Westinghouse
Type HL
Unit Switch Control
Equipment

Instruction Book 5134-B

Westinghouse Electric & Manufacturing Company
East Pittsburgh Works East Pittsburgh, Pa.

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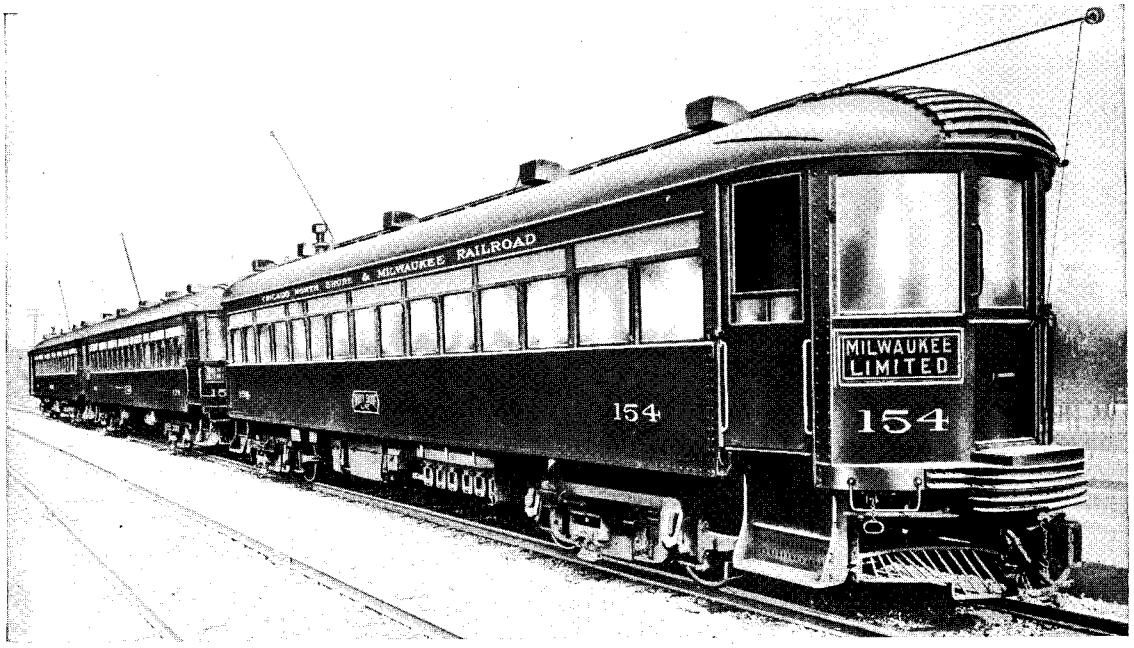


The Chicago, North Shore and Milwaukee High-Speed Multiple Unit Train

INTRODUCTION.

This Instruction Book is published primarily for the use of operators, inspectors and maintenance men on those railway companies where Westinghouse electro-pneumatic control equipments are in use, and it should serve as a ready reference and guide to all who are interested in the installation and care of this class of railway control apparatus. The type of apparatus covered in this booklet is standard HL control as applied to cars and locomotives for 600 volt, 1200 volt, and 1500 volt installations. The instructions and data covering the foregoing class of equipment apply in general to electro-pneumatic control equipment of special construction, such as would be required to multiple with other manufacturers' apparatus. Therefore, the information covered in this Instruction Book for individual pieces and parts of apparatus, such as controller boxes, switch groups, line switches, reversers, air cylinders, relays, etc., are practically the same regardless of special requirements.

This publication is assembled in sections so that information covering departures from the standard or special features, which are in

some cases required by operating companies, may be added to cover those specific cases. The text is divided into three sections; namely, Installation, Operation, and Maintenance, all of which are preceded by this general introduction.

For the special benefit of the platform operators a general list of the apparatus involved in a standard HL control equipment is given below. The list of apparatus covers an equipment for four 65 H.P., 600 volt motors arranged for double end operation in trains on 600 volt trolley. This may be considered as applying to all other standard HL equipments except that a separate line switch is used on equipments where the capacity is above four 75 H. P. motors.

Main Circuit Apparatus

2—Trolleys
1—Lightning Arrester
1—Main Knife Switch
1—Main Fuse Box
1—Control Box
1—Reverser (included in control box)
1—Main Grid Resistor
1—Set Insulating Details.
1—Set Pneumatic Details.

Control Apparatus

2—Master Controllers
2—Control and Reset Switches
1—Control Resistor
2—Train Line Junction Boxes
2—Train Line Receptacles
1—Train Line Jumper

Trolleys collect the current from the overhead trolley wire usually by means of a revolving contact wheel.

Lightning Arrester protects the control apparatus and main motors from lightning and other abnormal voltage surges.

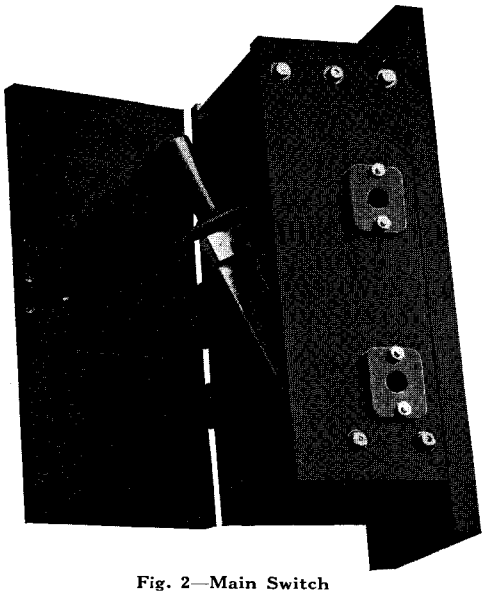


Fig. 2—Main Switch

Main Knife Switch (Fig. 2) disconnects the main motor circuit from the trolley circuit so that the controlling apparatus may be operated independently of the main motors for inspection purposes.

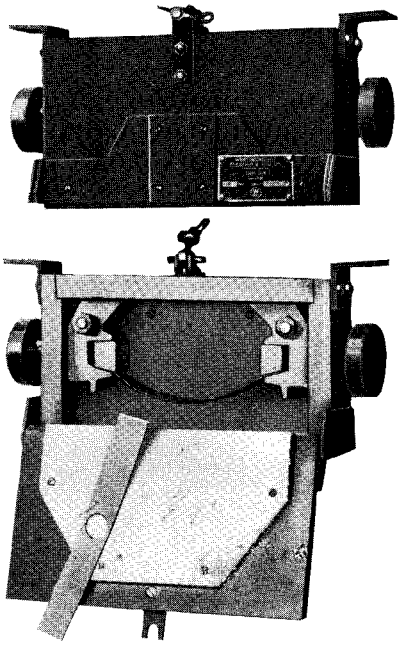


Fig. 3—Main Fuse Box

Main Fuse Box (Fig.3) provides ultimate protection to the equipment against sustained currents above the ratings of the apparatus, but below the setting of the overload trip protection.

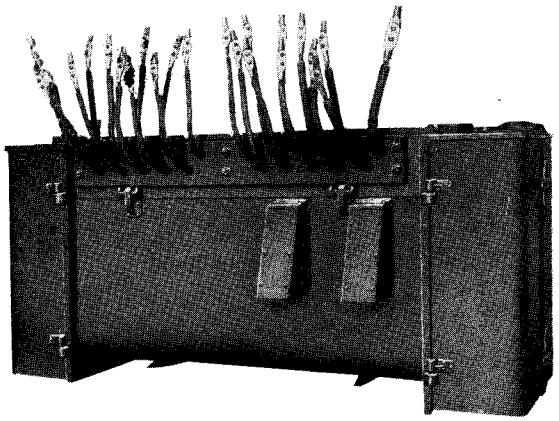


Fig. 4—Control Box Complete With Covers

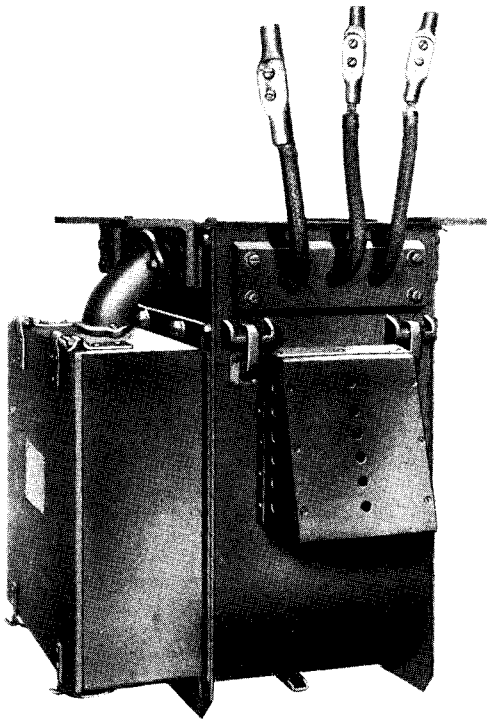


Fig. 5—Line Switch Complete With Covers

Control Box or Switch Group (Figs. 4 and 5), the main part of the equipment contains the resistance switches, the transition switches and where no separate circuit breaking line switch unit is used, the line switches. The difference between a control box and switch group is that the former includes the reverser mounted on one of the end plates, while a separate reverser is used with the latter.

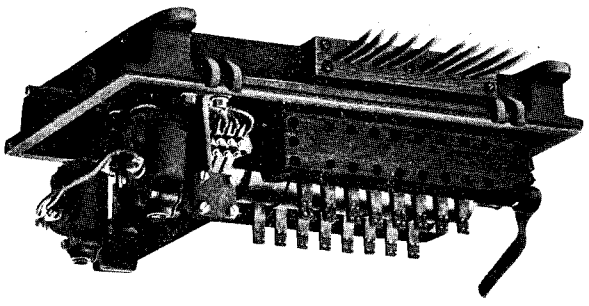


Fig. 6—Reverser for Separate Mounting

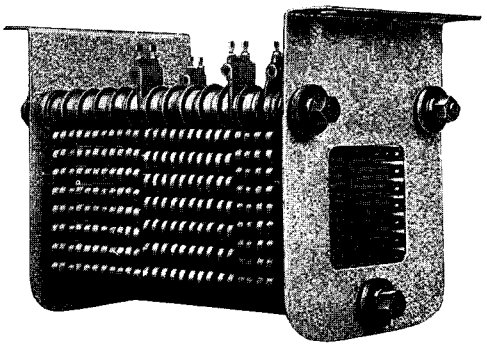


Fig. 7—Standard Grid Resistor

Reverser (Fig. 6), as its name implies, reverses the direction of current in the motor fields or armatures by interchanging the connections. This reversal of current in the field or armatures with relation to the armature or field current reverses the direction of running.

Main Grid Resistor (Fig. 7) limits the amount of current which flows

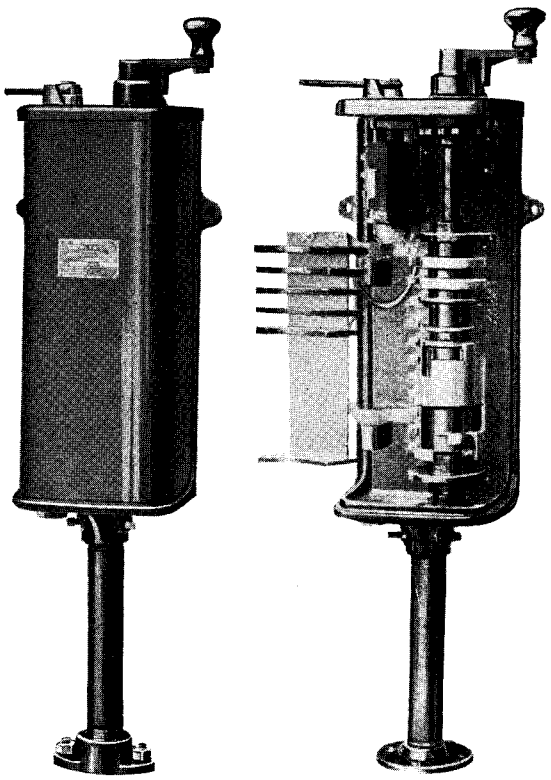


Fig. 8—Master Controller

and thus controls the torque developed by the motors. Notching of the master controller, which operates the switches in the control box or switch group, cuts out the resistance step by step, thereby permitting the motors to gradually speed up and hence the car to accelerate without excessive current and without undue discomfort to passenger.

Master Controller (Fig. 8) controls the starting and accelerating of the car. Closing and opening of main motor circuits are accomplished indirectly by the master controller energizing or de-energizing the control circuits of the switches in the control box or switch group.

Control and Reset Switch (Fig. 9) energizes or cuts off power from the control circuit. It also resets the overload trip by energizing the reset coil.

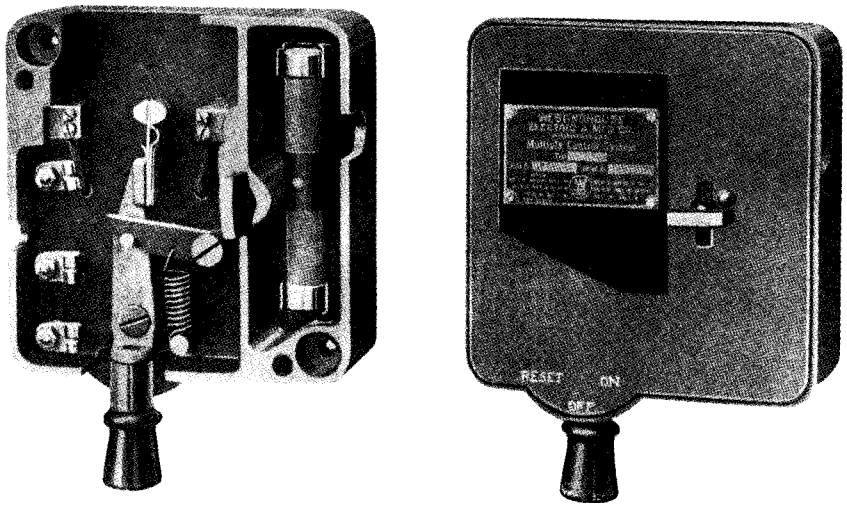


Fig. 9—Control and Reset Switch

Control Resistor (Fig. 10) provides relatively low voltages for the control circuits to the operating coils of the switches.

Train Line Junction Boxes (Fig. 11) are used to simplify the installation of control wiring and the inspection of equipments as a whole.

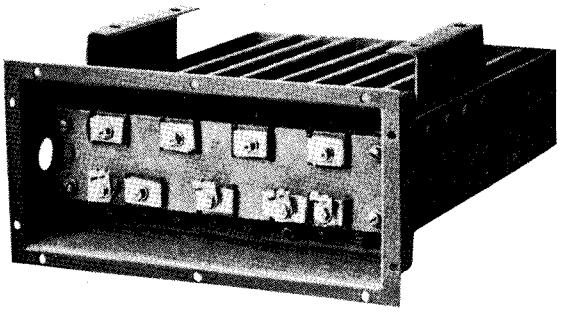


Fig. 10—Type 197-J Control Resistor

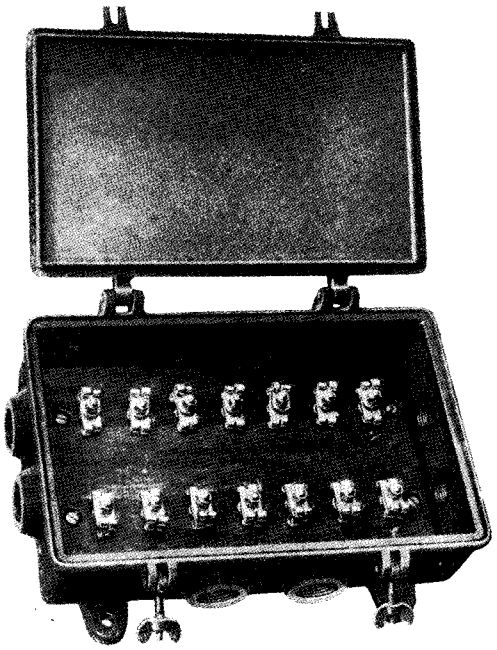


Fig. 11—Train Line Junction Box, Open

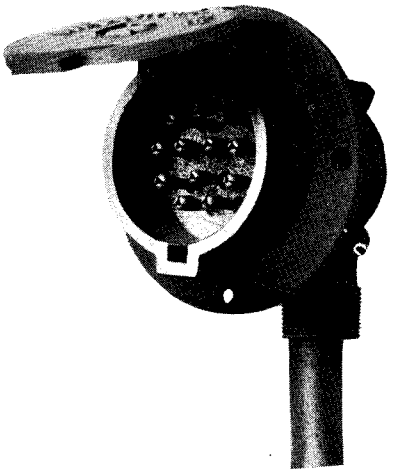


Fig. 12—Train Line Receptacle, Dashboard Type

Fig. 13—Train Line Jumper

Train Line Receptacles (Figs. 12 and 13) form control circuit terminals or extensions at the ends of car which in conjunction with the train line jumper completes the control circuits between adjacent cars of a train.

Insulating Details are used to insulate the frame supports of the apparatus from ground to reduce voltage strains between parts of different potential or voltages.

Pneumatic Details provide means for cutting off the compressed air supply, for equalizing air pressures, and for cleansing the air. In some cases where air pressures above 75 pounds are used a reducing valve for cutting down the pressure is supplied.

Installation

INSTALLATION

Installation of Westinghouse Type "HL" Unit Switch Control

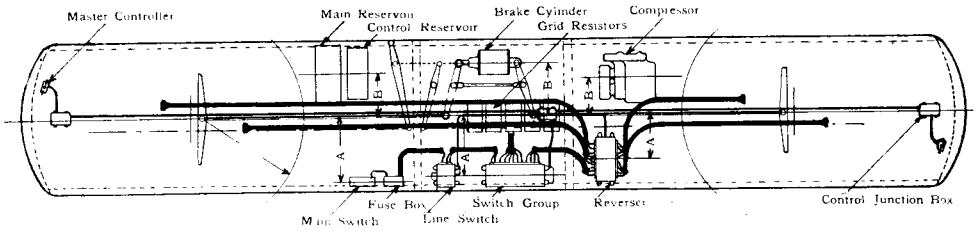


Fig. 14—Typical Car Layout

GENERAL

Preparatory to the actual installation of apparatus on a car, a layout of the apparatus is essential. (See Figure No. 14 and Figure No. 15. This preparation is necessary, due to the number of elements which enter into and affect the performance of the equipment. On a great number of cars it has been found possible to make up layout drawings which will fit average conditions. There are, however, a number of distinctive types of cars, such as the so-called "low floor", "center entrance and exit", etc., which require special arrangements. Some of the larger operating companies have found it advisable to equip one car after making a layout to determine the actual clearances and accessibility. Problems which the layout drawing helps to solve are:

(1) Actual position of hangers.
(2) Construction of hangers.
(3) Clearances between rail and apparatus and between top of apparatus and floor.
(4) Size and length of conduits.
(5) Number of cables in conduit.
(6) Minimum amount of cable required.
(7) Weight distribution.
(8) Accessibility for inspection and repair.

All main items as far as possible should be mounted on one side of car. When this is impossible the layout should be such that the inspection is not hindered to too great an extent. The position of the individual pieces of apparatus should be such that the item from which any one piece of apparatus obtains most of its connection, is adjacent to it.

The following points should be given careful thought when locating the apparatus on car.

(1) Air piping should be arranged to drain away from the apparatus.
(2) Insulated joints for both air pipe and control conduit should be placed in vertical runs with the diamond end up.
(3) When conduits are dead ended, a short distance from the lead bushing on the switch group or line switch, the cable connections between the conduits and the apparatus should be made to form "drip loops" so that water will not run into the apparatus through the cable holes in the lead bushings.
(4) When making bends in conduit, use a wide sweeping curve rather than an abrupt bend.
(5) Make certain that apparatus which is normally insulated from ground, is not grounded by hangers, brake rods, etc.
(6) Care should be taken to prevent the occurrence of water traps in piping. Where these occur, provision should be made for draining.
(7) Strict attention to piping and cooling system in compressor circuits will eliminate practically all air troubles. (See piping diagram Figure No. 25.)
(8) Separate hangers should be used for the individual pieces of apparatus, except the grid resistance which may be mounted as a group.
(9) Arc chutes should be located at least one foot distant from all grounded metal parts of car.

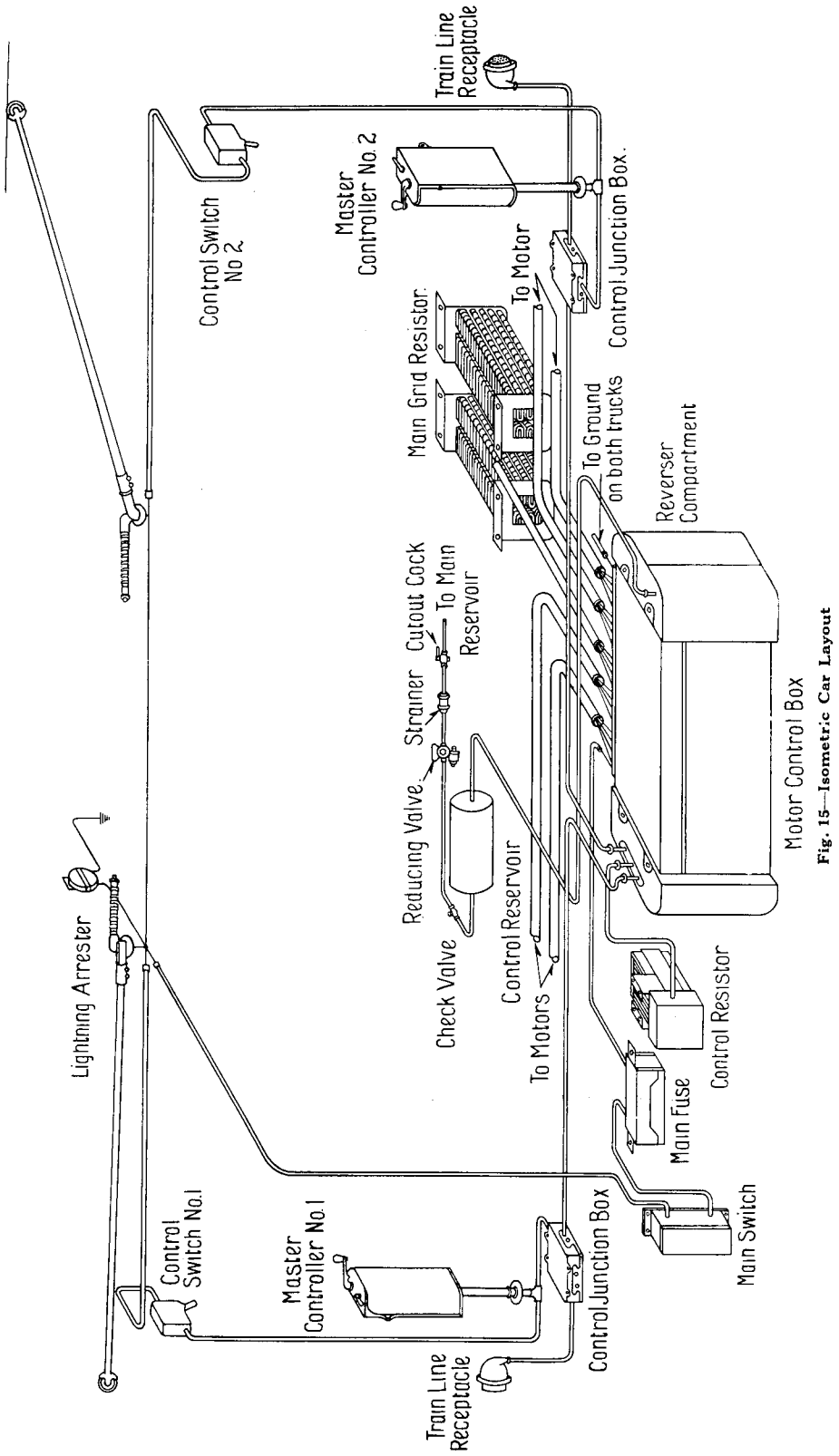


Fig. 15—Isometric Car Layout

INSTALLATION OF TROLLEY:

The trolley base or bases are mounted on trolley boards for 600 volt service. For 1200-1500 volt service an additional insulating base is used under each trolley.

On double end control equipments where the car length is greater than twice the length of the trolley pole, two trolleys are necessary. The trolley base on a single truck, single trolley, car is mounted in the center of the roof. The bases on double truck, double end trolley cars are mounted as near as possible to the center pins of the trucks. This location of mounting tends to make the trolley wheels follow the wire.

For 1200 volt trolley potential an insulator is inserted between the trolley pole and trolley rope to protect the operators from shock due to wet trolley rope.

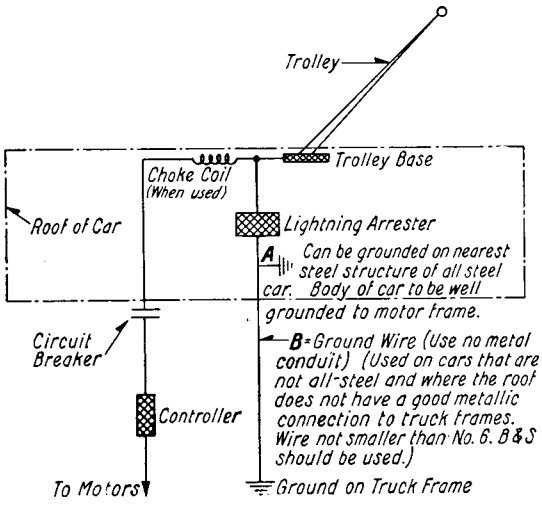


Fig. 16—Diagram of Connections for Mounting Lightning Arrester on Car Roof (Preferable Method)

LIGHTNING ARRESTER:

A lightning arrester, no matter how well designed and built, must be properly installed if its full effectiveness is to be obtained. (See Fig. 16.) Particular care, therefore, should be taken in installing arresters on electric railway cars,because of the extreme vibration, weather and other severe conditions to which they are subjected.

The paramount rule that should be followed in every installation is, make the circuit from the line to the lightning arrester and from the arrester to the ground as straight, as short, and of as low resistance as possible—as straight as possible because the more turns in the circuit the higher the inductance, as short as possible, because the longer the circuit, the higher the resistance, and the higher the resistance and inductance the more impedance there will be to the flow of the static charge, thus interferring with effectiveness of the arrester.

The lightning arrester should be mounted on the roof of car and connected to the power wire as close to the trolley base as possible. When a choke coil is used the arrester tap should be connected to the power or trolley cable on the trolley side of the choke coil.

When a choke coil is used, it should consist of at least 10 turns of the trolley cable wound on a wood core five inches or more in diameter. No choke coils are furnished with HL control as it is felt that sufficient choking effect is obtained from the blow out coils in the control box.

On all steel cars it is possible to use the frame of the car as a ground circuit provided a good connection is made between the car body and the truck bolsters.

Should it become necessary to mount the arrester inside or underneath the car body, care should be taken to keep the circuits short, straight and isolated from other car wiring. Metal conduits should be used for such mounting.

Lightning arresters having metallic cases should have the cases grounded.

MAIN FUSE BOXES:

In installing the fuse box under the car, it is usually difficult to find a location free from wheel wash, or where snow and water do not reach it in some way. For insulating purposes it is, therefore, desirable to use porcelain mounting insulation. When necessary, suitable splash guards or fenders should be provided to protect the fuse box because of the moisture absorbing properties of the arc deflectors used.

One of the main points to be considered in locating the fuse box is the accessibility and convenience in making fuse replacements. Care should also be taken to have no air pipes, brake chains, or any other grounded part of the car equipment below or in front of the arc chute of the fuse box.

When main fuse boxes are mounted on the roof of the car they should be protected by a weatherproof housing.

The main circuit fuse box should be connected in the circuit as close as possible to the point at which the trolley lead is brought down from the roof of car.

FUSE BOXES: AUXILIARY:

All auxiliary fuse boxes, particularly on 1200 and 1500 volt equipments, should be mounted underneath the car floor. It is not considered necessary to insulate these fuse boxes from ground. The location or mounting should be accessible and convenient to reach from the side of the car to facilitate the renewal of fuses.

MAIN SWITCH:

The main switch should be installed under the car in such a position as to be readily accessible and at the same time be fully protected from wheel wash and should be arranged so that the blade opens downward. In no case should the switch be mounted with the width of the blade in a horizontal position, as dirt and sand deposits become lodged between the blade and jaws and quickly wears out the contact surfaces.

LINE SWITCHES, CONTROL BOXES AND SWITCH GROUPS:

These equipment parts should be mounted on suitable hangers fastened to the car underframing. For 600 volt apparatus, the moulded insulators are customarily used to insulate the apparatus from the hangers,—(See figure No. 20) while for 1200 and 1500 volt equipments porcelain insulated bolts are desirable, (See figure No. 20-A.)

The arc chutes and the lead plates should face towards center line of car.

Care should be taken in mounting line switch, so that all car rigging, such as brake levers, chains and pipes are not less than 12 inches distant from the arc chute. Where it is impossible to adhere to this clearance, an insulating baffle should be placed in front of the arc chute, but not closer than 6 inches to the arc chute opening.

Clearance between the bottom of the switch box and the top of the rail should not be less than 10 inches. A minimum of 6 inches has at times been tolerated where the apparatus is located close to the truck. Sufficient clearance should be provided between all other apparatus to permit removal of all covers with ease.

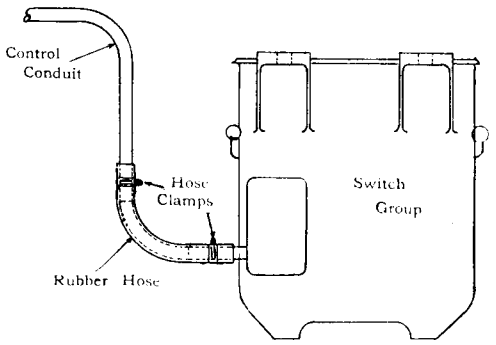


Fig. 17—1200 and 1500 Volt Conduit Insulation

When installing 1200 or 1500 volt line switches and switch groups, the insulation in the control conduit is obtained by means of a short length of rubber hose and hose clamps. (See figure No. 17.) This piece of insulation can be placed either in the straight run or at the bend. The general method of forming the "drip loop" connection between the apparatus and conduit is shown in figure No. 18.

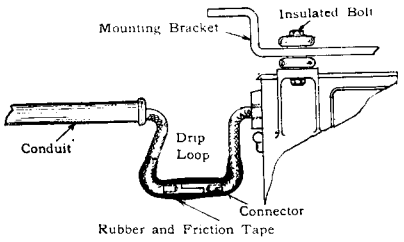


Fig. 18—Drip Loop Connection

In order to make it unnecessary to use any rubber or special insulation, except friction tape on the connectors, all drip loop connections are held rigidly in place by means of two wood strips with half the connector hole cut in each strip. This is of more benefit on switch groups than on the line switch.

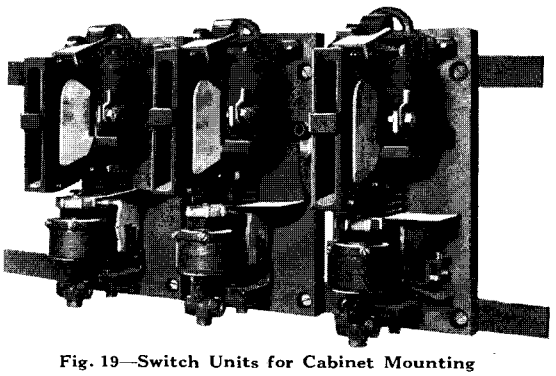


Fig. 19—Switch Units for Cabinet Mounting

MAIN RESISTORS:

Mounting of the grid resistors will depend to a considerable extent on the space requirements of other apparatus. As a general rule, it is mounted on the side opposite that occupied by the line switch, switch group, fuse box and main switch. This is mainly due to the lack of space on the side occupied by the switch group, etc., but is also done to obtain an equalization of weight or balance so that car will not list to one side.

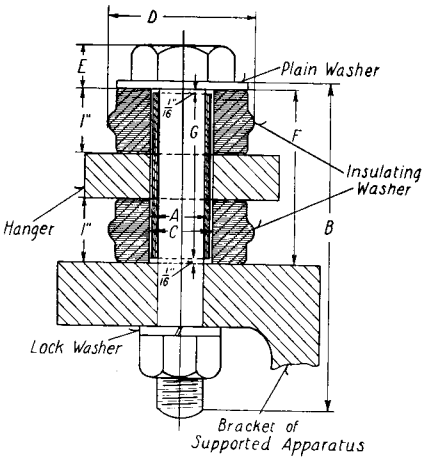


Fig. 20—Insulated Mounting Bolts for 600-Volt Mounting of Control Boxes, Etc.

With each frame of grid resistors is furnished a set of insulation for the mounting bolts. This insulation consists of 8 porcelain washers, 4 micarta tubes and 16 fish paper cushion washers per frame of resistors. (See figure No. 20-A.) For 600 volts, the frames are supported from the hangers by these insulated bolts. The hangers are in turn mounted directly on the car under framing. For 1200 and 1500 volt service, insulated bolts are also furnished for insulating the hangers from the car underframing.

Resistor frames should be arranged on hangers with the grid units extending lengthwise of the car. This insures a maximum amount of ventilation between grid units.

Where the grids are exposed to wheel wash, due to congested mounting or other reasons, splash guards should be provided.

Sufficient room between the floor of car and top of grid frames must be allowed for cable connections and for adequate ventilation.

A clearance of at least 10 to 12 inches be-

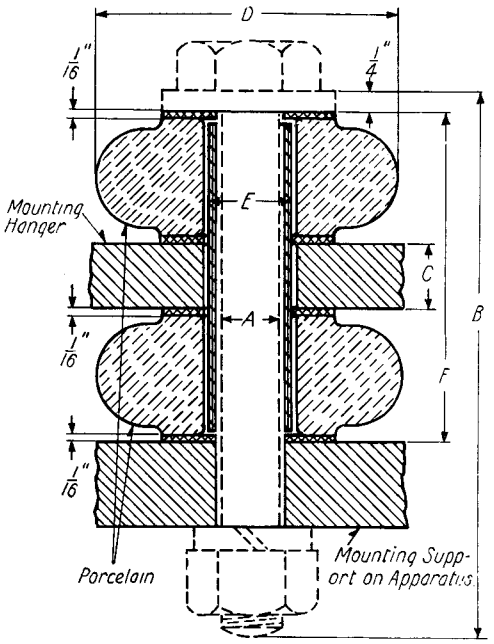


Fig. 20-A—Porcelain Insulated Bolts

tween the top of rail and the bottom of the grid resistance should be allowed.

The arrangement of resistor mounting for 600 volts is shown in figure No. 21. The distance between frames on 1200 and 1500 volts should not be less than 2 inches.

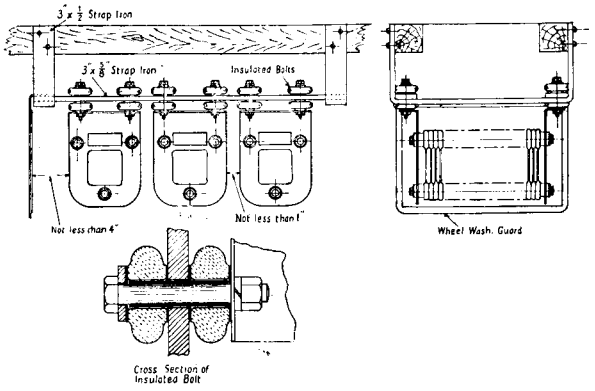


Fig. 21—Resistor Mounting, 600 Volts

Five frames of grid resistors are usually the maximum number of frames for a two-hanger arrangement. Frames in excess of five usually require three hangers, or else may be divided into two separate mounting units requiring four hangers.

The code of the National Board of Fire Underwriters specifies certain protective precautions against fire in the mounting of grid

resistors. When the car underframing is composed entirely or partly of wood an asbestos lumber covering of at least ¼ inch thickness should be used above the resistor assembly. This covering should extend a full eight inches beyond the edges of the resistor frames.

Cable should be bared of its insulation for a distance of at least 6 inches from the terminals of the grid resistor and should be supported in a manner to give a rigid construction to prevent vibration.

REVERSER:

Cable connection between the conduit and the lead bushing of the reverser should be made in the form of a "drip loop". (See figure No. 18).

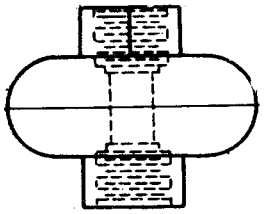


Fig. 22—Insulated Joints for Air Pipes and Control Conduits

All reversers require the use of one insulated joint in the air pipe leading to reverser. With 1200 volt equipments, however, double insulation is necessary and is provided for by an additional pipe insulator already installed in the air pipe inside of 1200 volt reversers. (See figure No. 22.)

The reverser should be installed so that there is no interference with the removal of covers by providing for the clearances specified on the reverser outline dimension drawing. The handle for the manual operation of the reverser should be easily accessible to the operator. Insulated bolts are used for supporting and at the same time insulating the reverser from its hangers.

CHANGEOVER SWITCH:

The changeover switch should be installed with the same provisions as for the reverser, the handle end being placed toward the outside of the car.

Changeover switches which are electro-pneumatically or simply pneumatically operated may be and usually are insulated from ground by means of insulated bolts. Where

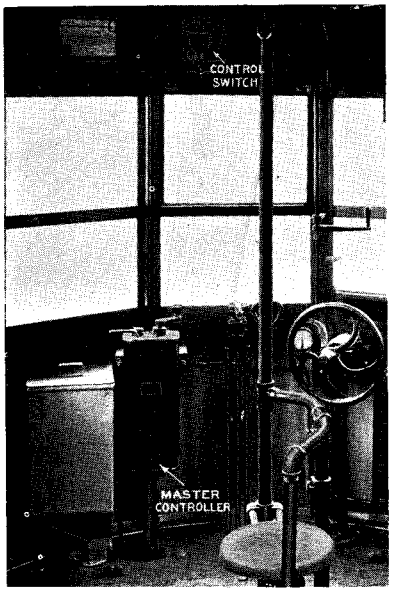


Fig. 23—The Master Controller and Control Switch Shown in this View Are the only Control Parts Located on the Platform. All of the Main Circuits and Circuit-Breaking Devices Are Beneath the Floor

hand operation of changeover switches is employed, the frame must be grounded. Therefore, no insulated bolts are supplied for mounting in this case.

CONTROL SWITCH:

The control switch is to be installed in a position near the master controller so that it will not be necessary for the operator to leave his station to reset or open the control circuit.

MASTER CONTROLLER:

The master controller should be installed with proper clearance for removing cover, and the swinging out of the arc deflector. There should also be sufficient clearance for the unhampered operation of the handles.

When the control circuit is grounded on the frame of the master controller, the frame should be grounded to the main ground wire.

The actual position of the controller will depend on the practice of the operating company. On subway, elevated and large inter-

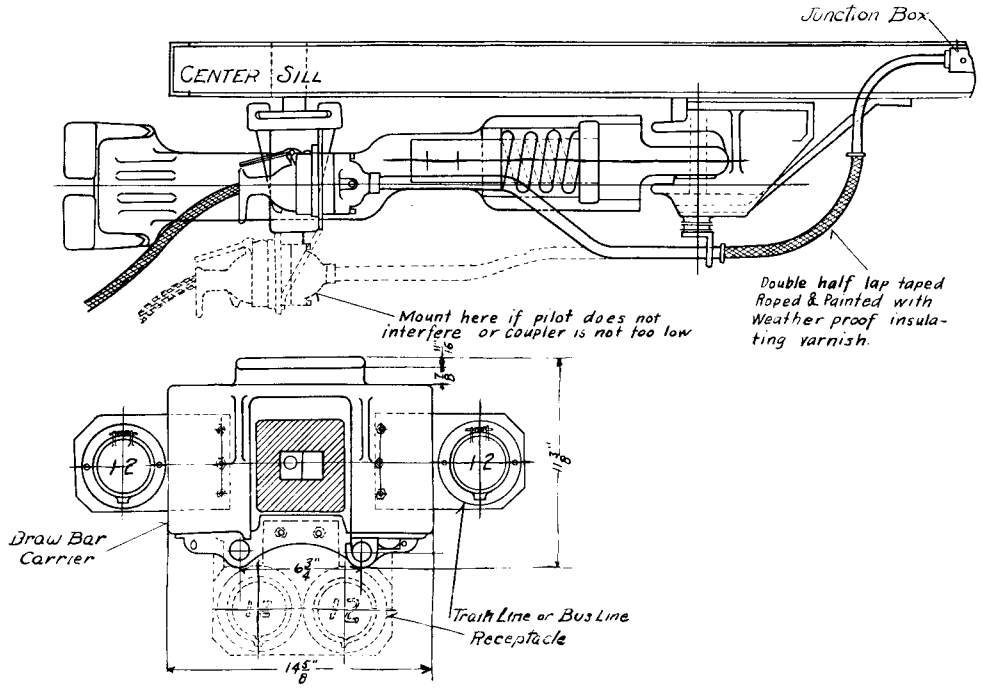


Fig. 24—Mounting of Receptacles on Draw-Bar

urban cars this position is usually on the right hand side of the platform. The mounting on city cars is usually to the left of the center, the brake valve occupying the central position. A typical installation is shown in figure No. 23.

JUNCTION BOXES:

The use of junction boxes whether for main or control circuits is to simplify the wiring and conduit system. They simplify the wiring by taking care of connections which would ordinarily require splicing or would otherwise have to be made within the apparatus.

Hence the position of the junction boxes under the car floor is determined by the location of the greatest number of branches to the train line cable. On 600 volt equipment employing control boxes and when train operation of the cars is required, two control junction boxes are furnished. In this case the terminal board in the control box forms a junction point. For most 1200 and 1500 volt equipment under the same conditions three boxes are used. One of these boxes is located approximately centrally, while the other two boxes are placed one at each end of car.

TRAIN LINE AND BUS LINE DETAILS:

Where no end doors are encountered, receptacles should be mounted on the dash-board, and when the number of train line wires is small enough to be enclosed in one receptacle head only one receptacle at each end of car is required.

In the case of cars having end doors, such as subway, elevated and some interurban cars, it is necessary to mount the receptacles on the dash board at the side of the door or on the bumper near the side of the car. This arrangement requires twice the number of receptacles as for dash board mounting on cars without end doors. It is necessary to do this to eliminate crossing of jumper cable from the side of one car to the opposite side of the car adjacent.

For draw-bar mounting of receptacles and jumpers two receptacles per car are required. When using this form of mounting the receptacle mounting or support on the draw-bar should be cushioned on account of the severe shocks and vibration to which the draw-bars are subject. One method for spring mounting receptacles on draw-bars is shown in figure No. 24. Receptacles for draw-bar mounting must be specially constructed to withstand this severe condition.

JUMPERS:

Jumpers are assembled with the cable attached to one head only. The other head is furnished with sufficient wax filler for assembly.

Cable connections—No cable connections should be made until all conduit has been installed and all cables have been drawn into the conduit. Considerable care should be used in soldering cables in the terminals to insure permanent connections, especially the control cables, as many of the troubles which are encountered after the equipment has entered service can be traced directly to poor

with several bends and a length of conduit run that would make it difficult to withdraw a defective single wire, it is considered good policy to pull in one or several extra wires. These wires may be dead ended inside of the apparatus and in the junction boxes.

The trolley or main power lead conduit should be located as near the main switch or

Motors are numbered 1, 2, 3 and 4, starting from one end of the car. Since it is difficult to determine which is No. 1 motor, for example, and which is No. 4, particularly on a double end car, the cutout switches are arranged to cutout motors in pairs, No. 1 and No. 4 (the two outside motors) or No. 2 and No. 3 (the two inside motors.) In case of damage to a motor, it is only necessary to determine whether it is an inside or an outside motor and open the corresponding switch.

With one pair of motors cut out of the circuit on four-motor equipments, using main circuit motor cutout switches, manipulation of the master controller gives series-parallel control of the remaining two motors. Series-parallel operation cannot be obtained with two-motor equipments nor with four-motor equipments using the control circuit type of cutout switch when one or a pair of motors is cutout. Normal operation of the master controller simply produces straight rheostatic acceleration.

If the unit switches fail to operate at any time, see that the fuse in the control and reset switch is in place. If it has blown, replace it. Before touching this fuse the trolley pole should be lowered, as this fuse is connected directly to the cable leading to the trolley. See that the control and reset switch makes contact, and that it shows a flash when opened with the controller on the first notch. Try the "reset"; if it does not show a flash when opened, try resetting by tripping the latch of the overload trip relay located on the end of the switch group or the line switch by hand.

If none of these tests show the cause of the trouble, remove master controller cover and observe whether the various fingers make contact on the drum segments, and that a flash occurs when controller is moved from the first notch to the "off" position.

are making contact with the plates against which they rest and that none of the small wires leading to them or to the magnet valves are broken or disconnected.

If, after making the above investigations, the trouble cannot be located the car should be reported as dead and removed to the car barn where a more thorough inspection can be made.

When leaving a car see that the control switch is in the "off" position and the main and reverse handles removed from the controllers.

EMERGENCY BRAKING:

In case of extreme emergency only, when the brakes have failed, a four motor equipment may be stopped by moving the reverse handle to the opposite running position and putting the main handle on the first notch. **After braking by this means has been set up the reverse handle must not be moved until the car has come to a dead stop.** The braking effect produced is very severe, cannot be regulated, and should only be used when every other means of stopping the car has failed. This method of retarding the motion of the car is known as dynamic braking.

A two motor equipment may be stopped under the same circumstances, by throwing the reverse handle to the opposite running position and then moving the main handle to any parallel notch. The reverse handle must not be moved again until the car has come to a dead stop.

Should the reverse handle be moved after the dynamic braking has once been set up, the heavy regenerated current will be broken at the reverser fingers and contacts resulting in excessive burning of these parts.

TRAIN OPERATION:

Where two or more cars are to be operated

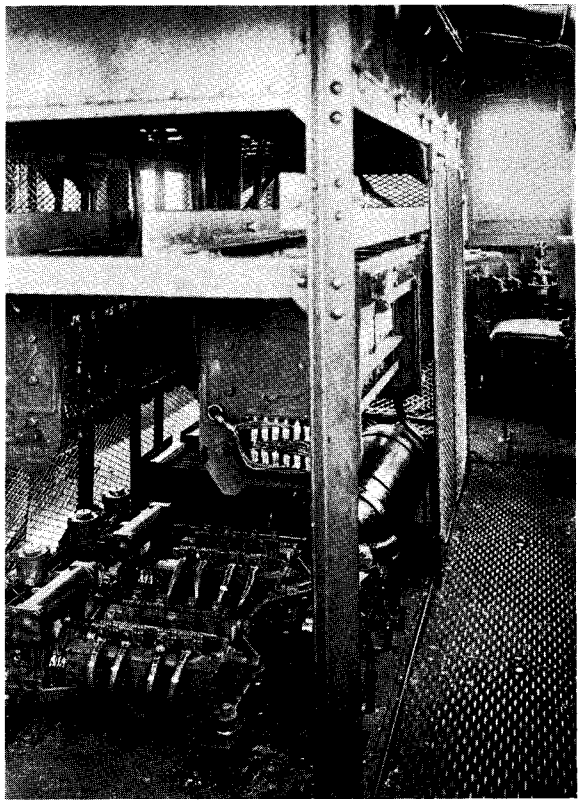


Fig. 32—HL Control Mounted in a Locomotive

and jumpers and should be handled in the same manner. Care should be taken **not to insert or withdraw them unless the trolleys on all cars are down or all bus line disconnecting switches are open.**

Only one pair of master controller handles should be in place on the train, and these should, of course, be on the master controller at the head of the train.

All control switches except the one at the operating master controller should be in the "off" position.

After the above precautions have been observed a train of two or more cars is then handled exactly as if it were a single car.

The operation of 1200 volt and 1500 volt equipments is essentially the same as that of the 600 volt equipments. They differ only in details of construction and in the arrangement of circuits.

LOCOMOTIVES:

Type HL control is used not only for the control of motor equipments on electric railway cars, but is extensively used where the heavy duty incident to electric locomotive service makes a reliable type of control necessary. The chief difference between car and locomotive equipments of HL control lies principally in method of mounting in that for cars the main parts are mounted underneath the car body, while for locomotives they are usually mounted on structural iron framing inside of the locomotive cab. The instructions herein apply equally to both locomotive equipments and car equipments.

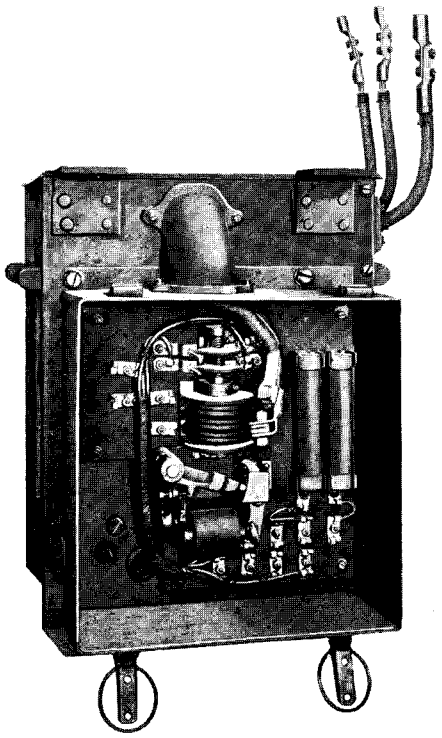


Fig. 37—End View of Line Switch

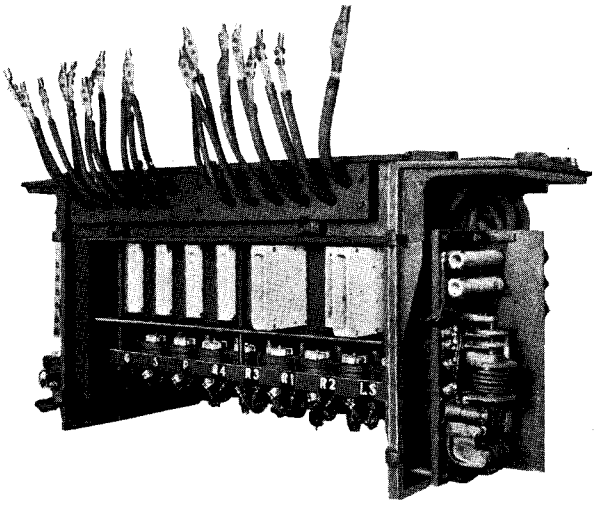


Fig. 38—Control Box With Covers Removed Showing Overload Trip Relay and Front Side of Switch Group

The frames of the control box or switch group, line switch, reverser, and grid resistors **should be tested for ground** by means of a bank of lamps connected to the trolley. If found to be grounded, the cause should be located and corrected.

The screws through the insulating base on which the reverser fingers are mounted should be tightened, if necessary, to take up any shrinkage that may have occurred during service.

All junction boxes and terminal boards should be examined for dirt or loose connections.

The master controller fingers should be examined for wear and, if necessary, adjusted to have a lift of $\frac{1}{16}$ inch, and to make good contact and then lubricated by wiping with a greasy cloth. Finger tension should be adjusted if necessary. (See figure No. 49)

The master controller drum and reverser drum should be examined to see if there is any cutting of the contact surface by the fingers. If cutting is found, the drum and fingers should be smoothed up with fine emery cloth.

The parts of the interlocking and star wheel mechanisms of the master controller should be examined to see that they work freely and are in good order. They should be oiled when necessary. The handles should fit their respective positions properly.

Train line receptacles should be examined to see that the hinge joints and springs are in good condition, so that the covers automatically close when the jumper is removed and thus protect the contacts from the weather. The split contacts should be examined and if compressed, should be adjusted to their original condition.

OVERHAULING:

About every eighth heavy inspection, or at least every three years, the apparatus should be given a complete overhauling. In addition to the work done at heavy inspection periods, this overhauling should consist in general of the following:

The switches and blowout coils of the control box or switch group and line switch should be removed, and all the cables and insulating material painted or shellaced according to the original finish.

The drums of the reverser, changeover switch and master controller should be removed to permit similar painting of the interior.

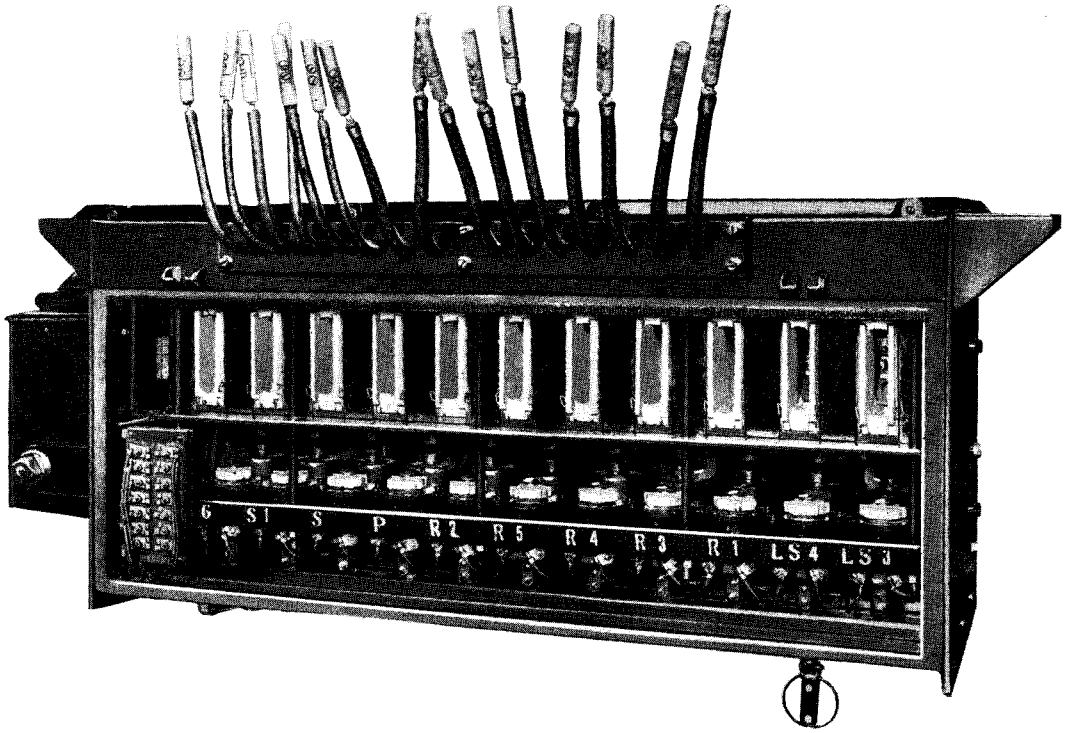


Fig. 38-A—Switch Group for 1200-Volt Service

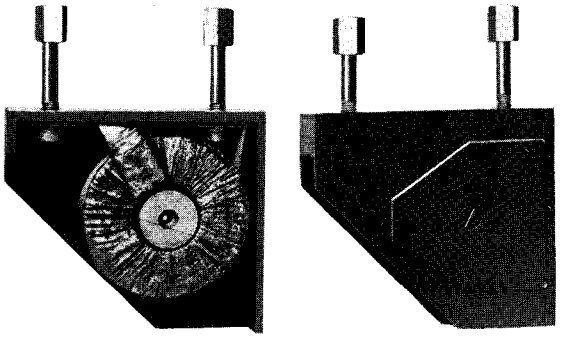


Fig. 39—Blowout Coil
Side of Box Cut Away Complete With Pole Piece

The cylinders of the control box, switch group, line switch, and reverser should be opened up, thoroughly cleaned and lubricated with HL oil.

The air gap and travel of the magnet valves should be checked and adjusted if necessary (see maintenance of valves, page 33.)

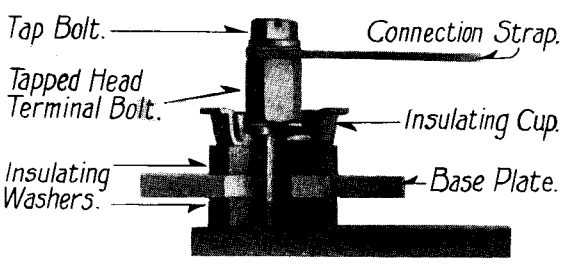


Fig. 40—600-Volt Terminal

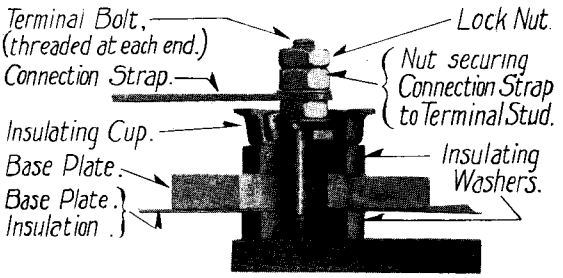


Fig. 41—1200-Volt Terminal

INSTRUCTIONS FOR ADJUSTING AND REMOVING WORKING PARTS OF APPARATUS

Many of the adjustments and operations described below should not be necessary except after years of normal service. Instructions covering them have been included, however, for the sake of completeness, as well as to show how readily emergency conditions may be handled.

SWITCH PARTS

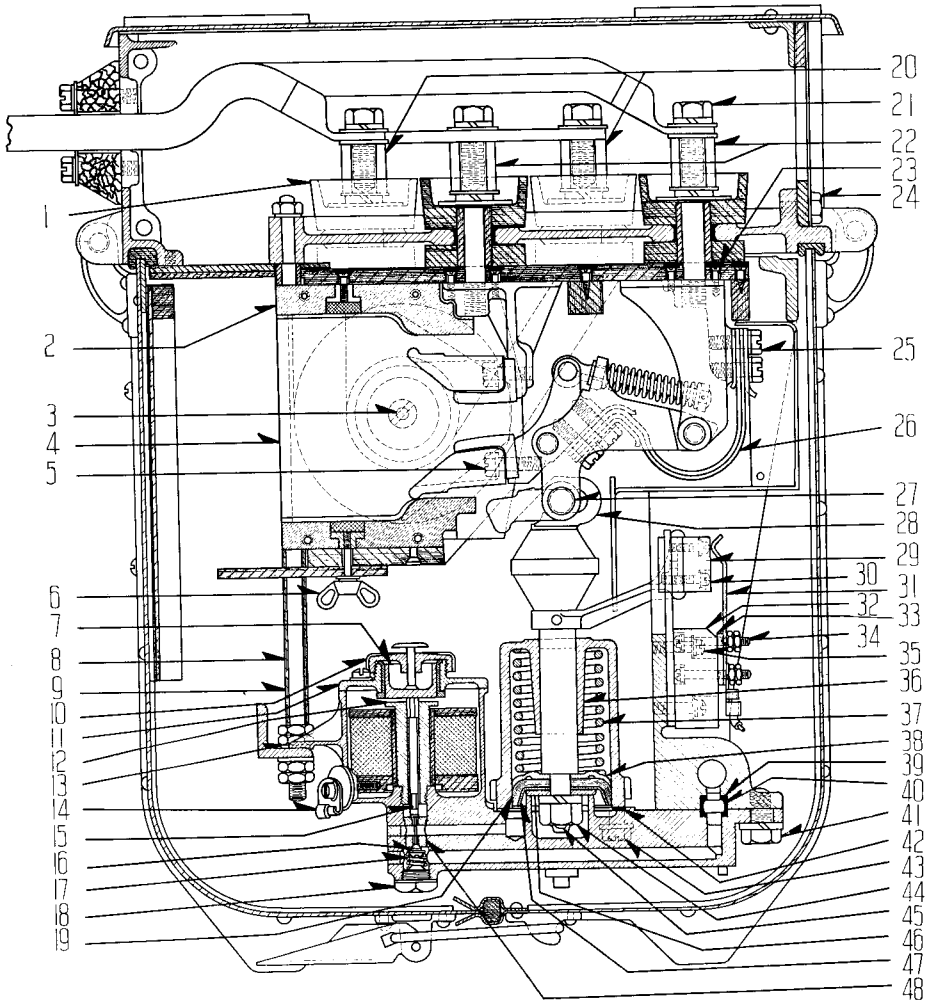


Fig. 42—Cross Section of HL Control Box Showing Parts

DETAIL LIST OF SWITCH PARTS SHOWN IN FIGURE NO. 42.

1. Insulating washers.
2. Arc chute.
3. Screw holding pole piece on blowout coil.
4. Arc chute side.
5. Bolts holding switch contacts.
6. Wing nut holding arc chute in place.
7. Armature of magnet valve.
8. Bolt holding angle iron which supports front end of valve magnet casting.
9. Insulating tube.
10. Magnet valve cap.
11. Iron cover of valve magnet.
12. Magnet valve core.
13. Foot supporting front end of magnet bracket.
14. Magnet coil terminal.

15. Upper valve stem.
16. Lower valve stem.
17. Valve spring.
18. Plug holding lower valve stem and spring in position.
19. Triple piston packing.
20. Tapped head terminal bolts supporting blowout coil.
21. Stud bolt attaching terminals or connection straps to terminal bolts.
22. Tapped head terminal bolts supporting switch.
23. Screws holding switch parts to switch box.
24. Screws holding cover.
25. Bolts holding copper braided shunt.
26. Copper braided shunt.
27. Pin on switch mechanism which engages in hook 28.
28. Hook end of air cylinder piston rod.
29. Interlock contact block.
30. Screw holding contact block.
31. Interlock finger.
32. Interlock finger base support.
33. Interlock finger base.
34. Bolts holding interlock fingers.
35. Screws holding interlock finger base.
36. Piston rod guide.
37. Cylinder spring.
38. Piston.
39. Gaskets for brass air connection bushing.
40. Brass air connection bushing.
41. Bolt supporting magnet valve bracket and cylinder.
42. Gasket for air cylinder.
43. Bolts holding cylinder in position.
44. Nut holding piston details in position.
45. Cotter pin to prevent loosening of nut 44.
46. Piston follower.
47. Expander.
48. Valve Bushing.

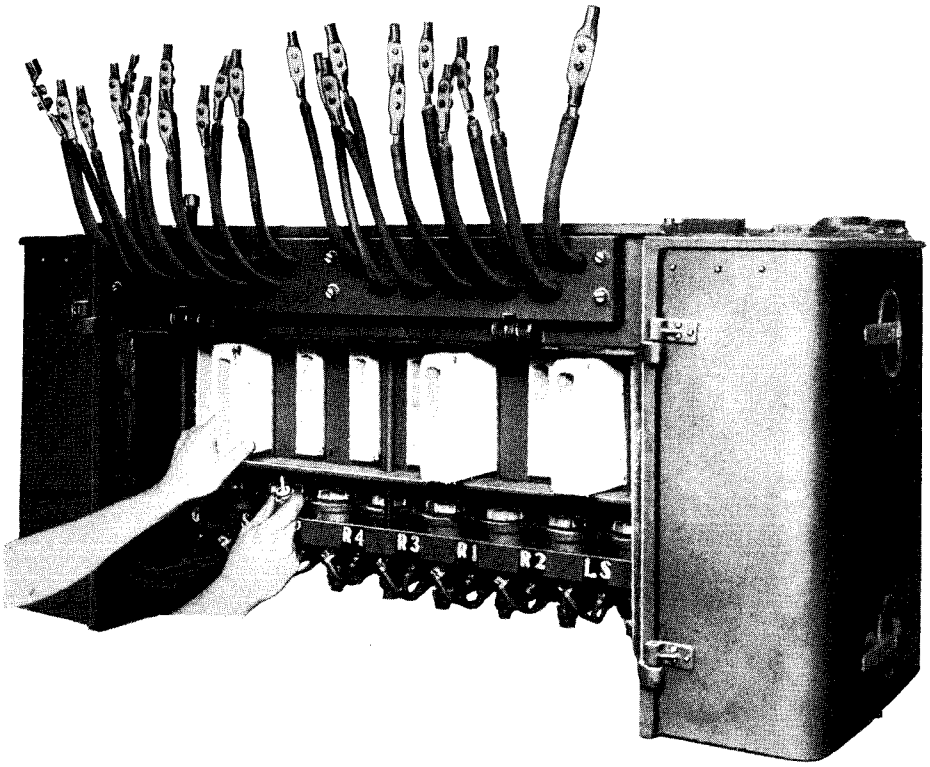


Fig. 43—Removing Arc Boxes

To remove the main covers of the control box, switch group or line switch, open the latches, swing the cover out seven or eight inches at the bottom and lift upward. Each half cover can be removed in this way and laid aside.

To remove an arc box (See Figure No. 43) for replacement or repairs, remove the thumb screw, No. 6 (Shown in Figure No. 42), when the complete arc box can be readily withdrawn.

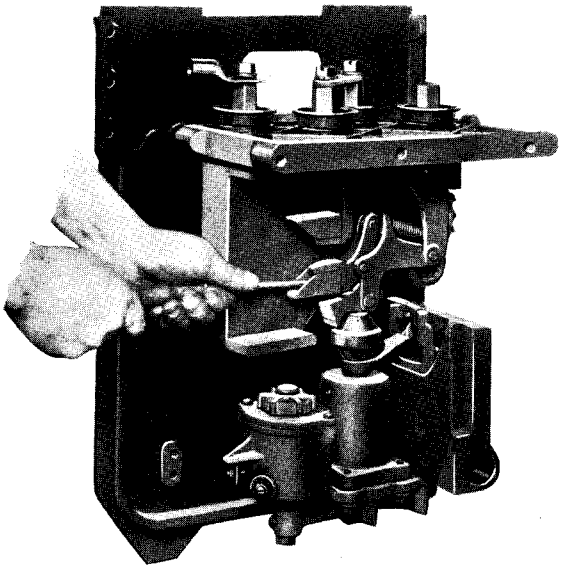


Fig. 44—Removing Contact Tips

To remove contact tips or arc horns remove the tap bolts, No. 5. (See Figure No. 44.) When renewing contact tips, it is best to install both new top and new bottom tips at the same time. If one is not completely worn out, it may be reshaped by filing at a work bench and used again with another partially worn tip.

In putting on contact tips or arc horns be sure that the lock washer has not lost its temper, and give the bolts the final turn with the switch closed. **Be sure that the bolts are tight.**

To remove the switch shunt, No. 26, take out the bolts, No. 25.

To remove a complete switch, first remove the top and side covers of the terminal compartment. Next remove the tap bolts, No. 21, removing the terminals or connection straps attached to the two bolts, No. 22. Next take out the latter two bolts, No. 22. (See Figure No. 35.) Take out the wing nut, No. 6, and the switch box complete can then be pulled out.

To remove switch parts from box, remove the screws, No. 23, after first scraping away the cement which covers them. In replacing these screws to be sure to cover them again, using No. 5 cement powder mixed to a paste with shellac.

BLOWOUT COIL PARTS:

To remove a blowout coil, remove the tap bolts, No. 21 and the two terminal bolts, No. 20, exactly as when taking out a switch. The coil complete in its box can then be taken out. (See Figure No. 39.)

To remove a blowout coil from its box, take out the screws holding the terminals to the top of the box, as in the case of a switch. Next remove the screws, No. 3, on each side and take off the pole pieces and push out the core. The coil can then be slipped out of the box. Be sure to cover the screws in the top of the box after replacing them as directed in the case of a switch.

CYLINDER AND MAGNET BRACKET PARTS:

To remove a cylinder and magnet bracket complete, first disconnect the valve magnet terminals, No. 14. If the unit to be removed carries an interlock, the interlock screws, No. 35, should also be removed and the finger base laid back out of the way.

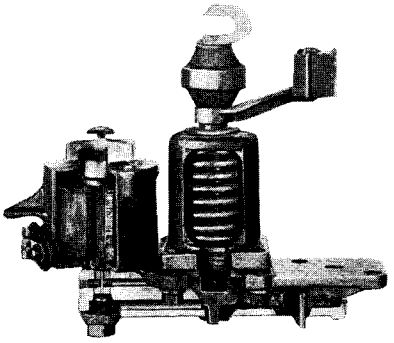


Fig. 45—Cylinder and Magnet Valve Unit Cut to Show Interior Details

Next take out the two bolts No. 41, by means of the special screw driver (See figure No. 68), supplied for that purpose. Then loosen the nuts on the angle iron support on which the point, No. 13, rests and move the angle iron out slightly. Next raise the point, No. 13, so as to disengage the hook, No. 28, from the pin, No. 27. The cylinder and magnet valve complete can then be lifted out, (Figure No. 46.)

Care must be taken not to lose the brass air connection bushing, No. 40, with its gaskets, No. 39, in removing the magnet bracket. When replacing the bracket, new gaskets, No. 39, should be used.

To remove a cylinder, first remove the magnet bracket and cylinder together and then remove the four bolts, No. 43. These should be slacked off in rotation, a few turns at a time, in order to avoid undue strain on any one.

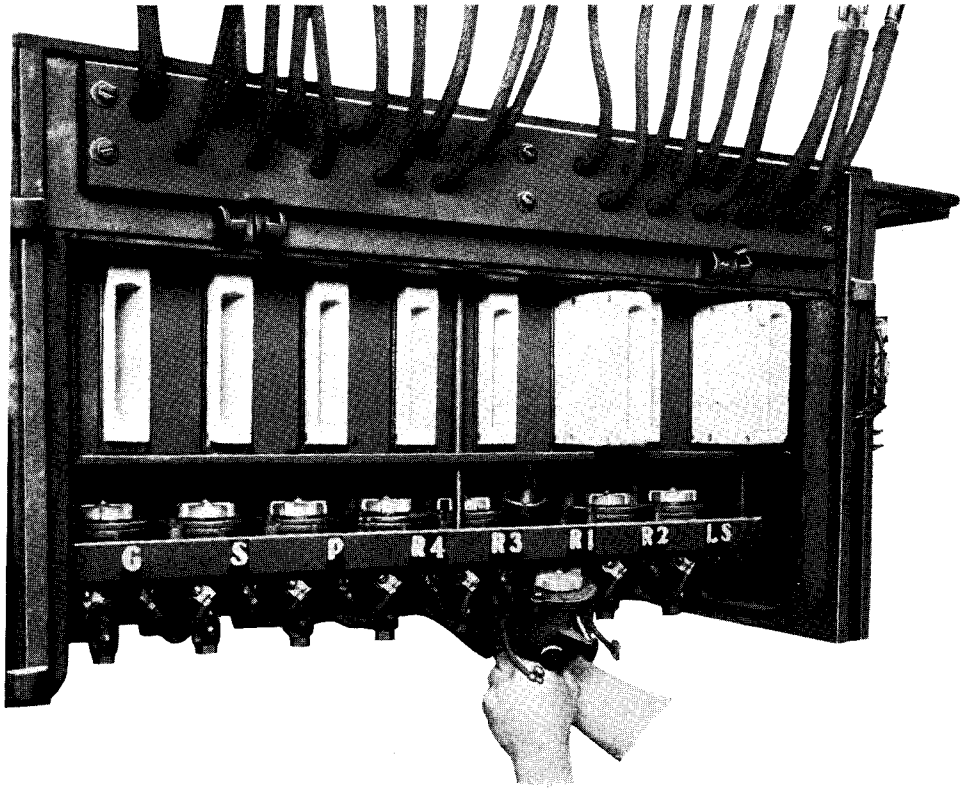


Fig. 46—Taking Out a Cylinder and Magnet Valve

In re-assembling a cylinder, be sure the paper gasket, No. 42, is in good condition. These gaskets are made from oil treated paper.

To remove the packing leather or piston details after a cylinder has been removed, clamp the hook, No. 28, in a vise, and remove the cotter pin, No. 45, and nut, No. 44, When this has been done, the piston follower, No. 46, expander, No. 47, triple packing, No. 19, and piston, No. 38, can then be lifted off the piston rod. Care must be taken not to separate the three pieces which form the triple packing, No. 19.

When a cylinder has been opened and is to be put together again, the inside walls should be wiped clean as well as the spring and all details. **A small amount** of HL oil should then be rubbed lightly with the finger on the part of the cylinder walls over which the packing travels, and also on the edges of the packing which rub against the cylinder. Care should be taken to see that the packing leather fits tightly on the piston rod. The piston rod guide, No. 36, should be lubricated by a few drops of oil.

To remove a magnet coil, first remove the iron magnet cover, No. 11, and the terminal screws, No. 14. Then unscrew the magnet core, by means of the special wrench (see Figure No. 68), furnished for this purpose. The coil can then be taken out.

To remove an upper valve stem, remove the magnet cap, No. 10, and armature, No. 7, when the valve stem, No. 15, can be removed.

To remove the lower valve stem and spring, (which should not be attempted with air on the apparatus) remove the plug, No. 18. The valve spring, No. 17, and lower valve stem, No. 16, will then drop out. When replacing the plug, No. 18, first remove the cap, No. 10, so that in case the valve stem, No. 16, does not properly enter the hole in the stem, No. 15, it is free to be lifted by the advancing stem, No. 16, instead of being damaged.

MAINTENANCE OF VALVES

A complete set of tools for maintenance of magnet valves is shown in figure No. 70. These tools should be used in adjusting new valves or in replacing leaky ones. Whenever,

for any reason, changes are made in a valve or valve seat, the travel and air gap should be checked as described on pages 35 and 36 and adjusted if necessary.

To repair a valve seat in a bushing, No. 48, which leaks due to excessive wear and which cannot be ground tight, the seat should first be re-shaped with the set, and then cut to shape with the scraper provided for that purpose (See figure No. 70). The use of these tools is illustrated in figures 73 and 74. When setting the lower valve seat, it is necessary to have a guide for the tools. This is easily obtained by drilling a clearance hole in a spare lower valve plug, as indicated in figures No. 73 and No. 74.

Replacement of a magnet valve bushing, No. 48, is seldom necessary, since the wear on the lower valve seat is taken care of by the valve spring, and that on the upper valve seat by the use of a new and slightly longer upper valve stem. When a new bushing is required, however, first dismantle the valve by removing the cover, No. 10, armature, No. 7, upper valve stem, No. 15, core, No. 12, the coil, lower valve plug, No. 18, spring, No. 17 and valve stem, No. 16. Then drive the valve bushing, No. 48, up through the magnet case, taking care not to injure the threads for the magnet core. Also remove the small brass plug opposite the port to the cylinder (this is the upper port) by filing off its riveted end and driving it into the cavity left by removing the valve bushing.

Drive in a new valve bushing, which is drilled only with a small starting drill hole through its length, until the flange on the upper end seats on the casting. Drill a ¼" horizontal hole through the valve bushing, using the hole in the casting from which the small brass plug was removed, as a guide. Return the magnet core, and using the hole in the core as a guide, first drill a hole through the entire length of the valve bushing the size of the lower or inlet port, and then drill out the larger upper or exhaust port as far as the horizontal hole through the bushing.

The following table indicates the **port sizes for standard equipments.** For special equipment refer to the manufacturer.

Type Switch Unit	Type Equipment	U. S. Twist Drill Gauge Inlet	Exhaust
267	Hand control	No. 37 (".104)	No. 6 (".204)
264, 265, 272, 275	Hand control	No. 37 (".104)	No. 30 (".129)
806, 480	Automatic control	No. 46 (".081)	No. 30 (".129)

Seal the hole in the side of the casting with a new plug of ¼" over size brass rod, riveting over and making air tight.

There are some valve magnets which have the bushings driven in from the bottom. When removing such a bushing, it must be driven out from the top with a special hardened drift.

Before grinding in new valve stems, they should be trimmed sparingly with the scrapers provided for that purpose as shown in figures Nos. 71 and 72. These tools should also be used for re-seating worn valves before re-grinding.

It is necessary to grind the valve stem into the seat for an air tight fit after the valve seats and stems have been scraped, either for slightly worn or new bushings, and stems.

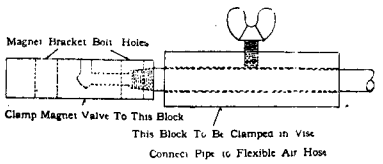


Fig. 47—Jig for Holding Valve Bracket

The most satisfactory results are obtained when a block for holding the valve magnet is used as shown in figure No. 47 and No. 47-A. With this arrangement both valve seats can be ground from above by turning the valve magnet upside down. It is also possible to test the condition of the valve seat with the air on. When using this device, the air passage to the cylinder should be plugged with a piece of cloth, and fibre plug.

Make a paste of finely-ground pumice and machine oil and place a little of this on the conical seat of the valve to be ground in. If pumice is not available, soapine or Bon Ami may be used. Put the valve stem in place as shown in figure No. 75, and spin back and forth with the device shown in figure No. 47-A, or with a screw driver, until the seat is tight. When grinding the lower valve always see that the upper valve is in place to serve as a guide.

After a good seat has been obtained, the stem should be wiped clean and any grinding deposit on the seat should be washed out by pouring in a little gasoline.

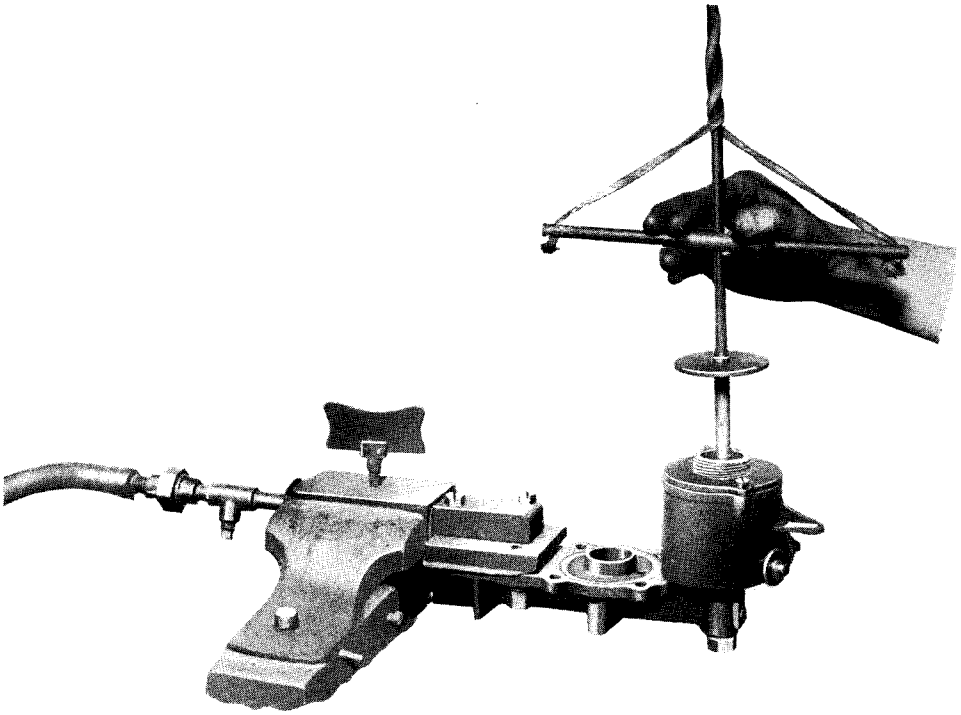


Fig. 47-A—Whirligig for Grinding Valves

After grinding in the valve stem and valve seat, or in making any change in the valve parts, the travel and air gap should be checked as described below, and adjusted if necessary.

To determine whether or not the valves have been properly "ground in", wipe the valve stems and seats clean and dry, then assemble in position, and by use of a screw driver roll them back and forth until when removing the valve stems a clean, shiny ring is formed completely around the stem. If there is any break in the bright circle there will be a leak in the valve.

To check or adjust the valve travel use the gauge shown in figure No. 76. The regular cap should be removed and the gauge screwed on in its place. Screw down the thumb screw until it touches the armature. Note the position of the pointer. Then screw down until the upper valve is tight (valve does not blow). The thumb screw should have made one complete revolution, giving a travel of $\frac{1}{32}$", since the thumb screw has 32 threads to the inch.

If the travel is excessive (more than one turn on gauge screw) trim the end of the lower valve stem. If the travel is insufficient, stretch the lower valve stem be peening or replace with a new valve stem. The lower valve should be adjusted or replaced when the travel reaches a minimum of ".024 or $\frac{3}{4}$ one turn of the gauge.

After adjusting the valve travel, it is necessary to **check or adjust the final air gap.** An excessive gap increases the voltage necessary to operate the valve, while an insufficient gap is apt to result in "sticking in" of the armature, due to residual magnetism, when the valve magnet is de-energized.

Standard valve magnets designed for line control or for 32 volt battery operation are supplied with a **long valve stem** to give a final air gap of ".052 to ".056 when the valve is energized. The final gap must not be allowed to wear down to less than ".032. For application on lower voltages, special valve magnets are supplied with a **short valve stem** to give a final gap of ".026 to ".030. The final gap must not be allowed to wear down to less than ".020.

To check the final air gap for the long valve stem, use the ".032 condemning gauge, style No. 224901. When using this gauge, remove the cap and armature and place the gauge with the slot over the end of the upper valve stem, as shown in figure No. 77, and press down. If the upper valve blows and the switch does not close, the upper valve stem is too short and should either be peened out or a new stem inserted.

To check the final air gap for a short valve stem, use the ".020 condemning gauge, style No. 224902 (See figure No. 78). If the upper valve blows and the switch does not close, the upper valve stem is too short and should either be peened out or a new stem inserted.

To adjust the initial air gap for long valve stem, use gap gauge Style No. 223677. First insert the gauge with the ".052 slot over the end of the upper valve stem and press down (see figure No. 77.) The switch should close and the valve should be tight, showing that the final gap is more than ".052, With the ".088 slot over the valve stem, the lower valve should not blow, showing that with ".032 travel, the final gap is not more than ".004 above ".052.

If the gap is too long, trim the end of the upper valve **flat,** with a smooth file. In order to file the top perfectly flat, it is well to use a jig similar to that shown in figure No. 48. Be careful not to cut too much off at one time before trying the gauge, as a stem which is too short must be peened out or thrown away.

To adjust the initial air gap for a short valve stem, use gap gauge Style No. 223678. First insert the gauge with the .026 inch slot over the end of the upper valve stem and press down (see figure 78.) The switch should close and the valve should be tight, showing that the final gap is more than ".026. With the ".062 slot over the valve stem, the lower valve should not blow, showing that with ".032 travel, the final gap is not more than ".004 above ".026. If the gap is too long, trim the end of the upper valve **flat,** with a smooth file as described above.

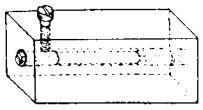


Fig. 48—Jig

INTERLOCKS

To remove an interlock complete, take out the two screws, No. 35, which hold the stationary part, and then the two screws, No. 30, which hold the moving part. If it is desired to remove fingers only, this can be done by removing the nuts No. 34.

The proper tension on interlock fingers is from 3 to 5 pounds per finger where steel fingers are used, and from 2 to 3 pounds when the material is phosphor bronze. The pressure is easily checked by means of a small spring balance and a wire stirrup as shown in figure No. 49.

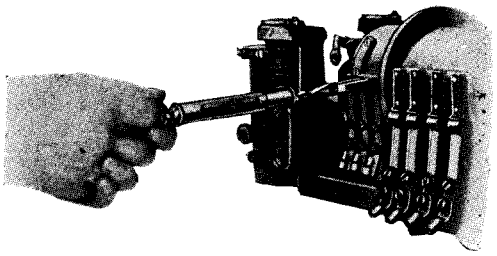


Fig. 49—Checking Control Finger Pressure

In testing interlock fingers to determine their tension, do not lift the fingers more than $\frac{1}{32}$ inch from the contact plate, otherwise they may take a permanent set.

To change the tension on an interlock finger, remove it from its base and bend it just above the point where it is fastened. Then replace. Do not try to bend it without removing.

The fingers should be adjusted to make contact over their whole width, otherwise cutting of the contacts will result (see figure No. 50).

OVERLOAD TRIP RELAY

The overload trip relay (371 type—see figure No. 51) **is calibrated** for four different currents. Each calibration is indicated by a notch on the calibration plate, No. 18, with the value of current corresponding stamped thereon.

The overload trip relay is set for a given current when the line corresponding to that current is directly opposite the pointer, No. 17, of the armature, No. 15. As shown in the figure, the relay is set to trip at 400 amperes. By moving the armature so that the pointer comes between two lines, approximate intermediate settings may be obtained. For example, if the pointer is opposite a point half way between the 300 and 400 marks, the setting will be approximately 350 amperes.

To adjust the overload trip relay for different settings, (see figure No. 52), loosen the lock nut, No. 7, and move the adjusting screw, No. 6, till the desired setting is obtained. This changes the position of the armature, No. 15,

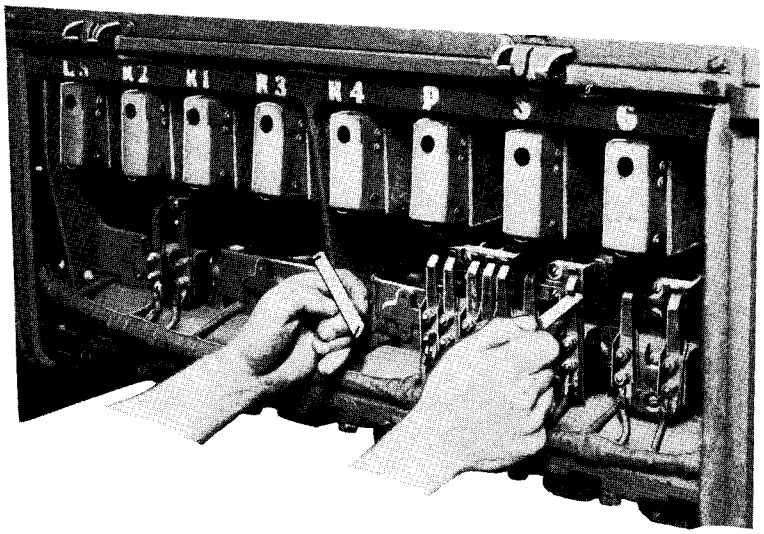


Fig. 50—Adjusting Interlock Fingers

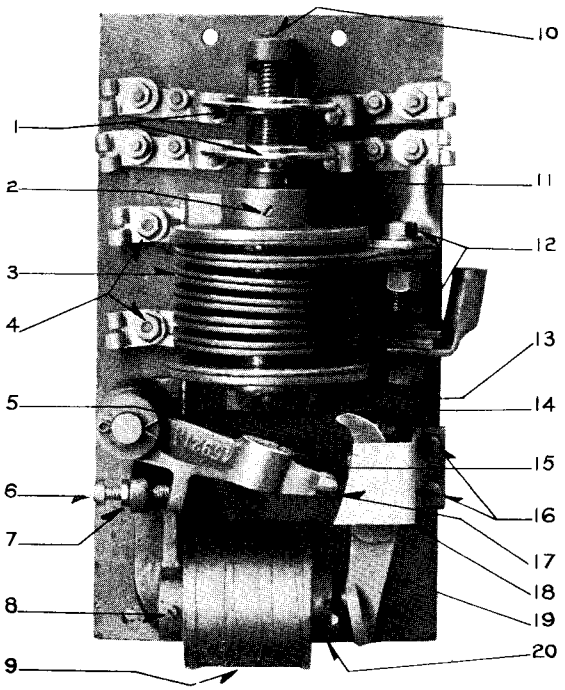


Fig. 51—Type 371 Overload Trip Relay

with reference to the core, No. 5, on which the trip coil, No. 3, is mounted (see figure No. 52.) When the desired setting has been obtained, care should be taken to again tighten the lock nut, No. 7.

To remove the reset coil, No. 9, first remove the calibration plate, No. 18, by removing the screws, No. 16, the pawl, No. 19, by taking out the cotter pin which will be found under the calibration plate. Next loosen the set screw, No. 8, and unscrew the core, No. 20, removing it from the frame. The reset coil leads should be removed at the terminal studs, No. 4. The reset coil may then be slipped off of the core.

To remove the main plunger, No. 10, and discs, No. 1, take out the cotter pin, No. 11. The main plunger can then be slipped up through the core, No. 5, clear of the frame. The discs, No. 1, can then be lifted from the plunger rod.

To remove the trip coil, No. 3, first remove the bolts, No. 12. The main plunger rod should be removed as described in the preceding paragraph. Remove the screws, No. 14, and the magnet core bearing, No. 13. Loosen the set screw, No. 2, and unscrew the core, No. 5. The trip coil is then easily removed.

OVERLOAD TRIP RELAY

This overload trip relay (392 Type—See Figure No. 53) **is calibrated** for three different currents. Each calibration is indicated by a line marked across the stem A, with the current values corresponding stamped on the surface of the stem.

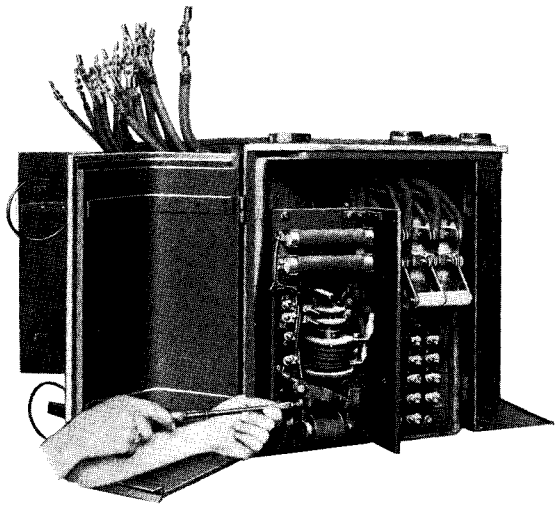


Fig. 52—Adjusting Type 371 Overload Relay

The overload trip relay is set for a given current value when the corresponding line on the stem is flush with the outside of the cover B. As shown in figure No. 53 the relay is set to trip at 600 amperes. By placing the stem so that the edge of the cover comes between two lines, approximate intermediate settings may be obtained. For instance, if the edge of the cover is half way between the 600 and the 800 marks, the setting will be approximately 700 amperes.

To adjust the overload trip relay for different settings (figure No. 54) remove the two bolts C, and the main cover, D. Then take out the four screws, E, remove the cover, B, and turn the stem, A, to the right or left a quarter of a turn at a time until the desired setting is obtained. This changes the position of the plunger, F, with reference to the blowout coil at the end of the switch group, or line switch, into which it projects, without moving the spring rest, G, or changing in any way the tension of the spring, B.

When the desired setting has been obtained, and the cover, B, and screws, E, restored to place, the action of the trip should be tried by pressing in the stem, A, until the plunger, I, engages with the shoulder, J. The trip should then be reset, by pulling on the wire, K. If the trip operates in this way, the stem, A, should again be pressed in and reset this time by the reset circuit from the control switch.

To remove the overload trip relay complete after the main cover, D, has been removed, take out the two bolts, L.

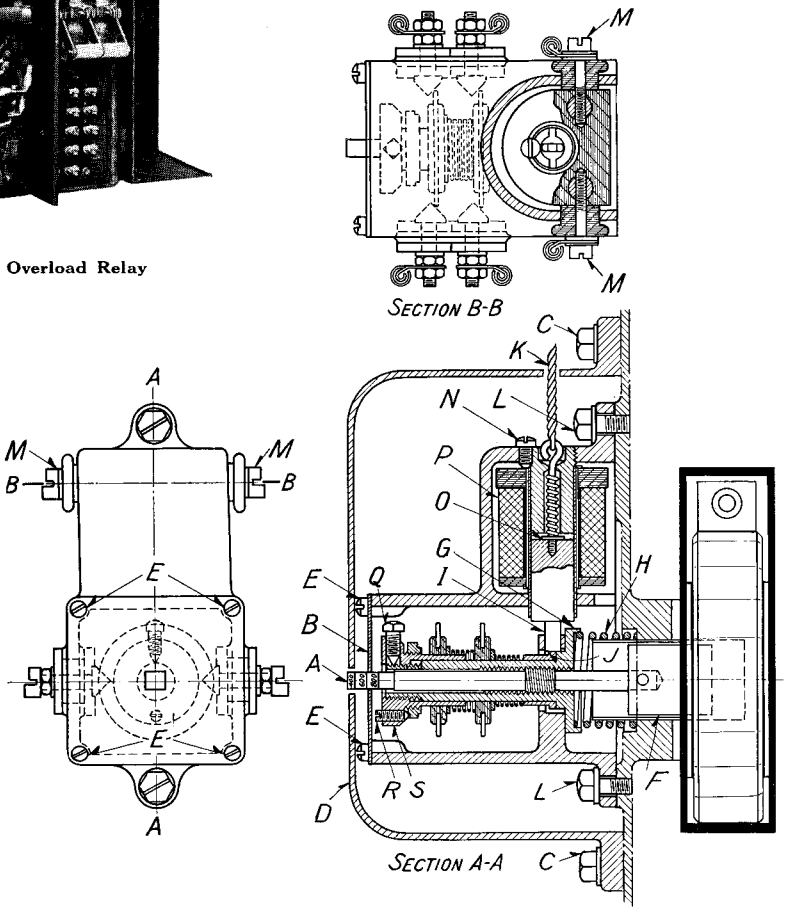


Fig. 53—Type 392 Overload Trip Relay

To remove the reset coil, should this ever become necessary, first remove the relay complete. Next take out the two terminal screws, M, and the set screw, N. The complete plunger, O, can then be unscrewed, after which the reset coil, P, may be lifted out.

To detach the main plunger and discs, whenever desired, loosen the set screw, Q, after the relay as a whole has been removed, and unscrew the nut, S. The discs may then be taken out from the front, and the plunger from the back. It is not necessary to touch the set screw, R.

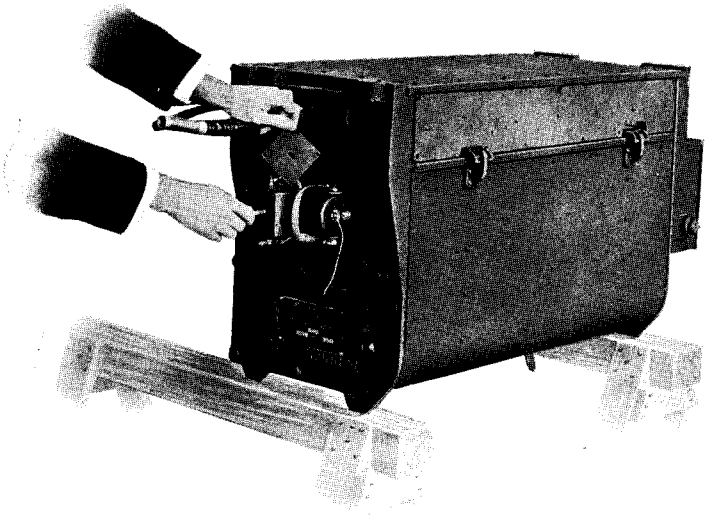


Fig. 54—Adjusting Type 392 Overload Trip

REVERSER

Figure No. 6 is a general view of a reverser arranged for separate mounting, while figure No. 55 shows a reverser mounted directly on the end plate of the control box.

A cross-section view of the type 279-C-4 reverser, which is representative of all types, is shown in figure No. 56. The magnet valves and cylinder details are very similar to those of the switch units previously described, and the same instructions regarding removal and replacement of parts apply.

If it is necessary to remove the main drum, the main and control finger-base supports should be loosened, rather than each individual finger. After removing the upper and lower bearing brackets, the drum and shaft complete can be removed.

It is very important that the main and interlock contacts be lined up carefully to insure an overlap between the main and control contacts. This precaution prevents the opening of the main circuit at the reverser with the line switches closed.

The main drum should be examined to see that each finger makes contact over its entire width in all positions of the drum segment which it engages. The drum segments should be turned true and the contact surfaces be in a straight line, parallel to the axis of the drum. The portion of the finger which makes contact with the drum should be true so that when pressed against a flat surface it makes contact throughout its entire width. Adjustment of each finger may then be easily made by using a wrench where necessary to bend the finger spring to insure proper alignment.

After adjustment, spread grease on the drum segment and move the drum back and forth to thoroughly lubricate contact surfaces several times.

Reversers in service should be lubricated in the foregoing manner after the fingers and contacts have been freed from burns and blisters and the contact tension has been properly adjusted. Afterwards, wipe around the fingers and around the edges of the segments with a cloth to remove any surplus grease. Waste should not be used for this purpose.

The reverser interlock contacts should be lubricated by wiping with a piece of cheese cloth, moistened with any light oil.

Each main finger should be adjusted so that it drops from $\frac{1}{16}$" to $\frac{1}{8}$" below the surface of the drum segment when it is in the open or "off" position. If the finger drops too far there is danger that the drum segment will jam the finger. If the finger is not adjusted far enough below the surface of the drum segment

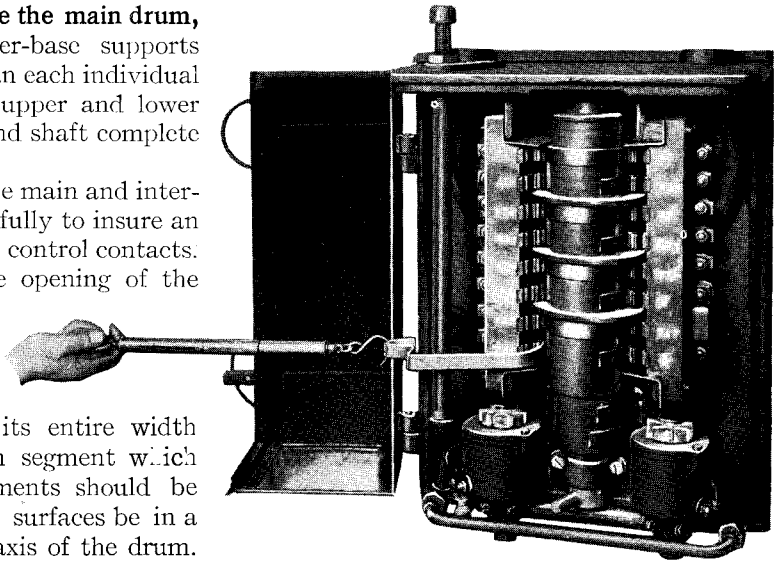


Fig. 55—Reverser Mounted on Control Box End-Plate

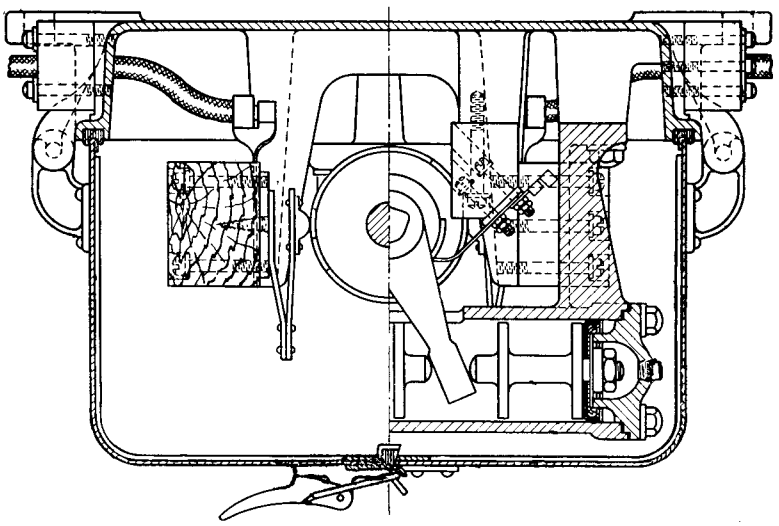


Fig. 56—Cross Section of Reverser

there will not be sufficient pressure between the contacts to carry the current, and overheating and welding of contacts may result.

In adjusting the finger for lift, care should be taken to see that the adjusting screw does not interfere with the movement of the finger. In some types of fingers this adjusting screw passes through a slot in the stop plate and unless the finger is central the screw will bend on the sides of this slot. See that the lock nut on every finger is tight after adjustment is made. The adjusting screws provided on Standard Westinghouse control fingers are for the purpose of adjusting the lift or movement of the fingers and do not in any way affect the spring pressure.

The main finger contact pressure should be adjusted to conform to the following table, measured normal to and at the point of contact with the drum.

Finger Width	Normal Capacity of Finger	Pressure
One inch	100 amperes	6 to 8 pounds
Three-fourths inch	75 amperes	5 to 6 pounds
One half inch	50 amperes	3 to 4 pounds
One-fourth inch	25 amperes	2 to 2½ pounds

The pressure can be measured with a small spring balance as shown in figure No. 55. If the pressure is not sufficient, remove the finger and bend the flat spring towards a straight position. A good rule to follow is to straighten this spring so that the holding screws for the contact finger can just be entered in the finger base with the finger in place. When the holding screw is tightened the finger spring will be under tension and give approximately the maximum pressure which it is capable of exerting.

When the drum is in the "off" position, the spring should have sufficient tension to cause the finger to exert a positive pressure against the stop. Do not raise the finger much above the drum surface in testing for pressure as this may cause the spring to take permanent set.

After replacing the finger, adjust for alignment as directed above.

Tension on interlock fingers is measured in the same manner as that of main fingers. (See figure No. 49.)

In testing interlock fingers to determine their tension, do not lift the fingers more than $\frac{1}{32}$ inch from the contact plate, otherwise they may take a permanent set.

The proper tension for interlock fingers is from 3 to 5 pounds per finger where steel fingers are used, and from 2 to 3 pounds for phosphor bronze fingers.

To change the tension on an interlock finger, remove it from its base and bend it just beyond the point where it meets the base. Do not try to bend interlock fingers without removing them.

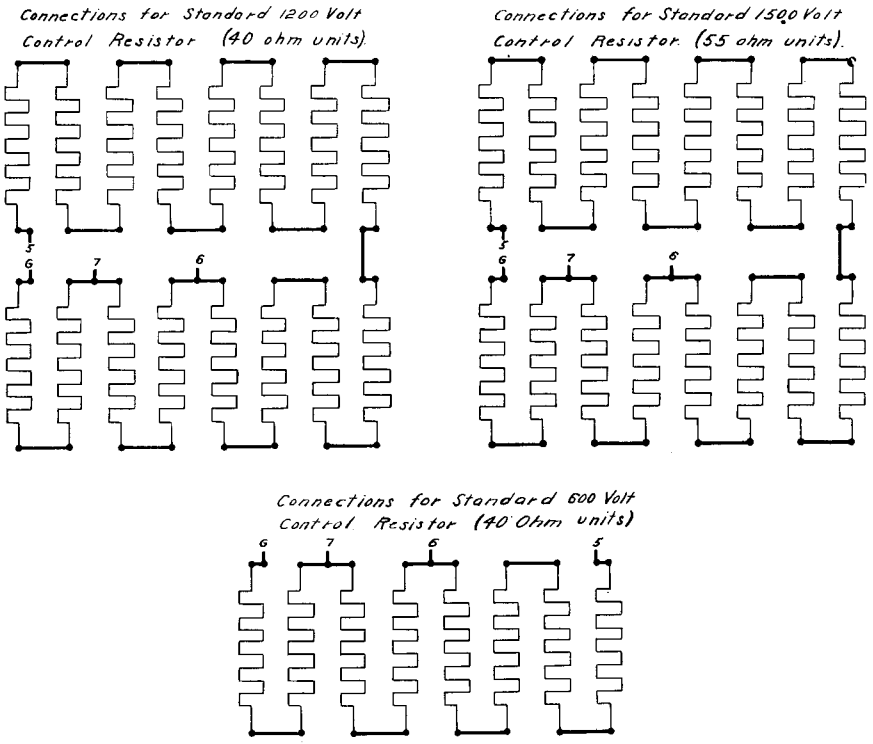


Fig. 57—Terminal Board Connections for 600, 1200 and 1500-Volt Control Resistors

CONTROL RESISTOR

To replace an individual resistor unit, remove the cover, disconnect at the terminals, and remove the terminal board and the screw at the back of the resistor which holds the unit in place. The unit may then be withdrawn and a new one substituted.

Figure No. 57 shows the terminal board connections for standard 600 volt, 1200 volt and 1500 volt resistors.

ASSEMBLY OF TRAIN LINE JUMPERS

Train line jumpers are usually supplied with one head unattached as previously mentioned, so that they may be adjusted to the correct length to suit each individual application.

After the proper length of cable has been determined **the unattached head should be prepared to receive the cable,** (see figure No. 58). Remove the four cap screws, B, first noting the position of the terminals with respect to the lug, L.

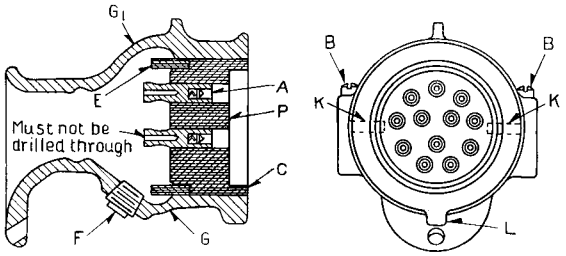


Fig. 58

Remove the main castings, G and G-1, and the short fish-paper cells, E.

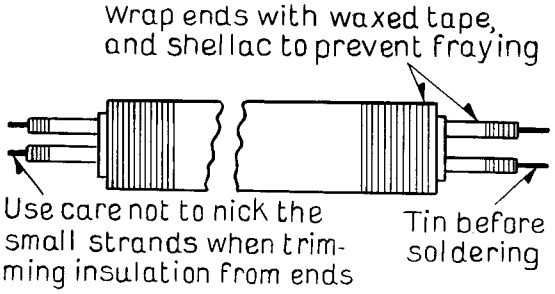


Fig. 59

Prepare the cable as shown in figure No. 59. Put the wood block, P, in a vise between strips of leather or soft metal and support the cable as shown in figure No. 60. This takes the weight from the leads and allows free entry of the solder into the terminal holes.

Use the wiring diagram supplied with the equipment as the guide in making these connections. Solder the individual leads to the terminals with a blunt soldering iron. Care is required in order not to char the wood block, fish-paper cells or cable insulation.

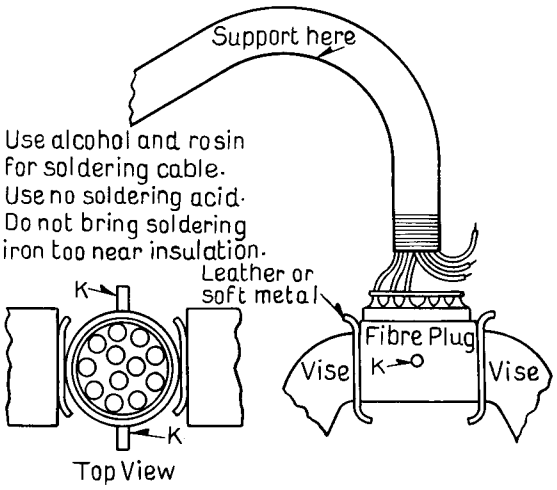


Fig. 60

Replace the fish-paper cells, E, staggering the joints, and secure them with shellac. Remove all excess solder and dirt from the bushing. This may be best accomplished by cleaning the whole bushing with alcohol or gasoline.

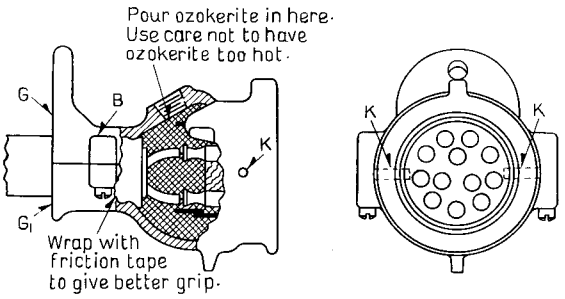


Fig. 61

Complete the assembly, putting the upper casting, G, in the vise; figure No. 61). After assembling tilt the casting and completely fill the space surrounding the terminals and leads with the sealing compound supplied with the jumpers.

INSTRUCTIONS FOR ASSEMBLING BUS LINE JUMPERS

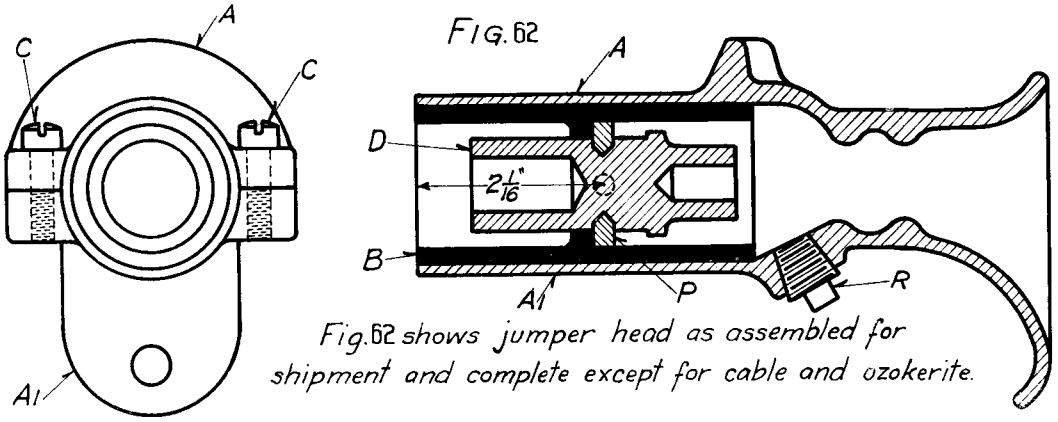


Fig. 62 shows jumper head as assembled for shipment and complete except for cable and ozokerite.

1 Remove cap screws C and main castings A & A1 and take out cable terminal D complete with its two guide pins P.

2 Prepare cable as shown in Fig. 63.

3 Solder cable to terminal D as shown in Fig. 64.

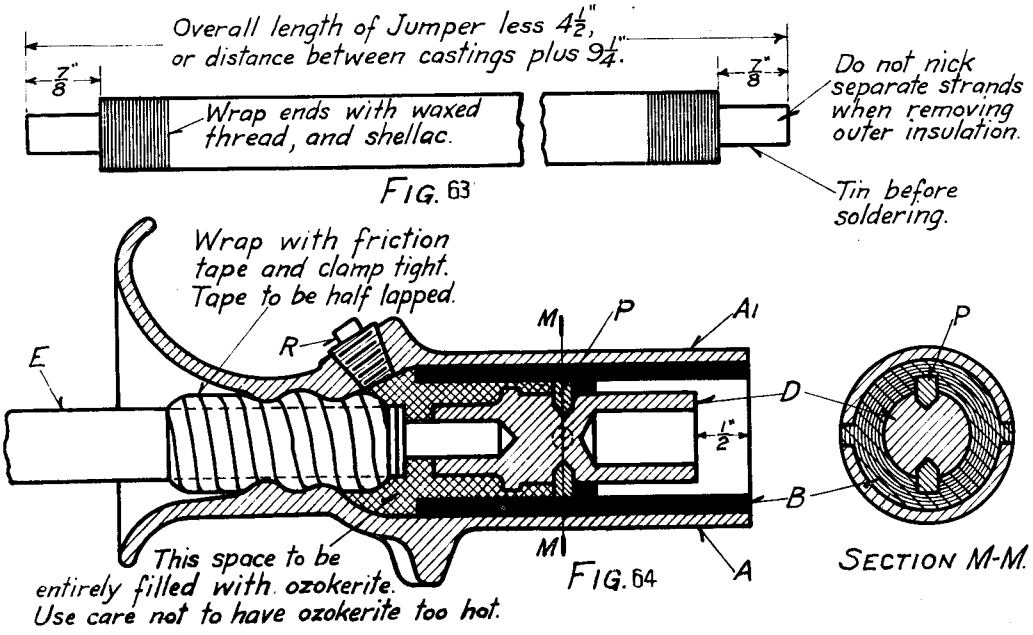
4 Clean off excess solder and tape cable as shown in Fig. 64.

5 Slide terminal D into insulation sleeve B so that pins P engage shoulder inside of sleeve.

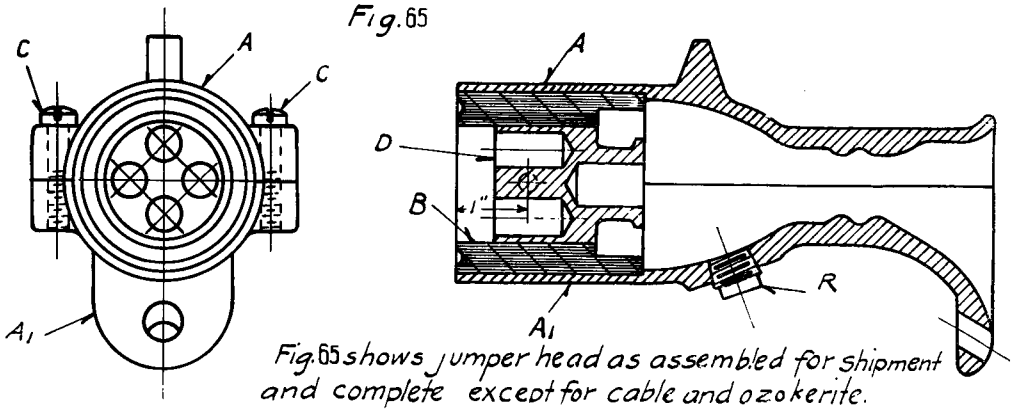
6 Replace castings A & A1 and cap screws C and hold in vise with casting A1 on top.

7 Remove pipe plug R and pour cavity full of melted ozokerite.

8 After ozokerite has cooled screw plug back into place.



INSTRUCTIONS FOR ASSEMBLING BUS LINE JUMPERS



1 Remove screws "C" and main castings A & A1 take out cable terminal "D" complete with its two guide pins and insulating tube "B".

2 Remove terminal "D" from insulation first making sure that Pins P1 have been removed.

3 Prepare cable as shown in Fig. 67.

4 Make sure that terminal is tinned and fill with hot solder.

5 Solder cable to terminal "D" as shown in Fig. 67 first having the end full of hot solder.

6 Replace insulating sleeve and pins P1 covering these with ozokerite.

7 Replace castings A & A1 and screws C and hold in vise with Casting A1 on top.

8 Remove pipe plug "R" and pour cavity full of melted ozokerite.

9 After ozokerite has cooled screw plug back into place.

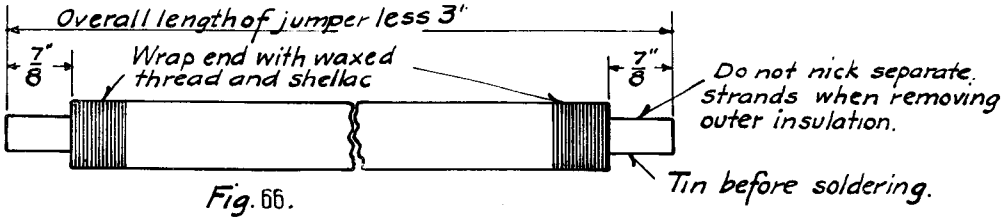


Fig. 66.

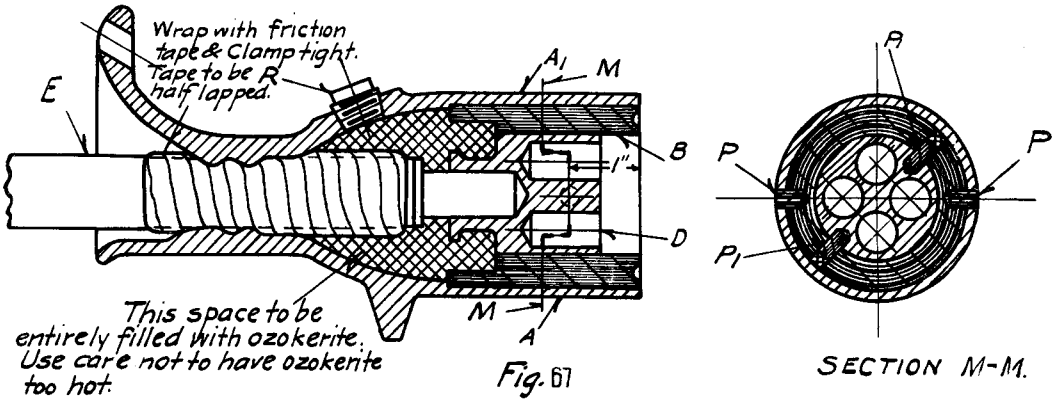


Fig. 67

INSPECTION TOOLS FOR CONTROL EQUIPMENTS USING 264, 265, 272, OR 480 TYPE SWITCHES

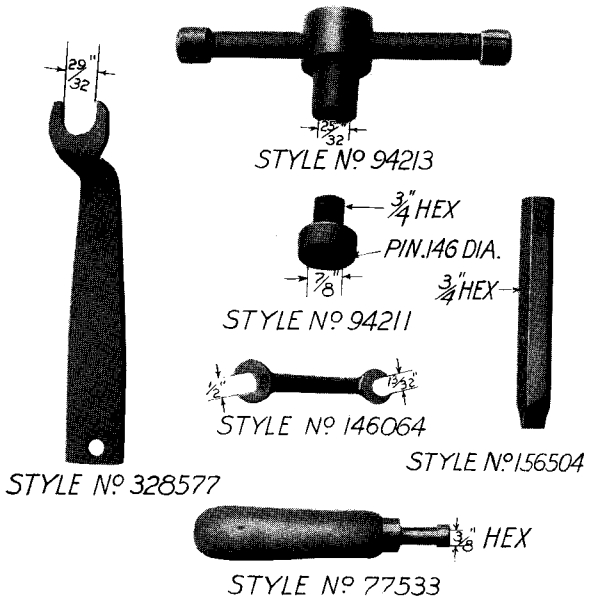


Fig. 68

Style No. 156504	Special Screw driver for removing magnet bracket bolts.
Style No. 77533	Wrench for interlock nuts.
Style No. 94211	Wrench for magnet core.
Style No. 94213	Socket for magnet core wrench and terminal tap bolts.
Style No. 328577	Wrench for terminal bolts.
Style No. 146064	Small open end wrench.
Style No. 328578	Tool Bag.
Style No. 328580	Tool Bag complete with tools.

INSPECTION TOOLS FOR LOW FLOOR CONTROL EQUIPMENTS USING 275 TYPE SWITCHES

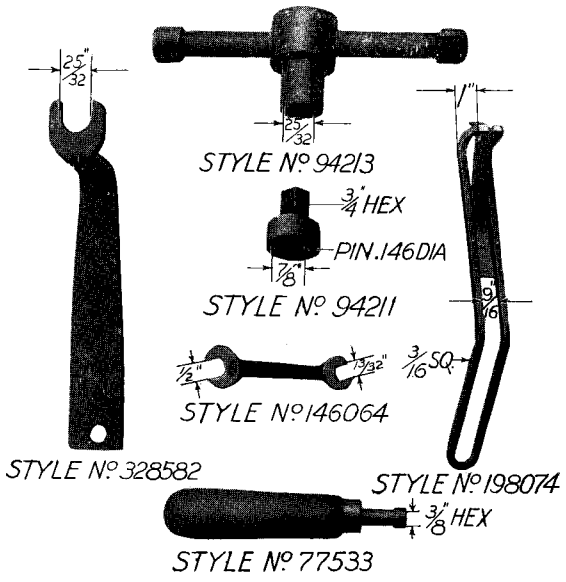


Fig. 69

Style No. 198074	Holder for contact tips and arc horns.	Style No. 328582	Wrench for terminal bolts
Style No. 77533	Wrench for interlock nuts.	Style No. 146064	Small open end wrench.
Style No. 94211	Wrench for magnet core.	Style No. 328578	Tool Bag.
Style No. 94213	Socket for magnet core wrench.	Style No. 328617	Tool bag complete with tools.

OVERHAULING TOOLS AND GAUGES FOR 264, 265, 272, 275, 480 AND 267 TYPE MAGNET VALVES

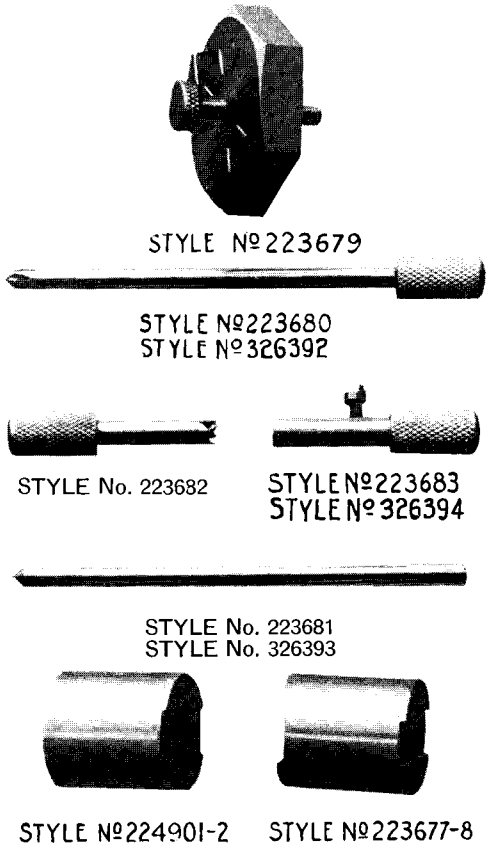


Fig. 70

Line Control Equipments Using Long Valve Stem

Style No. 264, 265, 272, 275 and 480 Types	Tool	Style No. 267 Type
328581	Complete set with bag	328619
223683	Scraper for upper valve	326394
223682	Scraper for lower valve	223682
223680	Scraper for valve bushing	326392
223681	Set for valve bushing	326393
223679	Travel gauge	223679
223677	Gap gauge for long valve	223677
224901	Condemning gauge for long valve	224901
328579	Tool bag for above	328579

Battery Control Equipments Using Short Valve Stem

Style No. 264, 265, 272, 275 and 480 Types	Tool
328618	Complete set with bag.
223683	Scraper for upper valve
223682	Scraper for lower valve
223680	Scraper for valve bushing
223681	Set for valve bushing
223679	Travel gauge
223678	Gap gauge for short valve
224902	Condemning gauge for short valve
328579	Tool bag for above

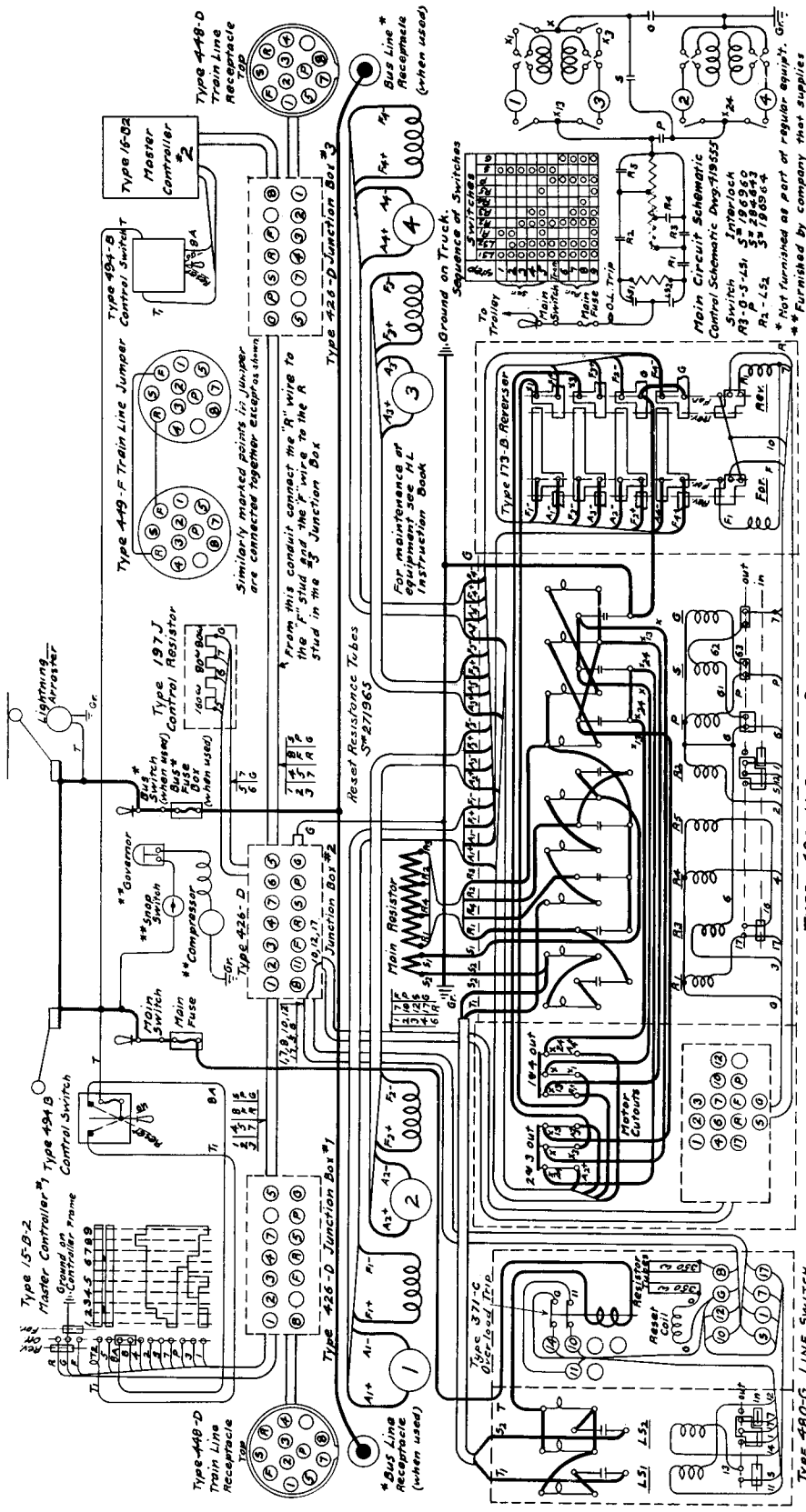


Fig. 80—Wiring Diagram for Standard 600 Volt HL Control for 4-100 Hp. 600 Volt Motors

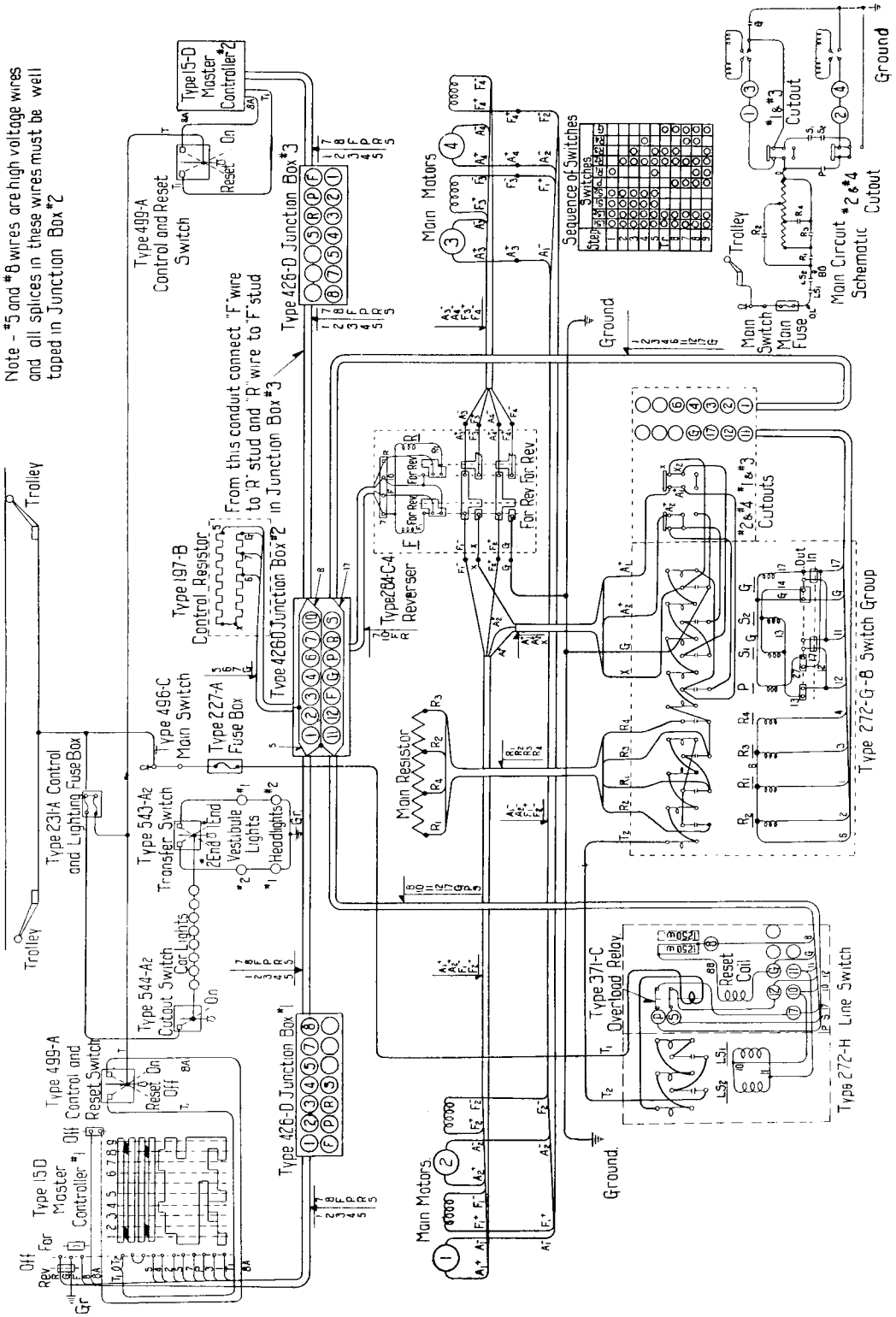


Fig. 81—Wiring Diagram for Standard 1200 Volt HL Control for 4-50 Hp.—600 Volt Motors, Connected Two in Series

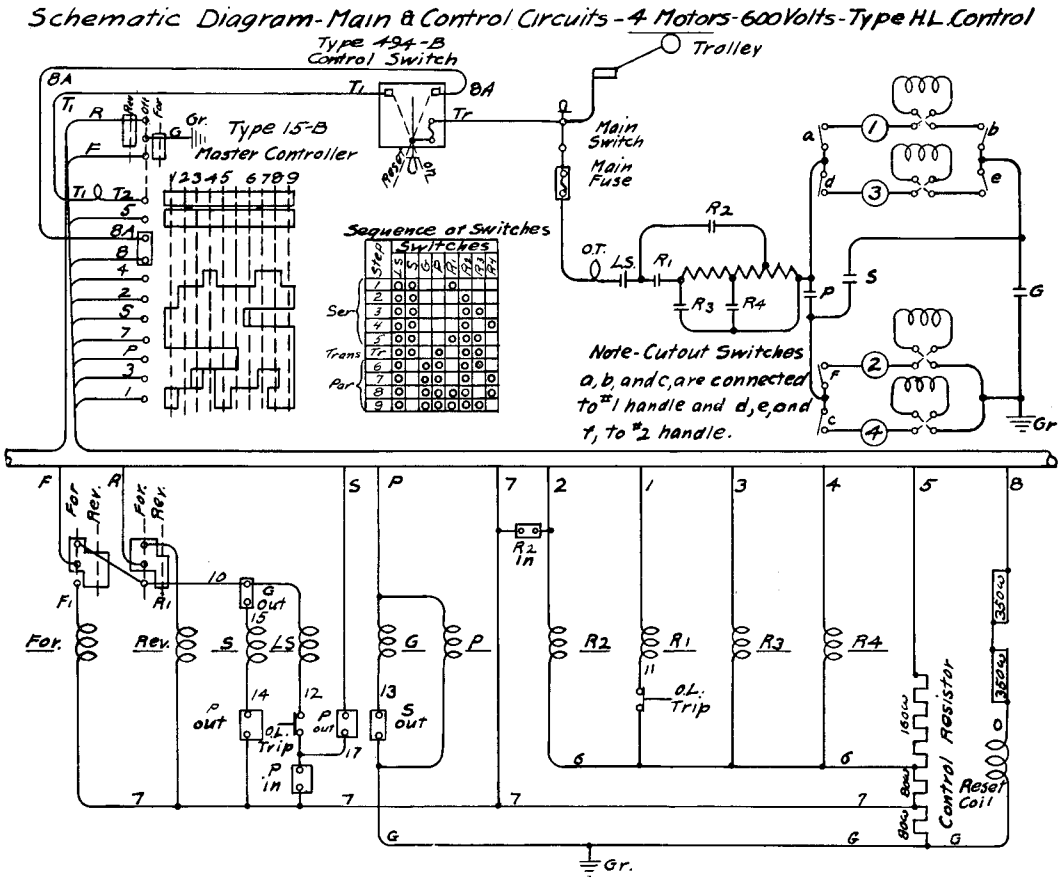


Fig. 82—Schematic Diagram for Standard 600 Volt HL Control for 4-65 Hp. 600 Volt Motors

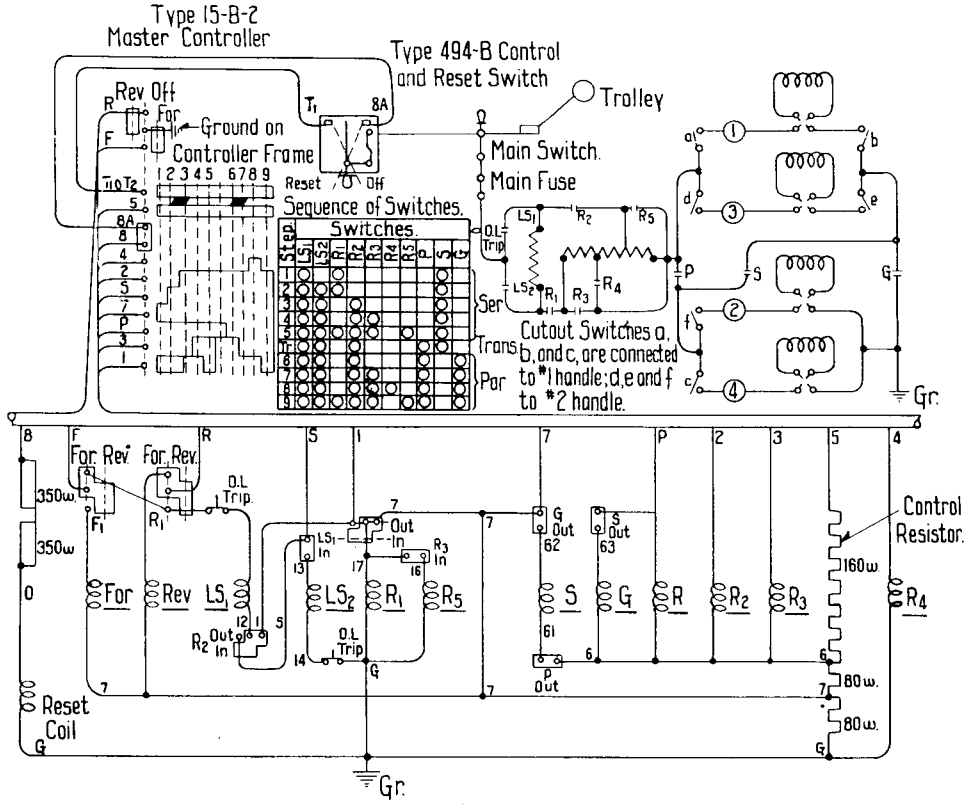
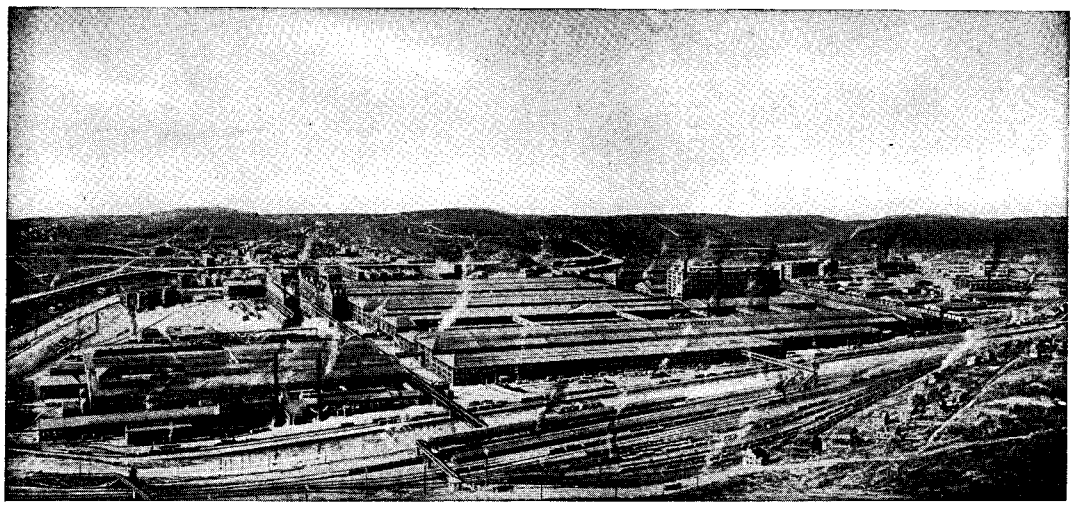


Fig. 83—Schematic Diagram for Standard 600 Volt HL Control for 4-100 Hp.—600 Volt Motors

Westinghouse Type HL Unit Switch Control Equipment



The Company's Works at East Pittsburgh, Pa.

Westinghouse Products

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

For Industrial Use

Instruments

Motors and controllers for every application, the more important of which are: Machine shops, woodworking plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.

Welding outfits

Gears

Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.

Lighting Systems

Safety switches

For Power Plants and Transmission Lines

Circuit-breakers and switches
Condensers
Controllers
Control switches
Frequency changers
Fuses and fuse blocks
Generators
Insulating material
Instruments
Lamps, incandescent and arc
Lightning arresters
Line material
Locomotives
Meters
Motors
Motor-generators
Portable Power Stands, 110 volts
Rectifiers
Regulators
Relays
Solder and soldering fluids
Stokers
Substations, portable and automatic
Switchboards
Synchronous converters
Transformers
Turbine-generators

For Transportation

Locomotives
Railway equipment
Marine equipment

For Mines

Lamps
Locomotives
Motors for hoists and pumps
Motor-generators
Portable substations
Switchboards
Line material
Ventilating outfits

For Farms

Fans

Household appliances

Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit cleaning machines and sorting machines.

Generators for light, power and heating apparatus

Portable Power Stands, 32 Volts
Radio Apparatus
Transformers

For Office and Store

Electric radiators
Fans
Arc lamps
Incandescent lamps

Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.

Ventilating outfits

For Electric and Gasoline Automobiles and the Garage

Battery charging outfits
Charging plugs and receptacles
Lamps
Instruments
Motors and controllers

Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.

Solder and soldering fluids

Starting, lighting and ignition systems, embracing: Starting motor generators, ignition units, lamps, headlights, switches, etc.

Tire vulcanizers

For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.

Automatic electric ranges
Fans
Incandescent lamps
Radio Apparatus

Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players

Sew-motors

Westinghouse Electric & Manufacturing Company

East Pittsburgh, Pa

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ALBANY, N. Y., Journal Building.
ATLANTA, GA., Candler Bldg., 127 Peachtree St.
BALTIMORE, MD., Westinghouse Bldg., 121 E. Baltimore St.
BIRMINGHAM, ALA., Brown-Marx Bldg., 2000 First Ave.
BLUEFIELD, W. VA., Law and Commerce Bldg., Federal and Raleigh Streets
BOSTON, MASS., Rice Building, 10 High St.
BUFFALO, N. Y., Ellicott Square Bldg., Ellicott Square.
BUTTE, MONT., Montana Electric Co. Bldg., 52 East Broadway.
CHARLESTON, W. VA., Kanawha National Bank Bldg., Capitol and Virginia Streets.
CHARLOTTE, N. C., Commercial Bank Bldg., 200 S. Tryon St.
CHATTANOOGA, TENN., Hamilton National Bank Building, 701 Market St.
CHICAGO, ILL., Conway Bldg., 111 W. Washington Street.
CINCINNATI, O., Westinghouse Bldg., Third and Elm Sts.
CLEVELAND, O., Swetland Bldg., 1010 Euclid Ave.
COLUMBUS, O., Interurban Terminal Bldg., Third and Rich Sts.
DALLAS, TEX., Magnolia Bldg., Akard and Commerce Street.
DAYTON, O., 14 West Fourth Street.
DENVER, COLO., Gas and Electric Bldg., 910 Fifteenth St.
DES MOINES, IOWA., 608 Securities Bldg., 412 W. Seventh St.
DETROIT, MICH., 1535 Sixth Street.
DULUTH, MINN., Alworth Bldg., 306 West Superior St.
EL PASO, TEX., Mills Bldg., Oregon and Mills St.
FRESNO, CAL., J and Mariposa Streets.
HOUSTON, TEX., Union National Bank Building, Main and Congress Streets.
HUNTINGTON, W. VA., Westinghouse Electric Building, Corner Second Avenue and Ninth Street.
*Government business exclusively.
INDIANAPOLIS, IND., Traction Terminal Bldg., Illinois and Market Sts.
JACKSONVILLE, FLA., Union Terminal Warehouse, East Union and Ionia Streets
KANSAS CITY, MO., Orear-Leslie Bldg., 1012 Baltimore Ave.
LOUISVILLE, KY., Paul Jones Bldg., 312 Fourth Ave.
LOS ANGELES, CAL., 418 So. San Pedro Street.
MEMPHIS, TENN., Exchange Bldg., 130 Madison Ave.
MILWAUKEE, WIS., First National Bank Bldg., 425 E. Water St.
MINNEAPOLIS, MINN., 2303 Kennedy Street, N. E.
NEW ORLEANS, LA., Maison Blanche Bldg., 921 Canal St.
NEW YORK, N. Y., City Investing Bldg., 165 Broadway.
NIAGARA FALLS, N. Y., 205 Falls Street.
PHILADELPHIA, PA., Widener Bldg., 1325-1329 Chestnut St.
PITTSBURGH, PA., Union Bank Bldg., 306 Wood St.
PORTLAND, ORE., Northwestern Bank Bldg., Broadway and Morrison Sts.
RICHMOND, VA., Virginia Rwy. and Pr. Bldg., Seventh and Franklin Streets
ROCHESTER, N. Y., Chamber of Commerce Bldg., 119 E. Main Street.
ST. LOUIS, MO., 300 N. Broadway.
SALT LAKE CITY, UTAH, Walker Bank Bldg., Second Street, South and Main Sts.
SAN FRANCISCO, CAL., First National Bank Bldg., 1 Montgomery St.
SEATTLE, WASH., Westinghouse Bldg., 3451 E. Marginal Way.
SYRACUSE, N. Y., University Bldg., 120 Vanderbilt Square.
TOLEDO, O., Ohio Bldg., Madison Ave and Superior St.
TUCSON, ARIZ., Immigration Bldg., 90 Church Street.
WASHINGTON, D. C., *Hibbs Bldg., 723 Fifteenth St., N. W.
WILKES-BARRE, PA., Miner's Bank Building, W. Market and Franklin Streets,
The Hawaiian Electric Company, Ltd., Honolulu, T. H.—Agent

WESTINGHOUSE AGENT JOBBERS

ATLANTA, GA., Gilham Schoen Electric Co.
BIRMINGHAM, ALA., The Moore-Handley Hardware Co.
BLUEFIELD, WEST VIRGINIA, Superior Supply Co.
BUFFALO, N. Y., McCarthy Bros. & Ford
BUTTE, MONTANA, The Montana Electric Co.
CHICAGO, ILL., Illinois Electric Co.
CHARLOTTE, N. C., Carolina States Electric Co.
CINCINNATI, OHIO, The Johnson Electric Supply Co.
CLEVELAND, OHIO, The Erner Electric Co.
DENVER, COLO., Mine & Smelter Supply Co.
DETROIT, MICH., Commercial Electric Supply Co.
EL PASO, TEXAS, Mine & Smelter Supply Co.
EVANSVILLE, IND., The Varney Electrical Supply Co.
HOUSTON, TEXAS, Tel-Electric Co.
HUNTINGTON, WEST VIRGINIA, Banks Supply Co.
INDIANAPOLIS, IND., The Varney Electrical Supply Co.
JACKSONVILLE, FLA., Pierce Electric Co.
KANSAS, CITY, MO., Satterlee Electric Co.
LOS ANGELES, CAL., Illinois Electric Co.
LOUISVILLE, KY., Tafel Electric Co., Inc.
MEMPHIS TENN., Riechman-Crosby Co.
MILWAUKEE, WIS., Julius Andrae & Sons Co.
NEW HAVEN, CONN., Hessel & Hoppen Co.
NEW ORLEANS, LA., Electrical Supply Co.
NEW YORK, N. Y., Alpha Electric Co.
OKLAHOMA CITY, OKLA., United Electric Co.
OMAHA, NEB., The McGraw Co.
PHILADELPHIA, PA., H. C. Roberts Electric Supply Co.
PITTSBURGH, PA., Robbins Electric Co.
PORTLAND, ORE., Fobes Supply Co.
RICHMOND, VA., Tower-Binford Electric & Mfg. Co.
ROCHESTER, N. Y., Rochester Electrical Supply Co.
SALT LAKE CITY, UTAH, Intermountain Electric Co.
SAN FRANCISCO, CAL., Electric Rwy. & Mfrs. Supply Co.
SCRANTON, PA., Penn. Electrical Engineering Co.
SEATTLE WASH., Fobes Supply Co.
SIOUX CITY, IOWA, The McGraw Co.
SPOKANE, WASH., The Washington Electric Supply Co.
ST. JOSEPH, MO., Columbian Electrical Co.
ST. LOUIS, MO., The McGraw Company
ST. PAUL, MINN., St. Paul Electric Co.
SYRACUSE, N. Y., H. C. Roberts Electric Supply Co.
TAMPA, FLA., Pierce Electric Co.
WASHINGTON, D. C., H. C. Roberts Electric Supply Co.
WICHITA, KANSAS, United Electric Co.

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ATLANTA, GA.:.....Cor. Markham and Mangum Sts.
BALTIMORE, MD.....501 East Preston St.
BOSTON, MASS.....12 Farnsworth St.
BRIDGEPORT, CONN....Bruce Ave. and Seymour St. Stratford
BUFFALO, N. Y.....141-157 Milton St.
CHICAGO, ILL.....32 South Peoria St.
CINCINNATI, O.....Third and Elm Sts.
CLEVELAND, O.....1255 West Fourth St.
DENVER, COLO.....1909-11-13-15 Blake St.
DETROIT, MICH.....1535 Sixth St.
HARTFORD, CONN.....220 Market St.
HUNTINGTON, W. VA.....9th Street and 2nd Ave
JOHNSTOWN, PA.....47 Messenger St.
LOS ANGELES, CAL.....2019 Bay St.
MINNEAPOLIS, MINN.....2303 Hennedy St., N. E.
NEW YORK, N. Y.....467 Tenth Ave.
PHILADELPHIA, PA.....214-220 North 22nd St.
PITTSBURGH, PA.....6905 Susquehanna St.
ST. LOUIS, MO.....12th and Gratoit Sts.
SALT LAKE CITY, UTAH.....573 W. 2nd St So.
SAN FRANCISCO, CAL.....1400 Fourth St.
SEATTLE, WASH.....3451 East Marginal Way.
SPRINGFIELD, MASS.....82-86 Worthington St.

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NEW YORK.....596 Court Street, Brooklyn
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SAN FRANCISCO.....141 Second Street
SAVANNAH.....406 E. 39th Street

CANADIAN COMPANY

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