shut down costs of the numerous utilities who have installed them.

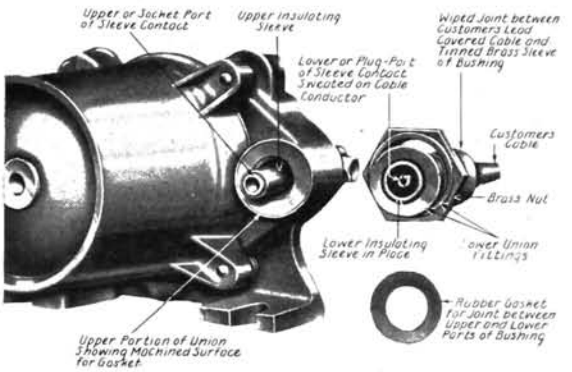
A second cause of dissatisfaction with the ordinary type of underground box was the length of time necessary in re-fusing.

The removal of numerous cover bolts which were usually small and corroded or rusted occasioned delay in restoring service. This worked a hardship on the consumer, as well as the utility. The simplicity and rapidity with which the D & W oil fuse cutout

D & W OIL FUSE CUTOUTS

may be re-fused reduces the period of interrupted service to a minimum. It is necessary to loosen but one large screw and lock nut in order to have access to the fusible element.

In underground service the frequent presence of gas in the manhole, which may be ignited during the operation of and re-fusing of cutouts having exposed contacts, introduces risks of no small moment. By arranging for the making and breaking of contacts under



D & W, SUBWAY TYPE, OIL FUSE CUTOUT WITH BUSHING SEPARATED TO SHOW SLEEVE CONTACTS, INSULATING SLEEVE, UNION AND GASKET

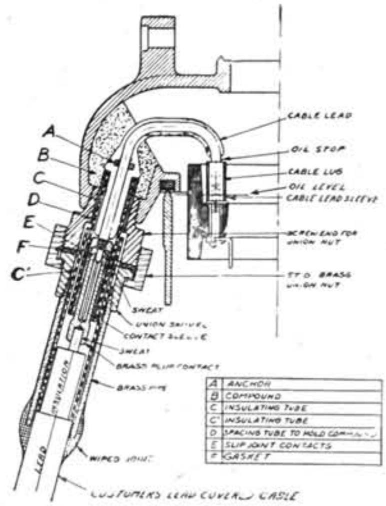
oil, as is effected in the oil fuse cutout, the danger from such explosions is eliminated.

Principal among the differences between the subway type and the pole type is the cable lead construction. The original designs required that the cutout be permanently coupled by wiped joints to the cables. This often necessitated sharply bending the cable leads and the splicing most always had to be done in the manhole.

The present design has reduced the difficulty of installing to a minimum. The customer's cable leads are now brought directly into the sleeve bushings and in practically all instances it is no longer necessary to make two of the cable splices formerly required. In addition much of the work can now be done in the workshop.

Bushings for the 50- and 100-ampere standard service and 100-ampere heavy service cutouts are all similar and interchangeable. This allows an exchange of cutouts without any change in the cables. It is possible to replace a 50-ampere device with a 100-ampere cutout when additional transformer capacity has been installed.

The bushing is made in two separate parts. The lower part is a brass sleeve threaded to



CROSS SECTION OF SLEEVE BUSHING OF SUBWAY TYPE CUTOUT

take a standard union fitting with a brass coupling nut. Inside the sleeve is an insulating tube of high dielectric strength and a plug contact into which the conductor of the customer's lead sheathed single conductor cable is sweated. The upper part of the bushing completes the union fitting and contains the socket part of the sliding contact which is permanently connected to the leads inside the cutout. Here an insulating tube also separates the live parts from the walls of the bushing. Ample creepage distances are obtained by having these insulating tubes telescope each other. The lower tube when in place projects out of the bushing beyond the plug contact acting as a shield in case the joint is separated when the circuit is alive.

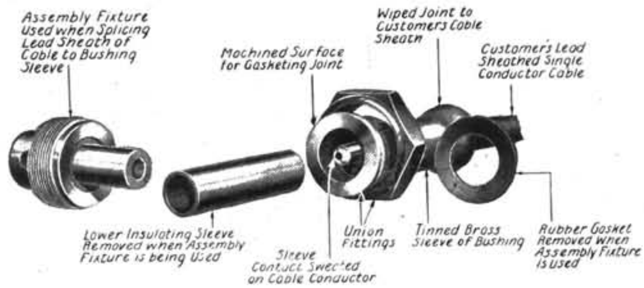
The end of the customer's cable entering the cutout is prepared in the following manner: The lead sheath is stripped back and a portion of the cable insulation removed. A

D & W OIL FUSE CUTOUTS

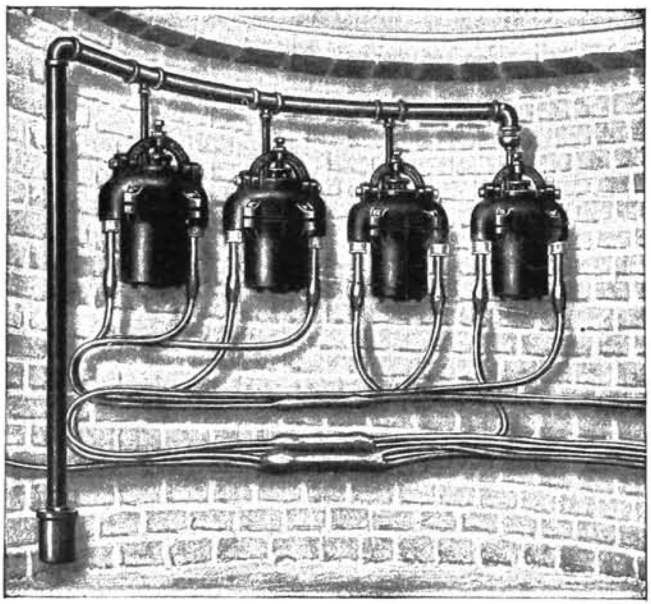
gauge, giving the proper dimensions, is supplied for this purpose. The split plug part of the sliding contact is then sweated to the bare end of the cable conductor. The next operation is the assembling of the lower bushing sleeve.

An assembly fixture which is in reality a dummy of the upper part of the bushing may be purchased, or the cutout itself may be used as the fixture.

The tinned brass sleeve with the lower part of the union in place is clamped to the assembly fixture by threading with the union nut. The joint is drawn down tight without a gasket. The end of the customer's cable with the split plug in place is then inserted in the sleeve with the contact plug firmly seated in the assembly fixture. The insulating sleeve is not put in at this time. The lead cable is then wiped fast to brass sleeve. The assembly fixture is then removed and the lower insulating sleeve is inserted from the open end. The bushing is then ready for coupling with the cutout. Cutouts of the old design cannot be economically changed to the present design.



ASSEMBLY FIXTURES AND CABLE END OF SPECIAL SLEEVE BUSHING FOR 50- AND 100-AMP., 2500-VOLT SUBWAY TYPE



INSTALLATION SHOWING METHOD OF VENTING SUBWAY TYPE

D & W OIL FUSE CUTOUTS

The remaining differences between the subway and pole type cutouts are necessitated to prevent moisture entering the cutout or cable system. A waterproof gasket is inserted between the cover and the fuse carrier. In order to compress this gasket against the V-shaped ring on which it rests, a swivel yoke is employed. This carries at its center a powerful compression screw provided with a lock nut. A quarter or half turn of this brings the gasket against the V ring with such force as to insure absolute tightness of the joint, even when the cutout is entirely submerged.

SUBWAY TYPE, 50-200 AMPERES FOR STANDARD SERVICE

SUBWAY TYPE, HEAVY SERVICE CUTOUT

In the standard service design a similar form of gasket is used between the oil container and the top of the cutout. In this case a suitable number of clamping bolts provide the necessary compression to draw the oil container into position and to insure tightness of the joint.

The venting arrangement is necessarily modified for subway service and provision is made for connecting the cutouts either to separate vent pipes, or, preferably, to a common pipe. In either case the piping should be run from the vent openings in the cutouts up as high as possible in the manhole and from there dropped to within a few inches of the floor and the joints made up with shellac. For all 2500- and 4400-volt subway cutouts, pipe not smaller than 1 in. should be used. When a number of cutouts are grouped to a single pipe, the size should be increased proportionately.

The lower end of each vent pipe should be fitted with an air bell made by screwing a short piece of larger pipe into a reducing cap attached to the end of the vent pipe. The lower end of the larger pipe is to be left open, and care must be used to have all of the joints in the venting system absolutely tight. In case the manhole becomes flooded with water, the air in the enlarged lower end of each vent pipe is compressed in the cutout, thus resisting the rise of water in the pipe. If the piping is tight and the proper size of air bell is used at the bottom, no water can enter the cutout even though the manhole be completely filled. This venting arrangement insures watertightness and yet provides an open passage for the escape of gas at all times.

Air bells should be at least as large as given in the table:

Voltage Rating	Ampere Capacity	Box Designation		Volume of Air Bell
2500	50	D-10	D-20	1 pint
2500	100	D-11	D-21	1 quart
2500	200	D-12	D-22	2 quarts
4400	150	D-22		2 quarts

NOTE.—When several oil fuse cutouts are attached to a common vent pipe the air bell should have a capacity equal to the sum of those required for the separate boxes.

D & W OIL FUSE CUTOUTS

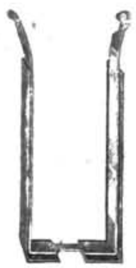
SUBWAY TYPES FOR STANDARD AND HEAVY SERVICE

Paralleling the pole type standard and heavy service cutouts are lines of subway type standard and heavy service D & W oil fuse cutouts having the same current rupturing capacities and designed to operate at the same voltages.

These are recommended for subway installation to the exclusion of all other types. The 5000-volt heavy service type represents the highest voltage subway design now in production. If subway cutouts are wanted for higher voltages (up to and including 15,000 volts) propositions should be requested.

FUSE LINKS

Two kinds of fuse links are furnished for D & W oil fuse cutouts and either kind may be used. The standard type of fuse link is the plain link and is made in sizes suitable for all of the cutouts. The reactive type fuse link is made for cutouts of 100 amperes capacity and larger. It is of utmost importance that only fuse links designed and furnished especially for these cutouts be used. Fuse links made of ordinary fuse wire should never be employed, as they have a tendency to cause an abnormal rise in temperature of the oil, with a resultant carbonization which rapidly destroys its effectiveness, and may boil the oil away causing the cutout to fail.



STANDARD TYPE FUSE LINK

HEAVY SERVICE REACTIVE TYPE LINK FUSE

STANDARD TYPE FUSE LINKS

These fuse links have laminated metal terminals supporting between them a small section of special fusible alloy of low melting point and high conductivity. They are attached under tension to the carrier by means of star thumb nuts, so that the lineman can quickly replace a blown fuse without tools. The links are inexpensive, and are boxed so compactly that a number of them may be readily carried in the trouble-man's kit without inconvenience.

This type of fuse link is most commonly used and will meet all ordinary requirements. The reactive type fuse link described below is useful on systems of large generating capacity where it is desirable to open the circuit in minimum time and with minimum disturbance.

REACTIVE TYPE FUSE LINK

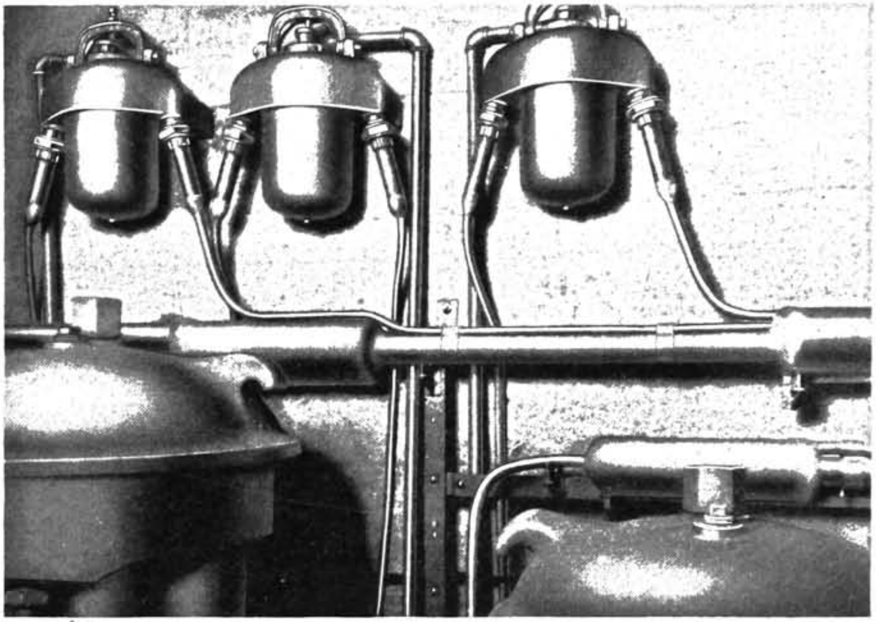
In connection with the development of the heavy service cutout, there has been designed a new form of fusible element for use where the conditions are exceptionally severe. This has been termed the "Reactive Link" and it is found to possess marked advantages over the plain link for the conditions cited.

In the reactive link the main fusible strip is shunted by means of two inductively wound, enclosed helixes of high resistance. By this construction the final rupture of the circuit occurs within these enclosures. When the main link melts, only a small arc results, because the current is shunted through the enclosed helixes. The current passing through these is quickly cut down in volume due to the rapid increase in resistance before the melting point is reached. The coils of the secondary links are surrounded by porous material thoroughly saturated with oil. This structure has the peculiar advantage that it causes the final interruption of the current to take place simultaneously at a number of points within the enclosures. In this way

D & W OIL FUSE CUTOUTS

very quiet operation is secured under the most severe conditions.

By means of the reactive type link, the period of arcing is materially reduced. Oscillographic records of the operation of the oil fuse cutout employing two types of links are shown on page 12. Although the reactive type fuse links are generally used in the heavy service type cutouts, they may, however, be used in the standard types with the same beneficial results.



INSTALLATION OF SUBWAY TYPE D & W OIL FUSE CUTOUTS AT AKRON, OHIO

SUMMARY OF DESIRABLE FEATURES

1. Safety First feature. Fuse carrier locked in place before circuit is closed.
2. No deterioration of fuse due to oxidation or electrolysis.
3. Fuses quickly and easily replaced.
4. Circuit broken under oil.
5. Breaks arc as fast as any device ever placed on the market.
6. Same characteristics as oil circuit breaker with inverse time overload relay, but does not have relays or tripping mechanism.
7. Inspection and care reduced to a minimum.
8. Never fails to operate.
9. The arc is under oil when the fuse blows and there is no danger of igniting any inflammable gases in the manhole.
10. Thoroughly tried in service and universally approved.

APPLICATION

D & W oil fuse cutouts may be applied in many places on primary circuits. While their principal function is the protection of transformers, they are now frequently used for fusing tapoffs, sectionalizing feeders and even as protection for feeders at substations.

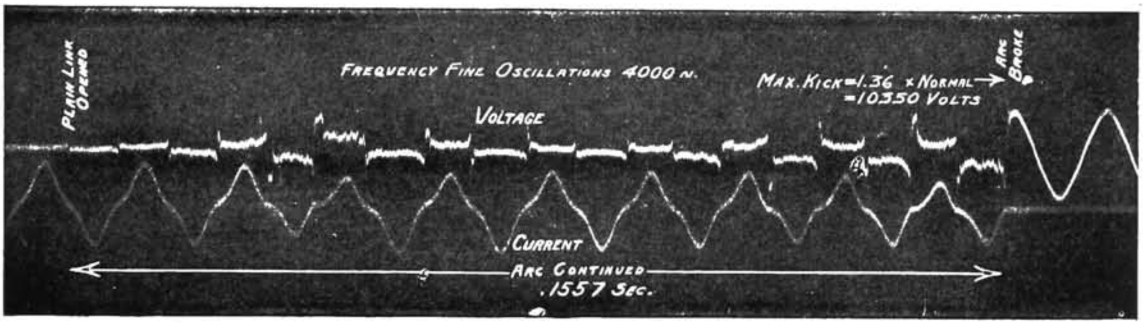
They are very effective for fusing important transformer substations, even of small capacity, where service is of importance. Their high rupturing capacity permits their

D & W OIL FUSE CUTOUTS

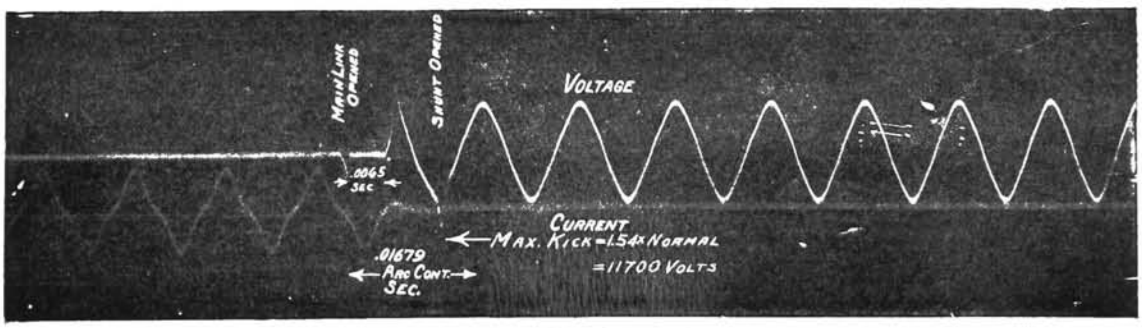
use near stations where large amounts of power may require interrupting.

These cutouts are suitable for overload protection and the uniformity and accuracy of the blowing of the fuse is exceptional. In this cutout is combined the ability to fuse against overloads, and at the same time the rupturing capacity of the cutout is very high, as indicated in the tables.

The selection of the correct cutout for a given location must depend upon the consideration of local conditions, taking into account the rated rupturing capacity, as well as the normal rated capacity in amperes. In order to promote standardization, it is advisable to keep the number of sizes of cutouts on a system to a minimum. Standardization of the 100-amp. and 200-amp. sizes can be strongly recommended.



OSCILLOGRAM SHOWING STANDARD FUSE LINK OPENING A 7600-VOLT, 60-CYCLE LINE SHORT-CIRCUITED THROUGH D & W OIL FUSE CUTOUT. MAXIMUM CURRENT, 770 AMPERES



OSCILLOGRAM SHOWING REACTIVE FUSE LINK OPENING A 7600-VOLT, 60-CYCLE LINE SHORT CIRCUITED THROUGH D & W OIL FUSE CUTOUT. MAXIMUM CURRENT 1040 AMPERES

D & W OIL FUSE CUTOUTS

ORDERING INSTRUCTIONS

When ordering, give catalogue number of cutout, maximum ampere capacity, and voltage of system on which they are to be installed.

Sufficient oil (G-E No. 21) is shipped with the cutouts in all cases and should not be specified as a separate item on the requisition.

Particular attention is directed to the fact that fuse links are not included with cutouts and must be ordered as a separate item. The factory will question all orders for cutouts which do not also call for fuse links or specify distinctly that they are not wanted. Ordinary fuse wire or fuse links for other kinds of cutouts will not operate satisfactorily and only the special links designed for these cutouts should be used.

When ordering **Fuse Links** specify catalogue number and ampere rating. When possible, also give catalogue number of the cutout in which they are to be used.

Care should be taken in ordering fuse links, since a fuse link for a 50-amp. cutout will not fit in a 100-amp. cutout, etc.

Orders for fuse links should be confined to standard packages wherever possible.

Supply parts should be positively identified by description and the form letter of the cutout as well as the catalogue number. "Assembly and Parts" prints on request.

D & W OIL FUSE CUTOUTS

PRICES AND DIMENSIONS

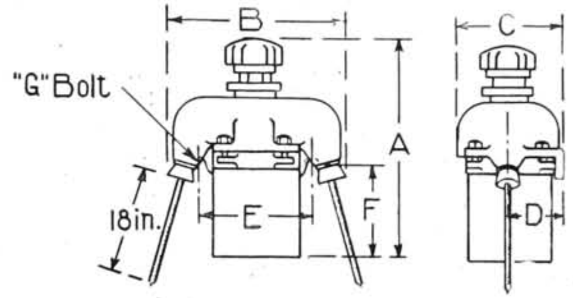


Fig. 1

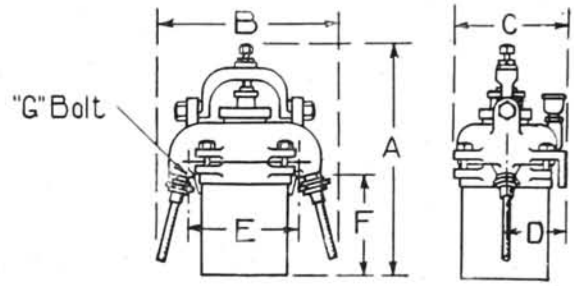


Fig. 2

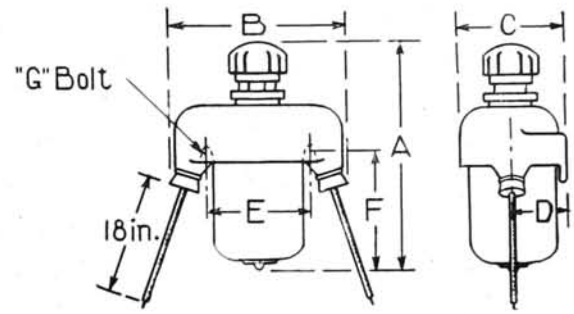


Fig. 3

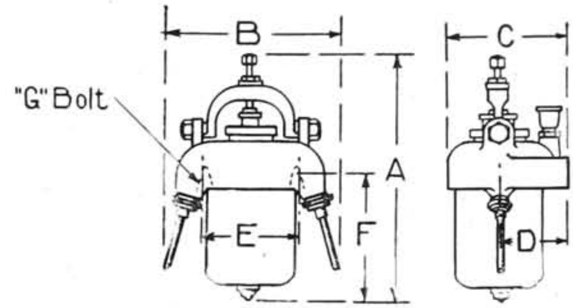


Fig. 4

Cat. No.	Type	AMPERES		† Volts	List Price Including Oil and Boxing F.O.B. Pittsfield, Mass.	WT. IN LB.				Oil Required in Quarts	See Fig. No.	DIMENSIONS IN INCHES						
		Rated Capacity	Inter-rupt-ing			Shipping Cut-out	Shipping Oil	Net Cut-out	Net Oil			A	B	C	D	E	F	G
STANDARD POLE TYPE																		
230014	D- 1C	5 to 50	500	2500	$30.00	51	5	33	4	2	1	14¼	11⅞	6¾	3½	7	6⅜	½
230000	D- 2C	10 to 100	1000	2500	45.00	62	8	41	6	3	1	15¾	12 11/16	7 9/16	4	7¾	7¾	½
230001	D- 3C	10 to 200	2000	2500	60.00	86	15	68	12	6	1	18 3/16	16 1/16	9¼	4¾	9	9 3/16	⅝
STANDARD SUBWAY TYPE																		
246103	D-10B	5 to 50	500	2500	$60.00	56	5	40	4	2	2	15¼	13 1/16	7¼	4	7½	6⅜	½
246104	D-11B	10 to 100	1000	2500	70.00	87	8	61	6	3	2	16⅞	13 13/16	7 11/16	4⅜	8¼	7¾	½
246105	D-12B	10 to 200	2000	2500	95.00	106	15	76	12	6	2	20 1/16	17¾	9¾	5¼	9½	9¼	⅝
HEAVY SERVICE POLE TYPE																		
230006	D- 8C	10 to 100	2500	2500	$51.00	60	7	38	5	2½	3	15⅞	12⅛	7 9/16	3 11/16	8	8 1/16	½
230007	D- 4C	10 to 200 10 to 150	5000 3750	2500 5000	75.00	104	18	82	14	7	3	19	16¼	9¾	5	10	9½	⅝
230008	D- 5C	100 to 300	7500	{ 2500 5000	*	188	30	133	23	12	3	24¼	22½	12 3/16	6¼	12¾	12⅛	¾
230009	D- 6C	10 to 150	3750	7500	*	188	30	141	23	12	3	24¼	22½	12 3/16	6¼	12¾	12⅛	¾
230010	D- 9C	10 to 100	2500	15000	*	273	30	210	23	12	3	25¾	25⅜	13½	7	16½	12⅜	¾
HEAVY SERVICE SUBWAY TYPE																		
246107	D-21B	10 to 100	2500	2500	$79.00	57	7	42	5	2½	4	16⅞	13 13/16	8⅜	4¾	6¾	8 13/16	½
246108	D-22B	10 to 200 10 to 150	5000 3750	2500 5000	119.00	112	18	85	14	7	4	20¾	18 7/16	10 9/16	5 13/16	8¼	10½	¾
ASSEMBLY FIXTURES FOR SPECIAL SUBWAY TYPE SLEEVE BUSHING																		
Small size (see page 10)				248664	$9.00	For use with Cat. Nos. 246103, 246104, 246107 subway cutouts												
Large size (see page 10)				248665	11.00	For use with Cat. Nos. 246105, 246108 subway cutouts												

* Prices on application. Fuse links not included in above prices, see page 15.

† 2500-volt cutouts are suitable for operation on 4000-volt Y-connected circuits with grounded neutral. 7500-volt cutouts Cat. No. 230009 are suitable for operation on 11,000-volt Y-connected circuits with grounded neutral.

Special Cutouts.—Propositions on cutouts not listed supplied upon application to our nearest office.

FUSE LINKS FOR D & W OIL FUSE CUTOUTS

STANDARD FUSE LINKS — For Use with Oil Fuse Cutouts Cat. Nos.

Rated Capacity of Links in Amps.	*235587	230014 230002 246103 230005 230011	230000 230003 246104 230006 230012 246107	230001 230004 246105 †230007 †230013 246108	230008 For 2500 or 5000 volts	230009 230010
	CAT. NOS. OF FUSE LINKS					
5	235673	230553	......	......	......	......
10	235675	230555	230566	230581	......	230608
15	235676	230556	230567	230582	......	230609
20	235677	230557	230568	230583	......	230610
25	235678	230558	230569	230584	......	230611
30	No larger link made for this cutout	230559	230570	230585	......	230612
35		230560	......	......	......	......
40		230561	230571	230586	......	230613
45	......	230562	......	......	......	......
50	......	230563	230572	230587	......	230614
60	......	No larger link made for these cutouts	230573	230588	......	230615
70	......		230574	230589	No smaller link listed for this cutout	230616
75	......		230575	230590		230617
80	......	......	230576	230591		230618
90	......	......	230577	230592		230619
100	......	......	230578	230593	230620	230620
110	......	......	No larger link made for these cutouts	230594	......	§230621
120	......	......		230595	......	§230622
125	......	......		230596	230623	§230623
130	......	......	......	230597	......	§230624
140	......	......	......	230598	......	§230625
150	......	......	......	230599	230626	§230626
160	......	......	......	230600	......	No larger link made for these cutouts
170	......	......	......	230601	......	
175	......	......	......	230602	235605	
180	......	......	......	230603	......	......
190	......	......	......	230604	......	......
200	......	......	......	230605	235606	......
225	......	......	......	No larger link made for these cutouts	235607	......
250	......	......	......		235608	......
275	......	......	......		235609	......
300	......	......	......		235610	......
List Price F.O.B. Pittsfield, Mass. Std. Pkg. of 10 links Class YY	$4.50	$4.50	$7.50	$18.00	$18.00	$18.00
Ship. Wt. of Std. Pkg.	½ lb.	½ lb.	1 lb.	2¼ lb.	2¼ lb.	2¼ lb.

REACTIVE TYPE FUSE LINKS — For Use with Oil Fuse Cutouts Cat. Nos.

Rated Capacity of Links in Amps.	230000 230006 230003 246104 230012 246107	230001 230007 230004 246105 230013 246108 For 2300 volts only	230007 230013 246108 For Use on 5000 volts	** 230008 For 2500 volts only	230009	230010
	CAT. NOS. OF FUSE LINKS					
5	......	......	......	......	......	......
10	230664	230704	235636	......	230681	235613
15	230665	230705	235637	......	230682	235614
20	230666	230706	235638	......	230683	235615
25	230667	230707	235639	......	230684	235616
30	230668	230708	235640	......	230685	235617
35	230669	230709	235641	......	230686	235618
40	230670	230710	235642	......	230687	235619
45	......	......	......	......	......	......
50	230672	230712	235644	......	230689	235621
60	230673	230713	235645	......	230690	235622
70	230674	230714	235646	No smaller link listed for this cutout	230691	235623
75	230675	230715	235647		230692	235624
80	230676	230716	235648		230693	235625
90	230677	230717	235649		230694	235626
100	230678	230718	235650	235663	230695	235627
110	No larger link made for these cutouts	230719	235651	......	230696	No larger link made for this cutout
120		230720	235652	......	230697	
125		230721	235653	235664	230698	
130	......	230722	235654	......	230699	......
140	......	230723	235655	......	230700	......
150	......	230724	235656	235665	230701	......
160	......	230725	No larger link made for these cutouts	......	No larger link made for this cutout	......
170	......	230726		......		......
175	......	230727		235666		......
180	......	230728	......	......	......	......
190	......	230729	......	......	......	......
200	......	230730	......	235667	......	......
225	......	No larger link made for these cutouts	......	235668	......	......
250	......		......	235669	......	......
275	......		......	235670	......	......
300	......		......	235671	......	......
List Price F.O.B. Pittsfield, Mass. Std. Pkg. of 10 links Class YY	$37.50	$37.50	$37.50	$37.50	$37.50	$37.50
Ship. Wt. of Std. Pkg.	2½ lb.	3½ lb.	3½ lb.	3½ lb.	3½ lb.	3½ lb.

* Cat. No. 235587 is obsolete. The links listed are for boxes already in service.

** Cat. No. 230008 when used on 5000-volt circuits will require special reactive type links. Full data on request.

† The standard links for 150 amperes and below listed for these cutouts will operate satisfactorily on 5000 volts.

§ Not suitable for use in Cat. No. 230010.

Fuse links shown in **bold face type** are standard.

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San Antonio, Tex............National City Bank Building

For HAWAIIAN Business refer to Catton, Neill & Co., Ltd., Honolulu

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Philadelphia............1223 Washington Ave.
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St. Louis............1007-1009 Spruce St.

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New York City
120 Broadway

General Sales Offices
Schenectady, N. Y.

London
Crown House, Aldwych, W. C. 2

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7-5-23