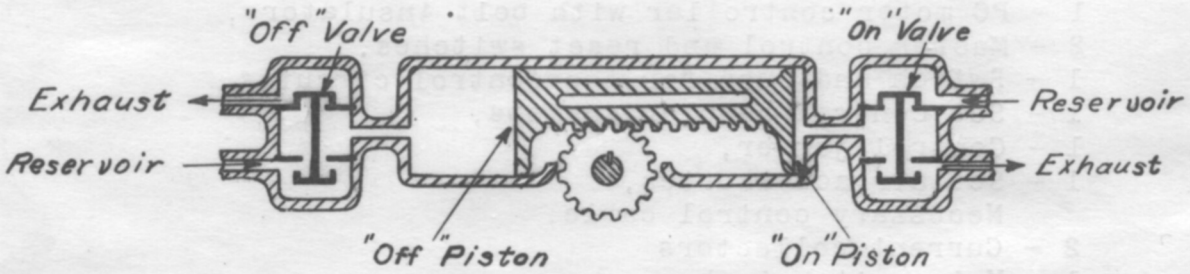
OPERATION OF MOTOR CONTROLLER

The line breaker, reverser and contactors are actuated by air pressure controlled by magnet valves. The line breaker and reverser are provided with individual magnet valves and air cylinders, while a single cylinder with a double piston and two valves is used for the operation of all the contactors. The contactors are actuated by cams mounted on a shaft, which is rotated by a rack and pinion, as shown on sketch A. Air is



Sketch A.

admitted to, or exhausted from, the air cylinder, by means of magnet valves, controlled by the master controller.

Sketch A shows the position of the magnet valves and the pistons when the master and motor controllers are in the "off" position. In this position, the air pressure is applied to the "off" piston thru the "off" magnet valve, while the "on" magnet valve allows any air in the "on" cylinder to pass thru to atmosphere. When the master controller is turned on, and the reverser throws, the line breaker closes, and then both the "on" and "off" magnet valves are energized. This applies air pressure to the "on" piston and allows air to escape from the "off" cylinder; the rack moves toward the "off" magnet valve, rotating the pinion and cam shaft until the "off" magnet valve is de-energized. When this occurs air pressure is applied to the "off" piston, and, as the "on" magnet valve applies air pressure to the "on" piston, all movement of the rack and pinion ceases with the motor controller in the first operating position. Subsequent positions on the motor controller are obtained by alternately energizing and de-energizing the "off" magnet valve. When the master controller is turned off, the "on" and "off" magnet valves are de-energized and air pressure is applied to the "off" piston and released from the "on" piston. This causes the rack to move toward the "on". magnet valve and rotates the pinion and cam shaft, turning the motor controller to the "off" position.

EQUIPMENT

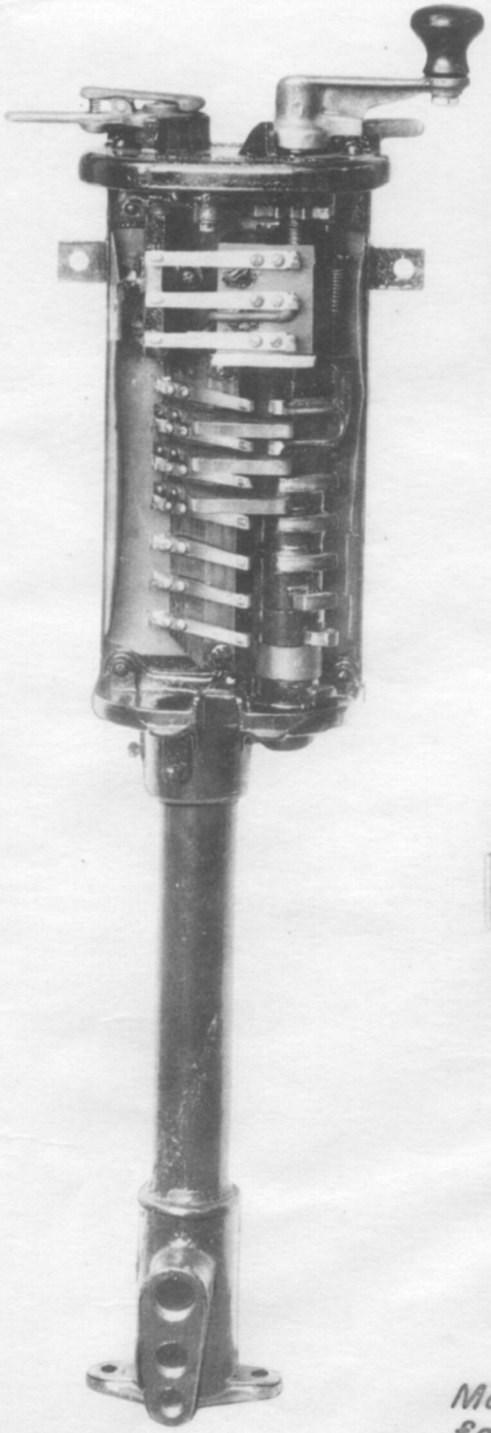
The list of apparatus comprising a complete PC control equipment for multiple unit operation is as follows:

600 VOLTS

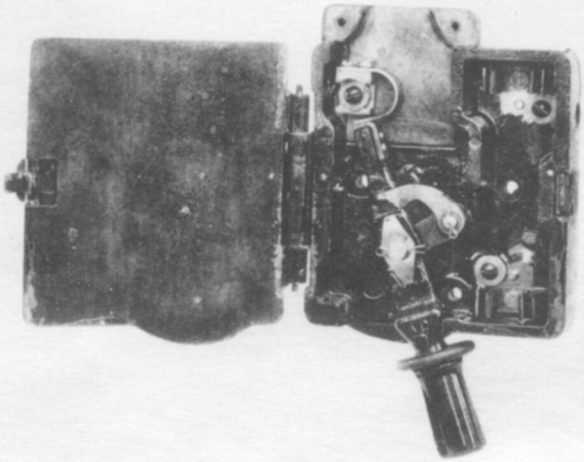
2 - Master controllers,
1 - PC motor controller with bolt insulators,
2 - Master control and reset switches,
1 - Switch and fuse for the control circuits,
1 - Set control coupler sockets,
1 - Control jumper,
1 - Set air accessories,
Necessary control cable,
2 - Current collectors
1 - Main switch in box
1 - Lightning arrester
1 - Set cast grid motor resistors with bolt insulators,
Main and Motor wiring
Car Lighting material,

1200 and 1500 VOLTS.

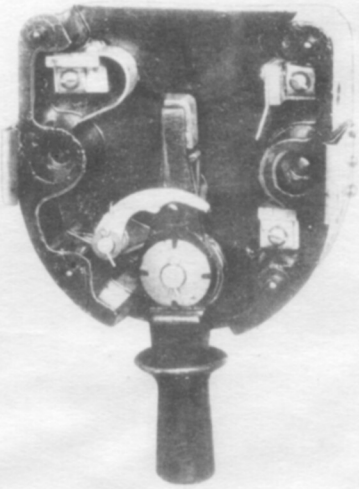
2 - Master controllers.
1 - PC - Motor controller with bolt insulators.
1 - 1 1/2 Kw. Motor Generator with 32 volt generator for control, Lights and headlight.
2 - Master control and reset switches with fuses.
1 - Set control coupler sockets.
1 - Control jumper.
1 - Set air accessories.
Necessary control cable.
2 - Current collectors.
1 - Main switch in box.
1 - Lightning arrester.
1 - Main fuse box.
1 - Set motor resistors with bolt insulators.
Main motor wiring.
Car Lighting material.
1 - Change over device. (When operation on 600 volts is required).



TYPE C-129 CONTROLLER.
INDEX E-353.2 - E-353.7



TYPE MS-46 SWITCH



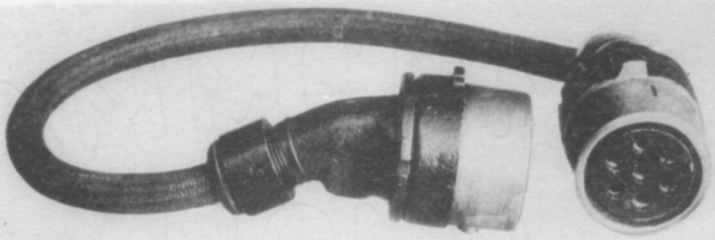
TYPE MS-14 SWITCH

Master Controller and Control Switches for PC Control Equipment.

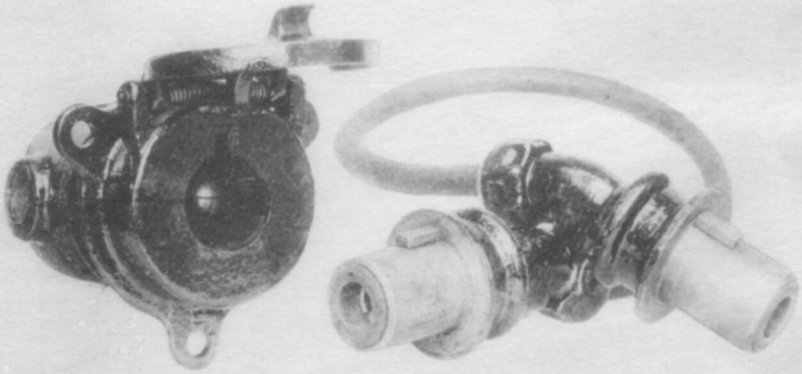
239846

6 6 17

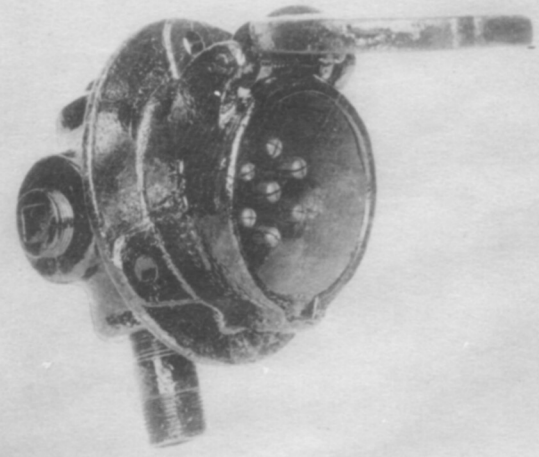
84700-5



TYPE DC-54-C COUPLER SOCKETS.

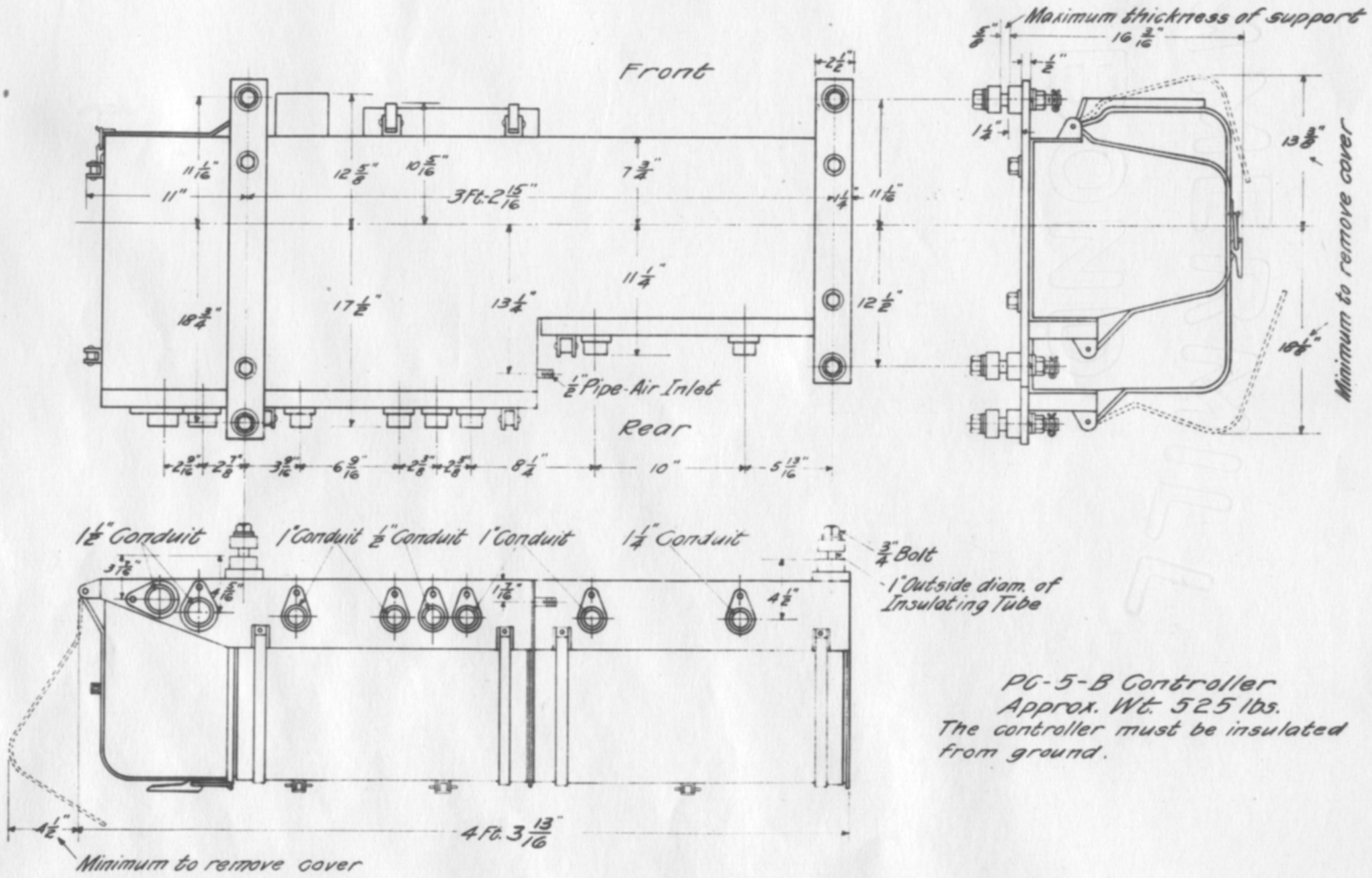


TYPE DA-35 COUPLER SOCKET AND DC-28 PLUGS.



239847 TYPE DA-82 COUPLER SOCKET.

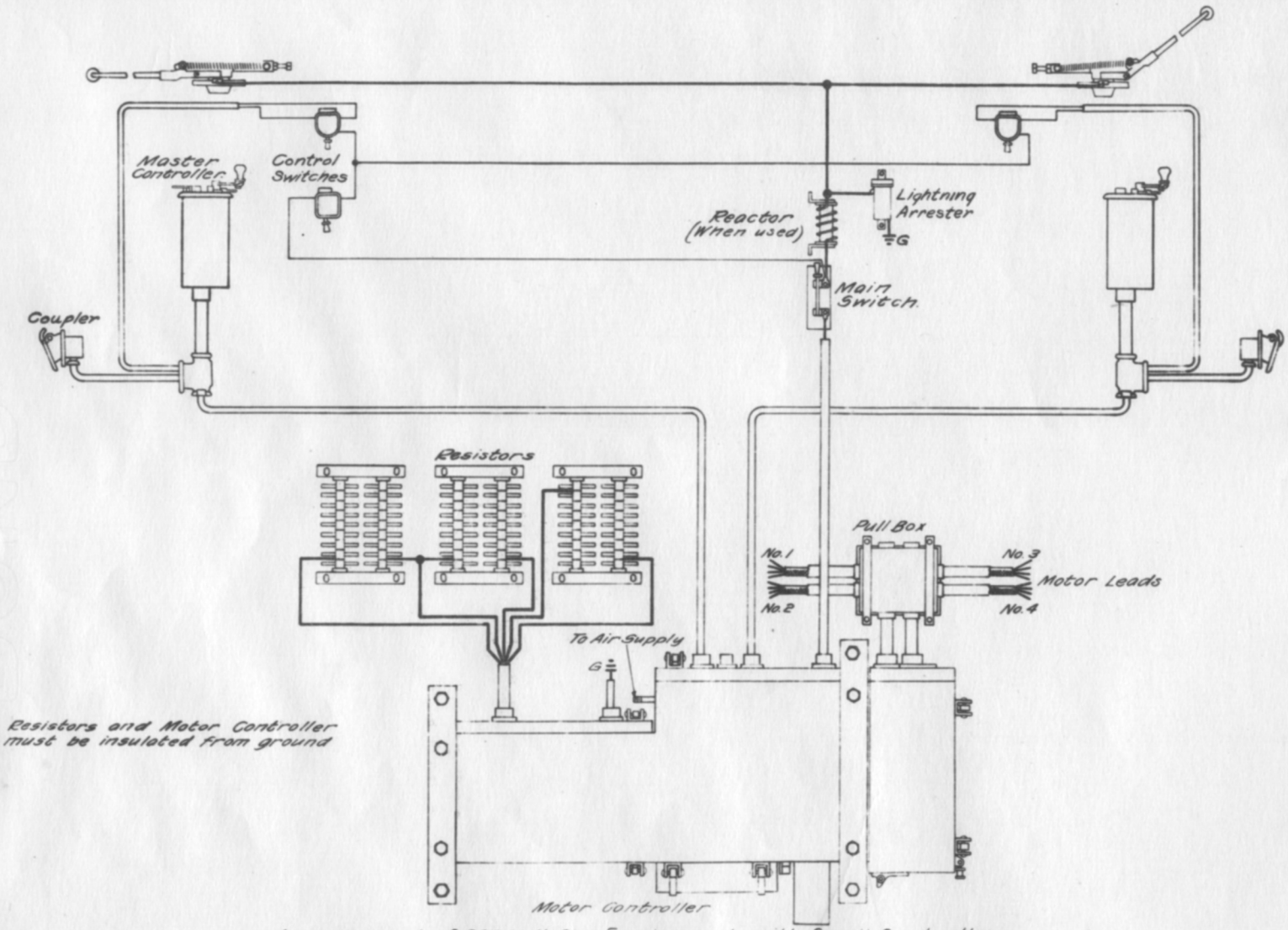
INDEX E-341.4 5 26 17



PC-5-B Controller
Approx. Wt. 525 lbs.
The controller must be insulated from ground.

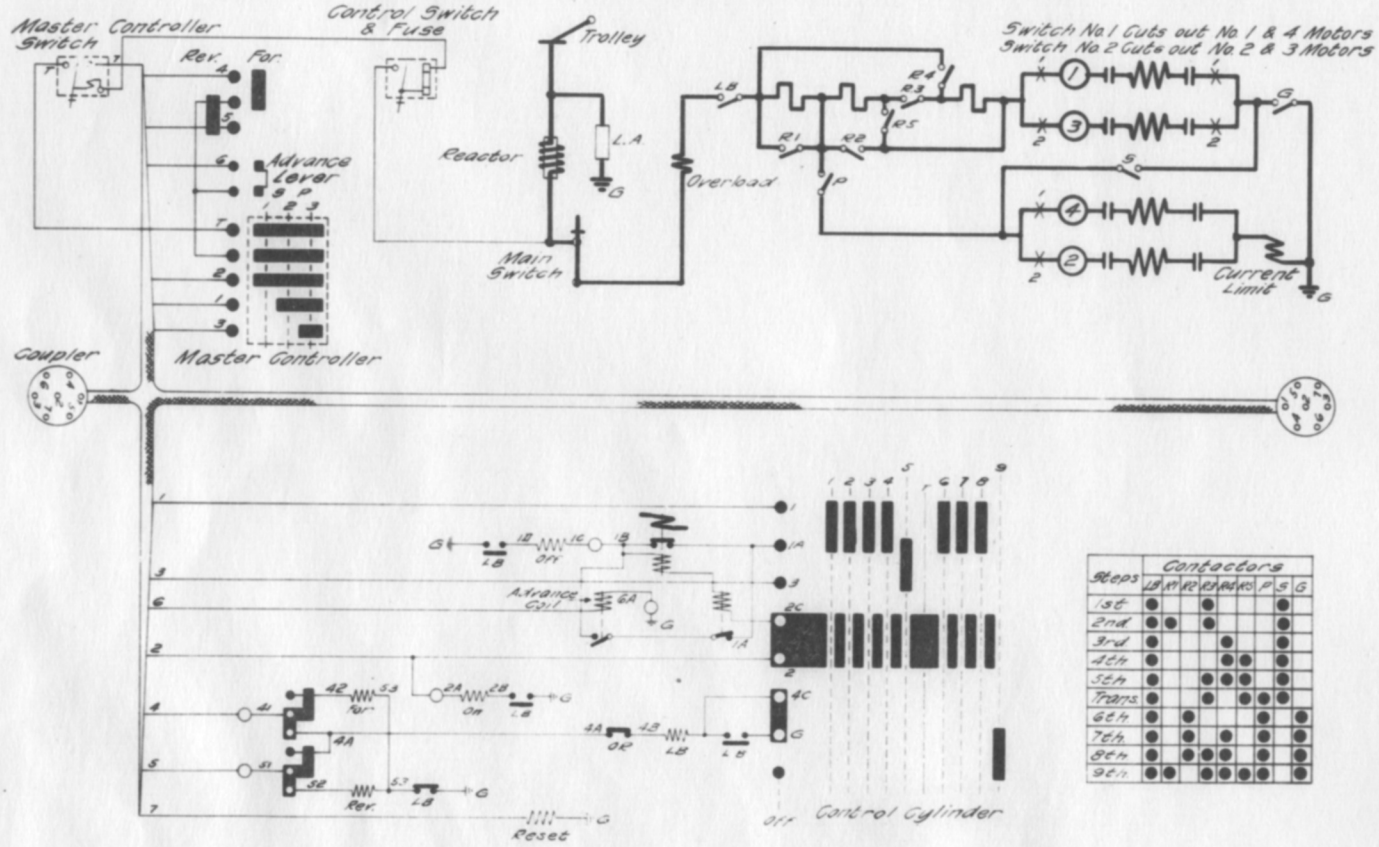
Outline of Small PC-Controller for Two or Four Motors. 600 Volts.

84700-7



Arrangement of 600 Volt Car Equipment with Small Controller.
PC-5

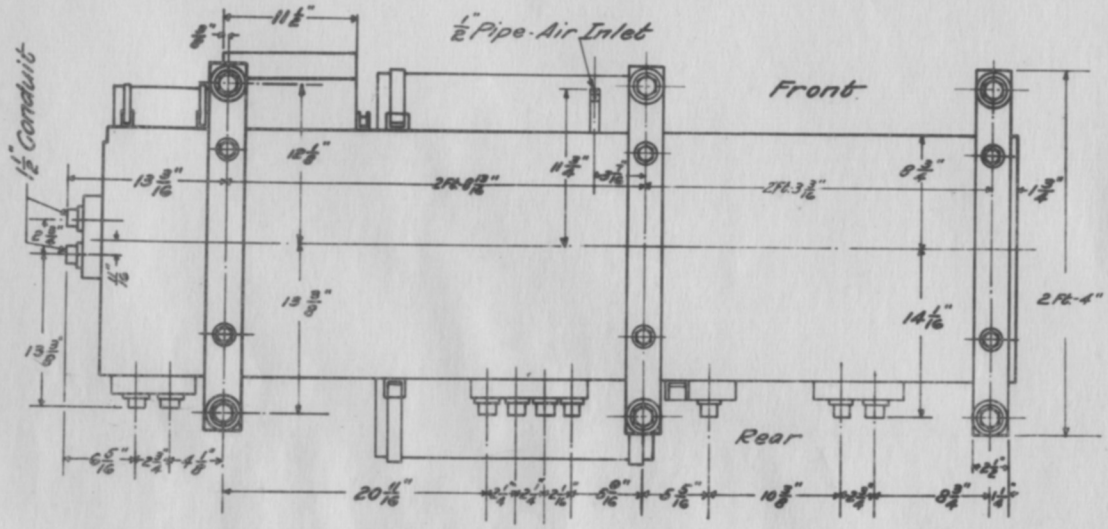
847008

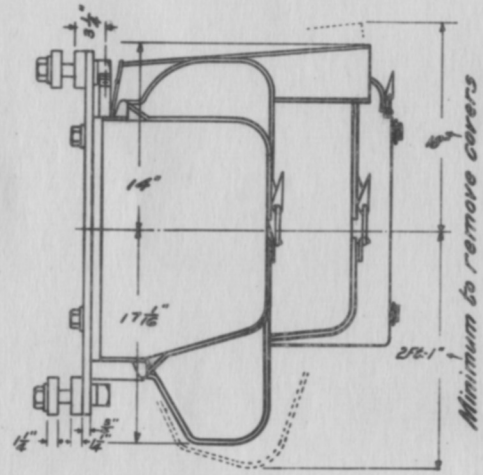


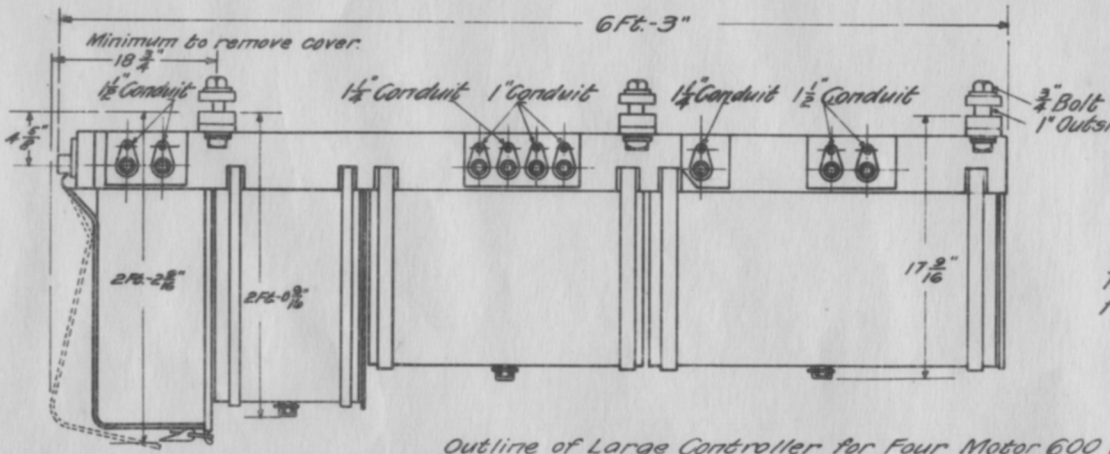
Steps	Contactors								
	LB	1A	2A	3A	4A	5A	P	S	G
1st	●			●				●	
2nd	●	●		●				●	
3rd	●				●			●	
4th	●				●	●		●	
5th	●			●	●	●		●	
Trans	●			●		●	●	●	
6th	●		●				●		●
7th	●		●			●	●		●
8th	●		●	●	●		●		●
9th	●	●		●	●	●	●		●

Connections of PC-5 Controller and Four Motors

84700-9



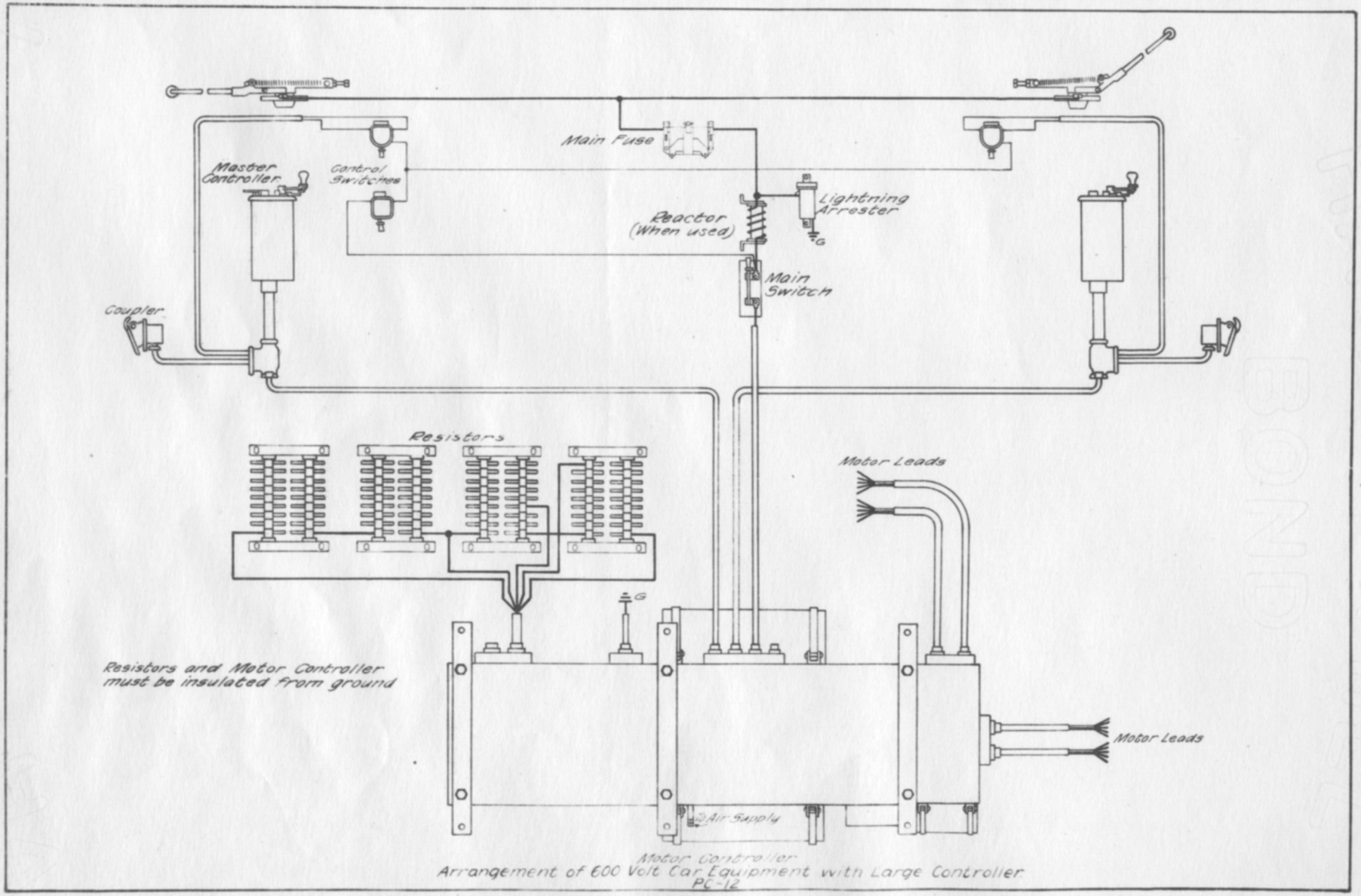




PC-12-A Controller
Approx. Wt. 980 lbs.
The controller must be insulated from ground.

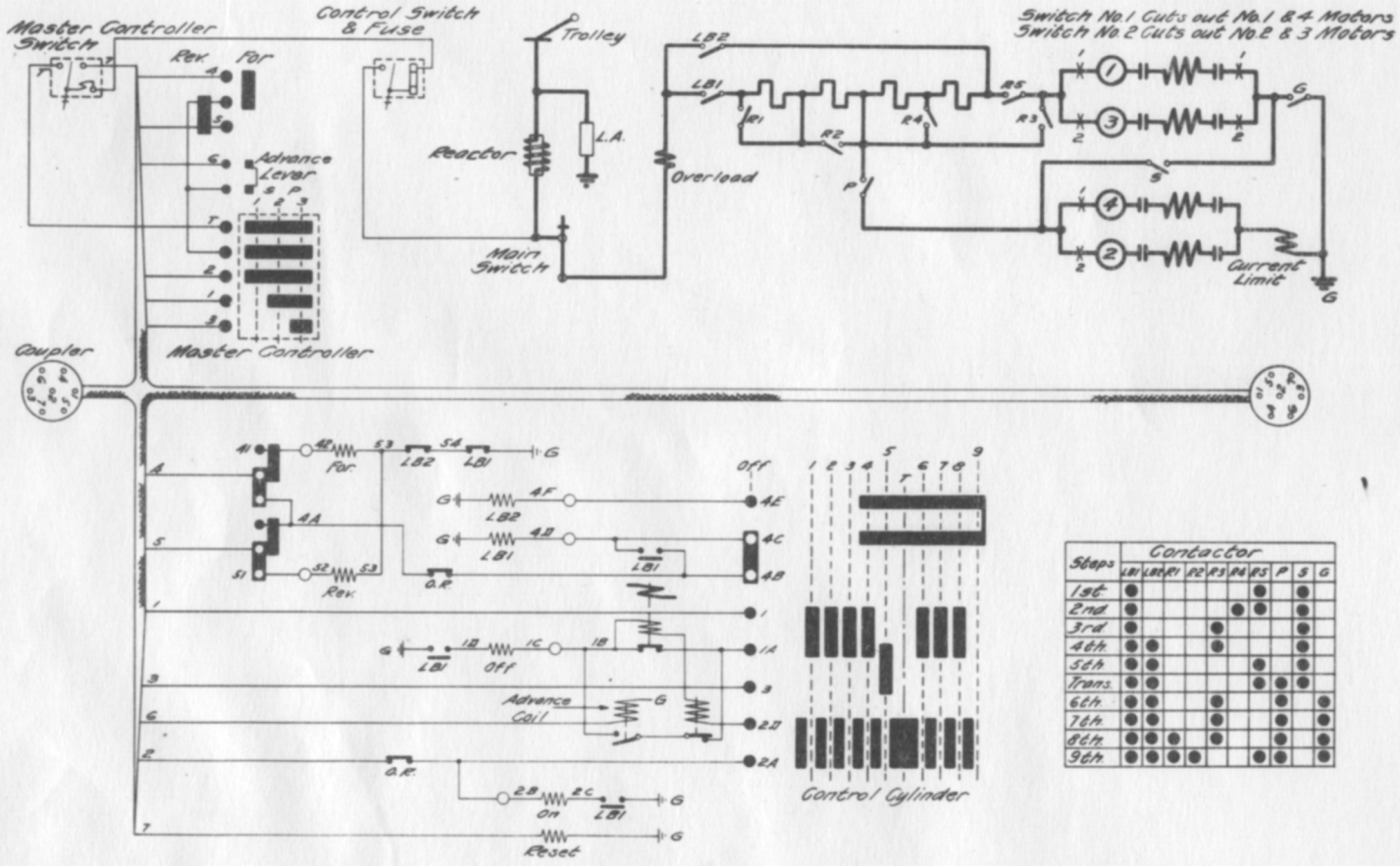
Outline of Large Controller for Four Motor 600 Volt Equipments
The Controller for Two Motor Equipments has Approximately the same Overall Dimensions.

84700-10



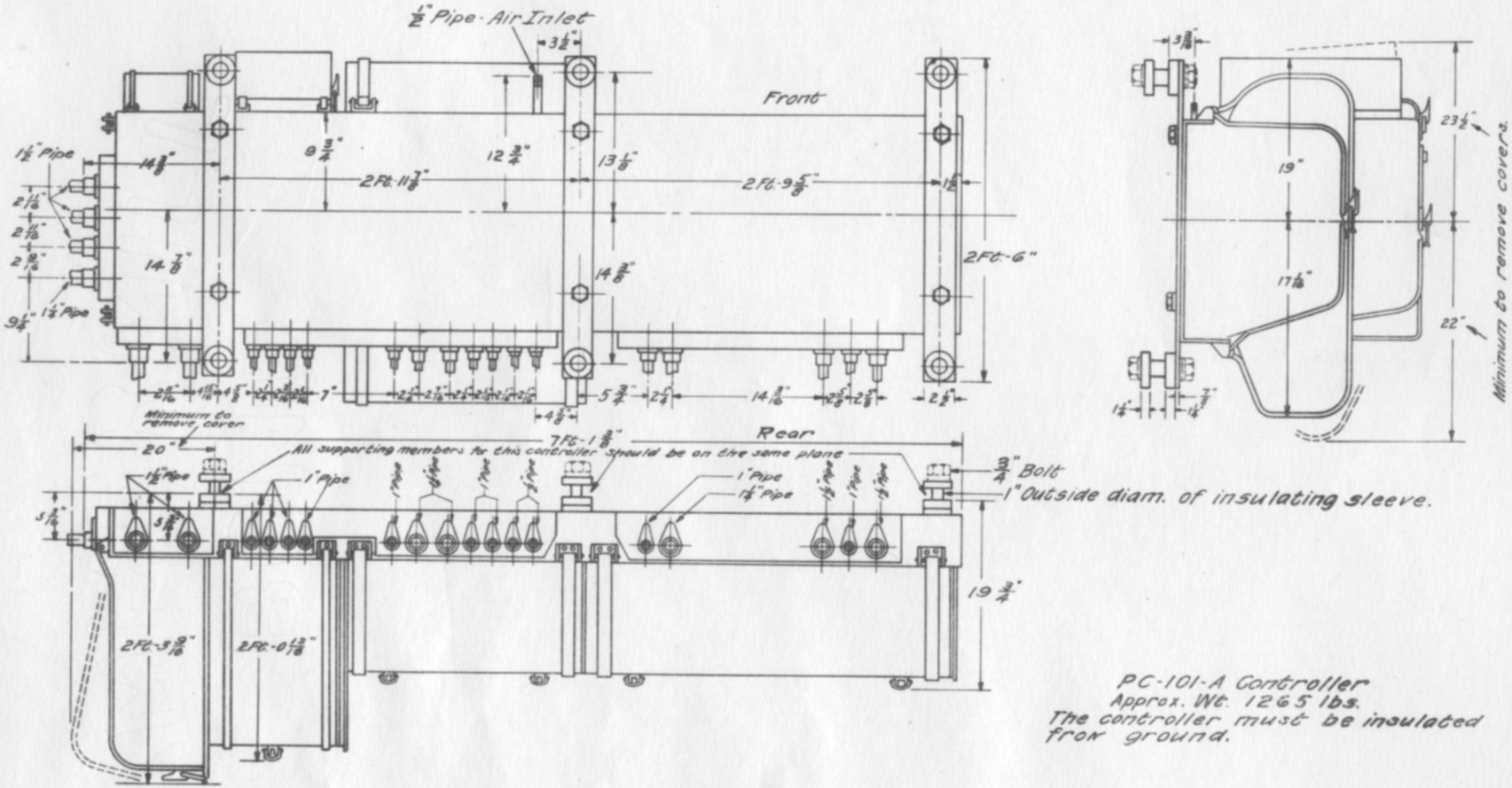
Arrangement of 600 Volt Car Equipment with Large Controller
PC-12

84700-11



Connections of PC-12 Controller and Four Motors

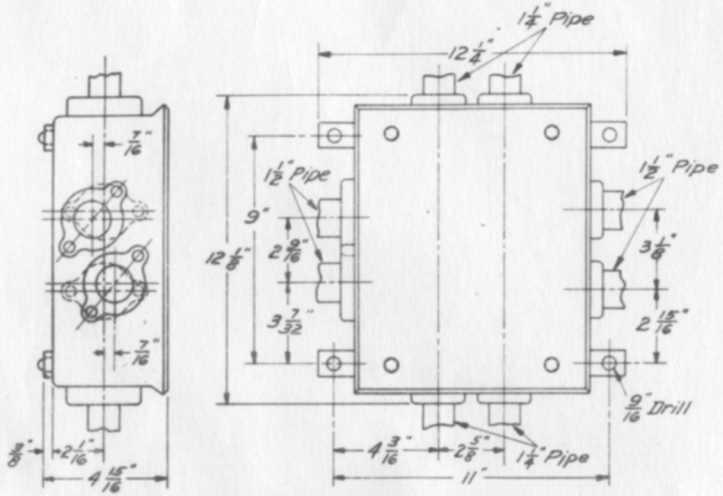
84700-12



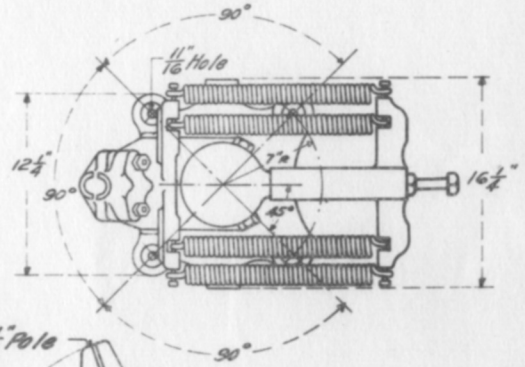
PC-101-A Controller
Approx. Wt. 1265 lbs.
The controller must be insulated from ground.

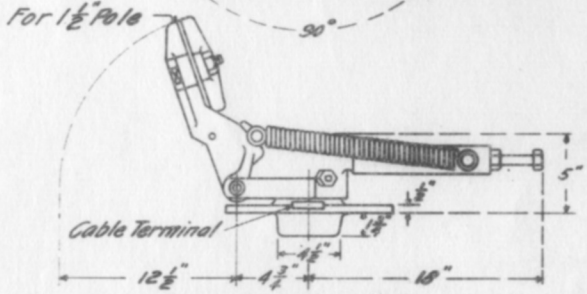
Outline of Four Motor 1500 Volt PC-Controller.

84700-13

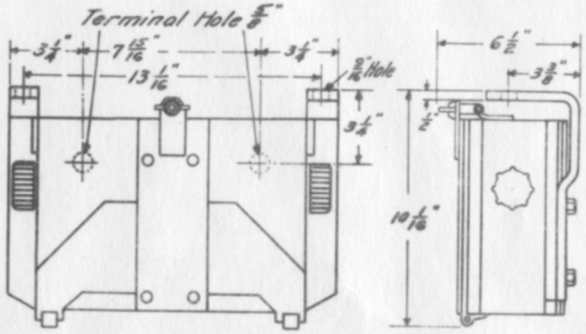


BJ-386-B Distributing Box
Approx. Wt. 18 lbs.

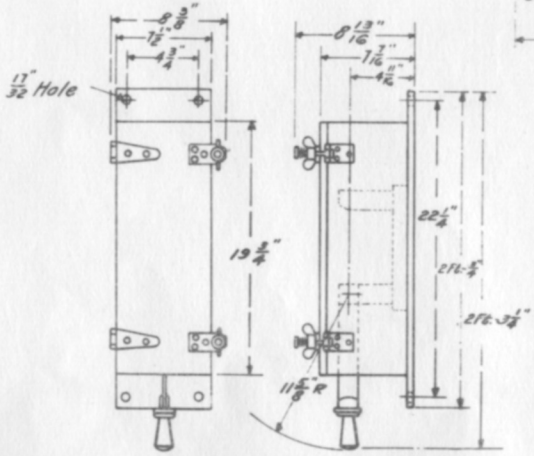




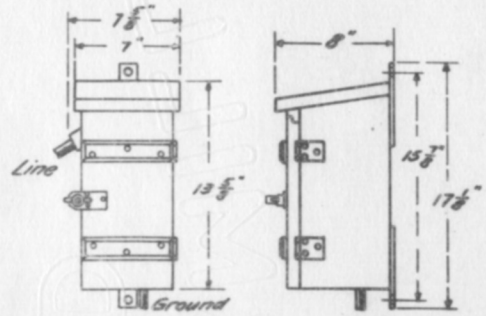
US-13-D Trolley Base
Approx. Wt. 115 lbs.



MA-19-A Fuse Box
Approx. Wt. 26 lbs.
Box must be insulated from ground



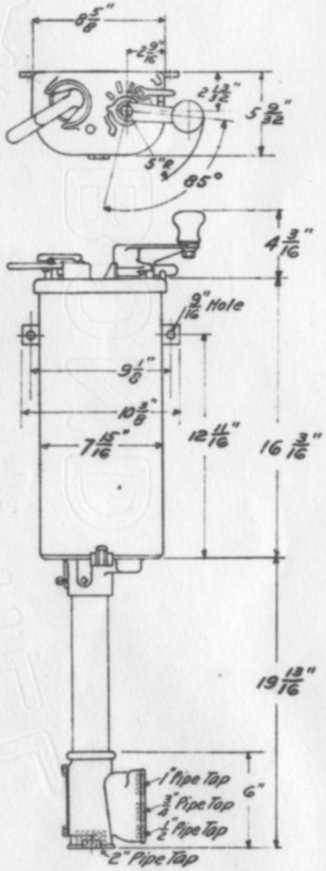
MS-118-A Main Switch
Approx. Wt. 20 lbs.



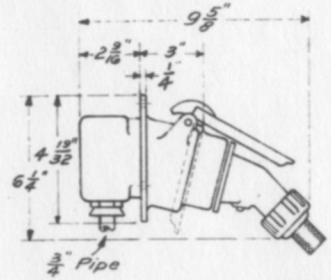
MD-3 Lightning Arrester
Approx. Wt. 15 lbs.

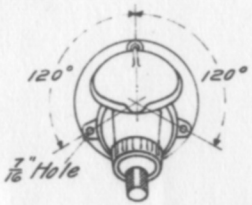
Outlines of Electrical Apparatus Used With 600 Volt PC Equipments.

84700-14

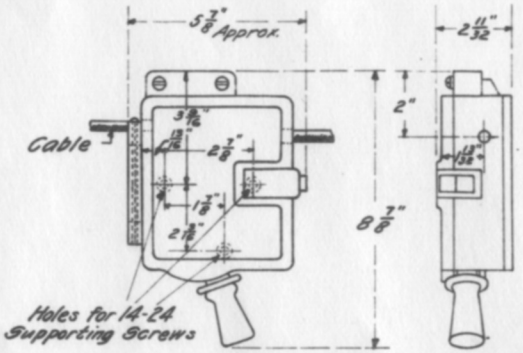


C-129-A Master Controller
Approx. Wt. 45 lbs.

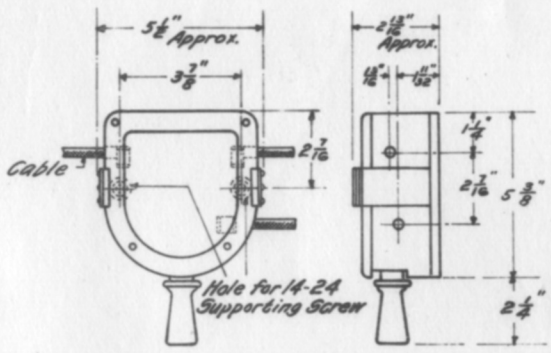




DA-82-B Coupler Socket & DC-54-C Coupler Plug
Approx. Wt. 12 1/2 lbs.



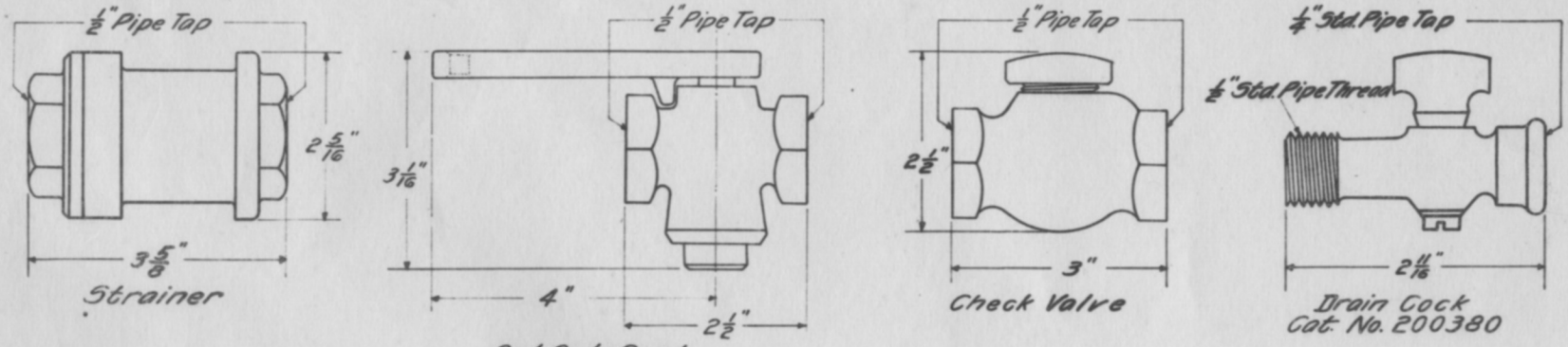
MS-46-H Switch
Approx. Wt. 4 1/2 lbs.

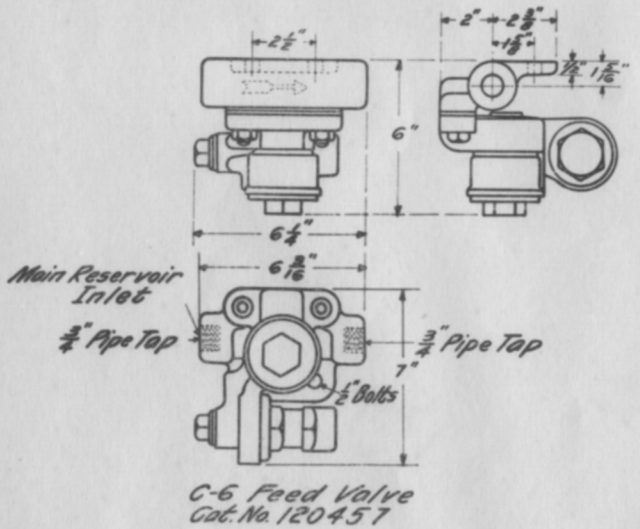


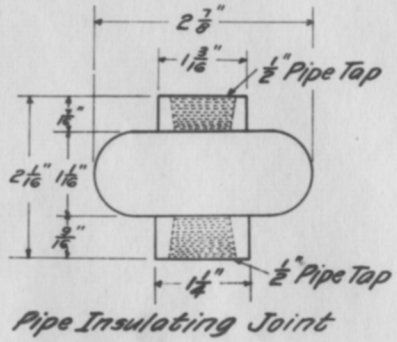
MS-14-C Switch
Approx. Wt. 4 lbs.

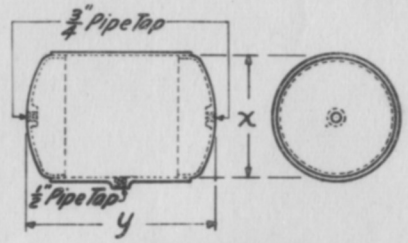
Outlines of Electrical Apparatus Used With 600 Volt P.C. Controllers

84700-15









X	Y
10"	15"
12"	33"
16"	48"

Reservoir

Outlines of Air Accesories Used With PC Equipments.

84700-16

INSTALLING

CONTROLLER SUPPORTS

Previous Sprague General Electric control systems have been made up with each contactor a self-contained unit and no particular care in lining up the car-body supports was necessary. With the PC controller, in which all contactors are operated from a cam shaft, it is essential that the supports attached to the car-body, from which the controller is suspended, be accurately installed, as, otherwise, the controller framework will be pulled out of shape and prevent the controller operating in a satisfactory manner. The points of support should not vary more than 1/8" from one plane. Poor alignment may be indicated by the cam shaft not rotating at 45 pounds air pressure, or controller may start slowly and pass beyond the point where it should stop.

INSULATING FROM GROUND

The PC controller is arranged to be insulated from ground and clearance should be provided between all grounded pipes, hangers, brake rods, etc. and the metal box of the PC controller.

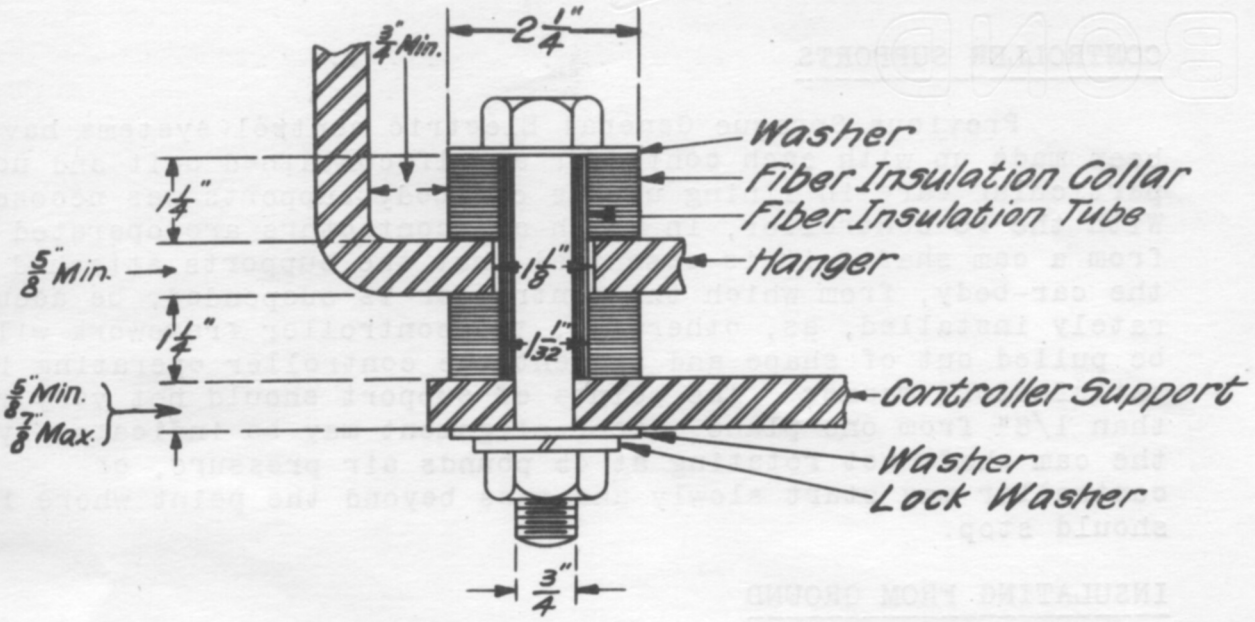
The insulation between the supports and the controller should be installed so that the bolts fastening the controller to its supports are not grounded. The method of insulation recommended is shown on Page 16.

The insulating joint used in the air pipe should be placed in a vertical pipe to prevent water collecting on the interior insulating surface.

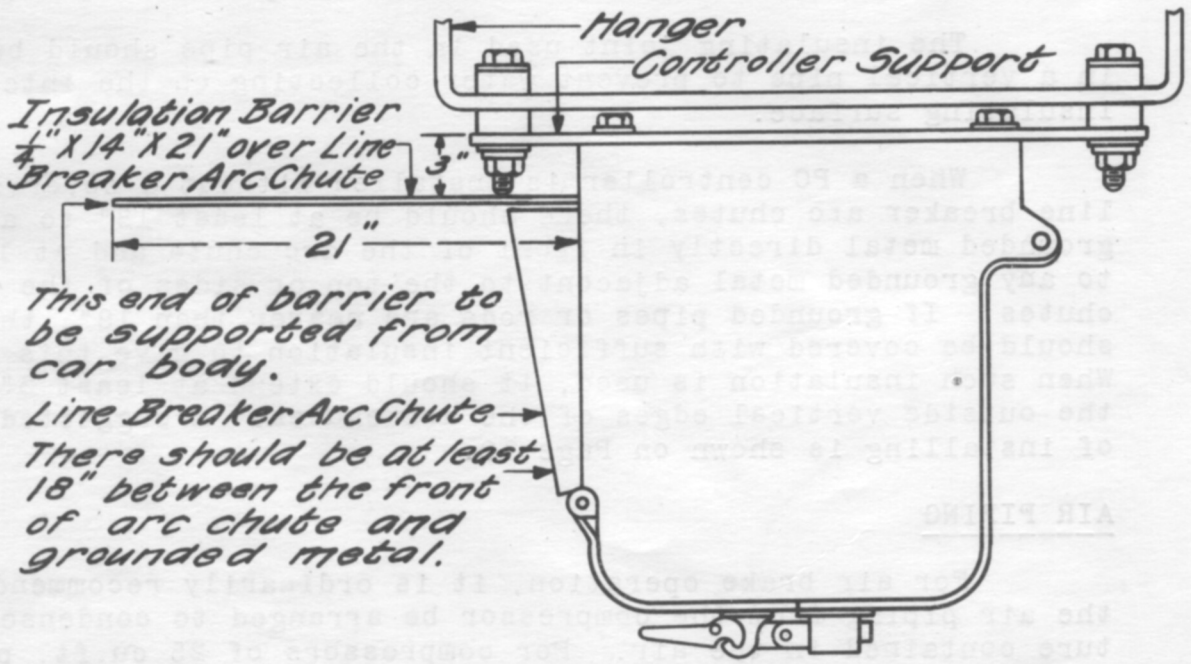
When a PC controller is installed without a cover over the line breaker arc chutes, there should be at least 18" to any grounded metal directly in front of the arc chute and at least 8" to any grounded metal adjacent to the top or sides of the arc chutes. If grounded pipes or rods are nearer than 18", they should be covered with sufficient insulation to give this distance. When such insulation is used, it should extend at least 3" beyond the outside vertical edges of the arc chutes. A suggested method of installing is shown on Page 18.

AIR PIPING

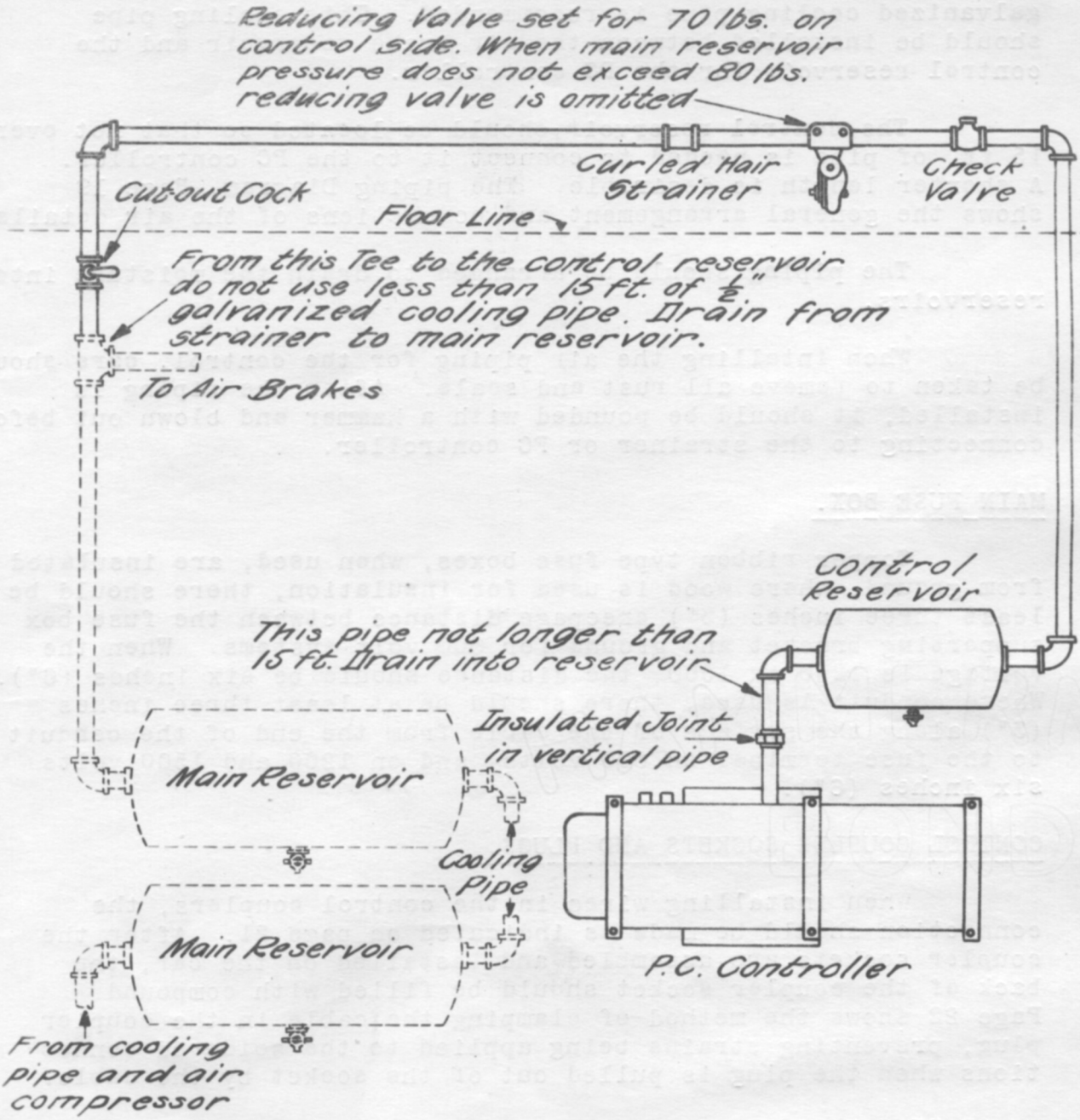
For air brake operation, it is ordinarily recommended that the air piping from the compressor be arranged to condense moisture contained in the air. For compressors of 25 cu.ft. per Min, capacity, not less than 25 ft. of cooling pipe is used. With compressors of larger capacity, a greater amount of cooling pipe is required.



Method of Insulating PC Controllers.



For Controllers without Covers over Arc Chute.



Piping Connections P.C. Control

For the PC controller, at least 15 ft. additional 1/2" galvanized cooling pipe is recommended. This cooling pipe should be installed between the air brake reservoir and the control reservoir for the PC controller.

The control reservoir should be located so that not over 15 ft. of pipe is needed to connect it to the PC controller. A shorter length is desirable. The piping Diagram, Page 19 shows the general arrangement and connections of the air details.

The piping should be arranged to drain the moisture into reservoirs.

When intalling the air piping for the control, care should be taken to remove all rust and scale. After the piping is installed, it should be pounded with a hammer and blown out before connecting to the strainer or PC controller.

MAIN FUSE BOX.

Copper ribbon type fuse boxes, when used, are insulated from ground, where wood is used for insulation, there should be at least three inches (3") creepage distance between the fuse box supporting bracket and ground for 600 volt systems. When the voltage is 1200 or 1500, the distance should be six inches (6"). Where conduit is used, there should be at least three inches (3") along the surface of the cable from the end of the conduit to the fuse terminal on 600 volts, and on 1200 and 1500 volts six inches (6").

CONTROL COUPLER SOCKETS AND PLUGS.

When installing wires in the control couplers, the connection should be made as indicated on page 21. After the coupler sockets are assembled and installed on the car, the back of the coupler socket should be filled with compound. Page 22 shows the method of clamping the cable in the coupler plug, preventing strains being applied to the soldered connections when the plug is pulled out of the socket by the cable.

MOTOR RESISTORS.

Porcelain bolt insulators are furnished for the supplemental insulation between the individual resistor frames and their hangers, as shown on Page 23. When installing, the bolt insulators should be arranged to prevent the short circuiting of the porcelain position by mud or grounded metal.

Grounded conduit should not be supported from the resistor frames.

Method of making Cable Connections in Type M Control Couplers

Fig 1
Insulation removed

Fig 2
Wires formed into „T" and pinched flat

Fig 3
Conductor inserted into Terminal. Wires projecting from Slots.

Fig 4
Terminal pinched together, by means of Gas Pliers to firmly grip the insulation.

Fig 5
Wires bent close to Terminal (on one side) ready for soldering.

Fig 6
Soldered (on one side only).

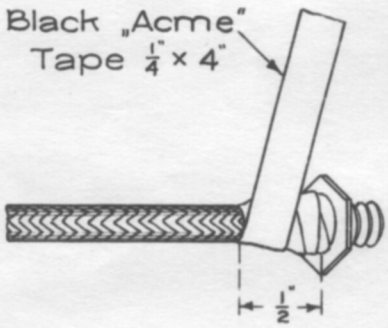
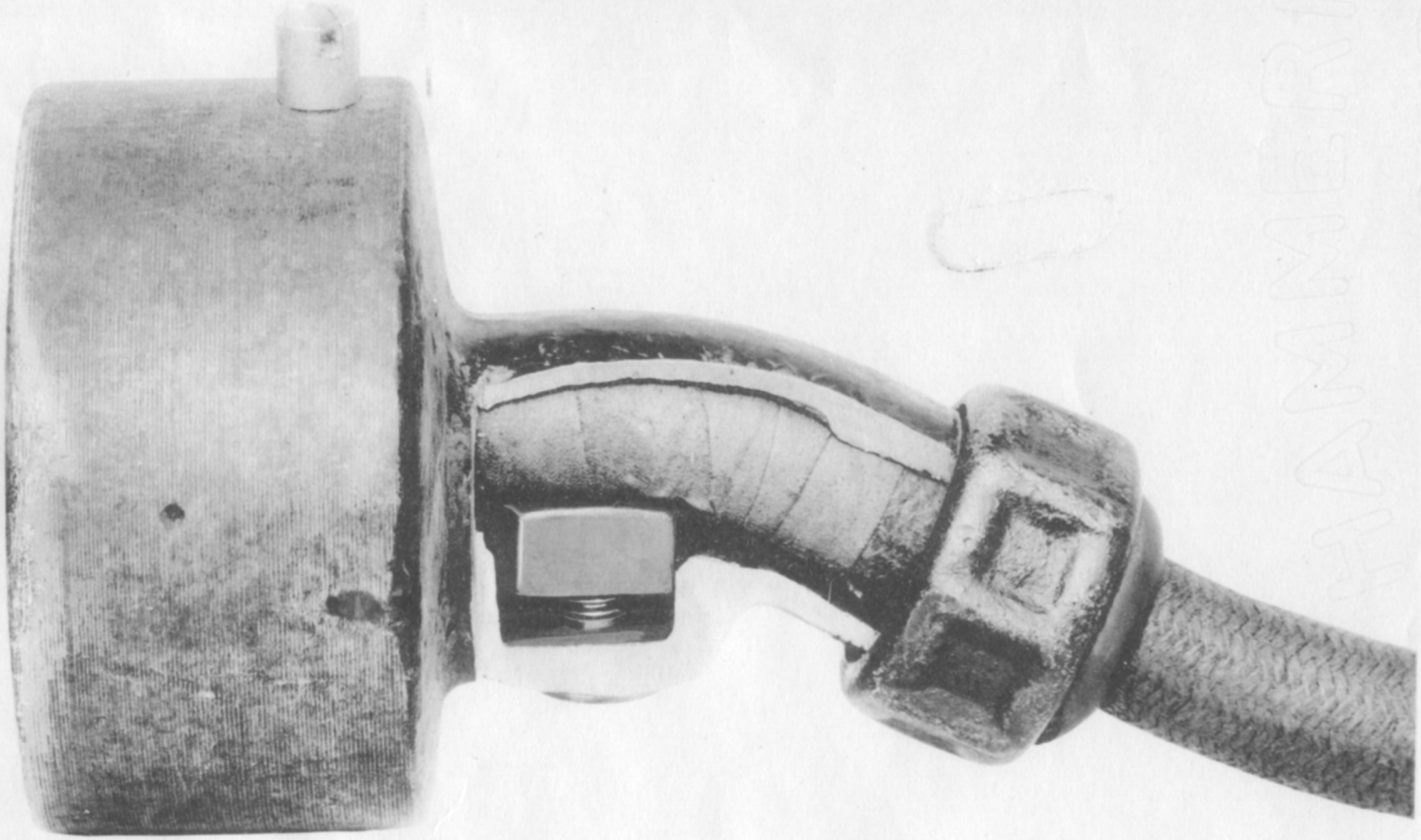


Fig 7
Tape to Dimension

Checked H. S. Carl
Engineering Dept.

D.S. 1981 General Electric Company 7 Aug 1901

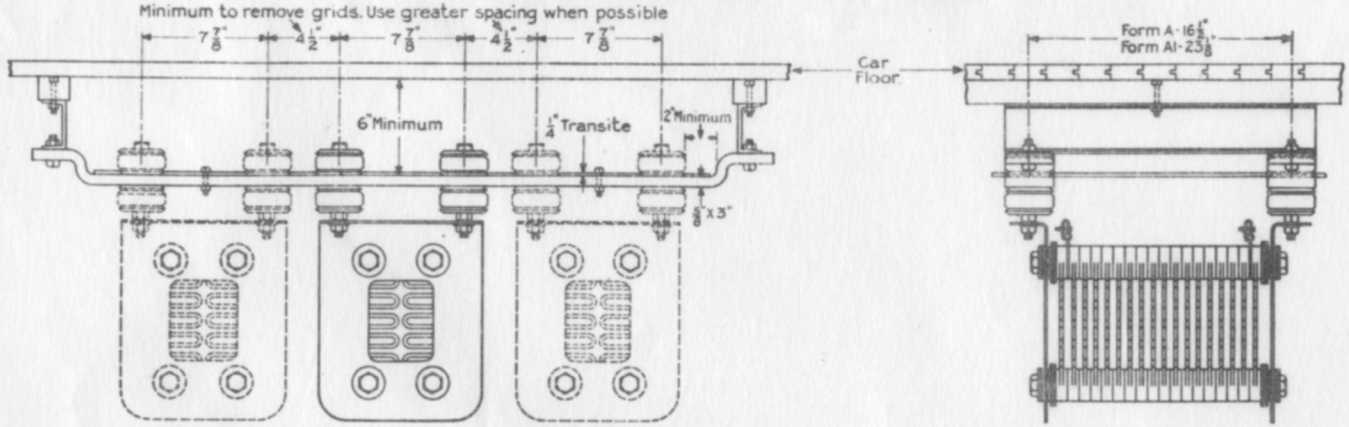
W. TORP.
84700-21

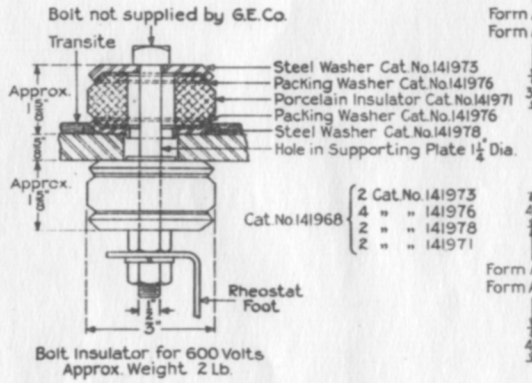


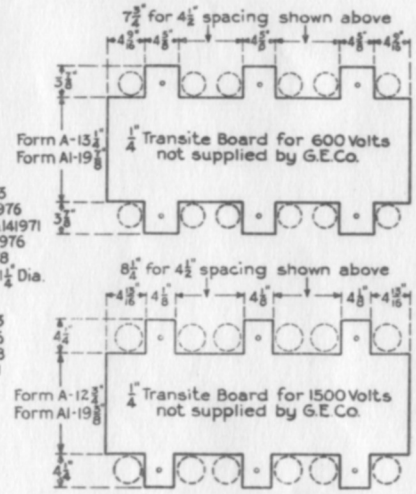
314992 TYPE DC COUPLER PLUG SHOWING METHOD OF CLAMPING THE CABLE.
ACTUAL SIZE INDEX E-341.4 5 7 17

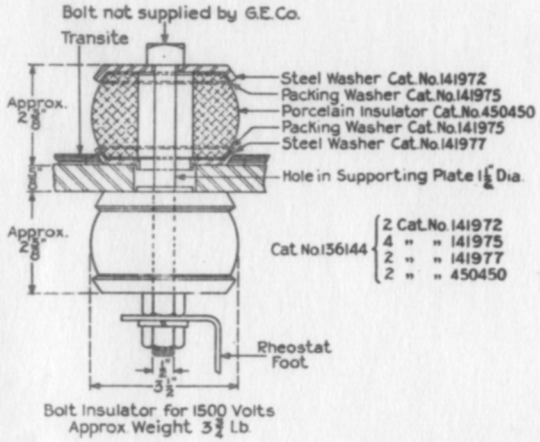
84700-22

METHOD OF SUPPORTING TYPE RG RESISTORS USING PORCELAIN BOLT INSULATORS FOR 600- AND 1500-VOLT WORK









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84700-23

1 JUNE, 1918

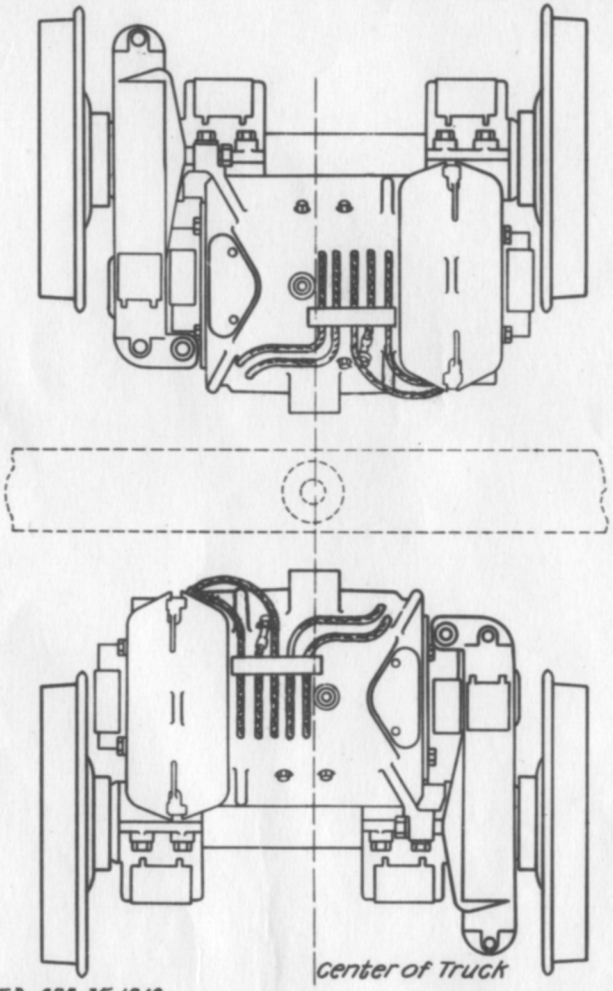
No. 15080

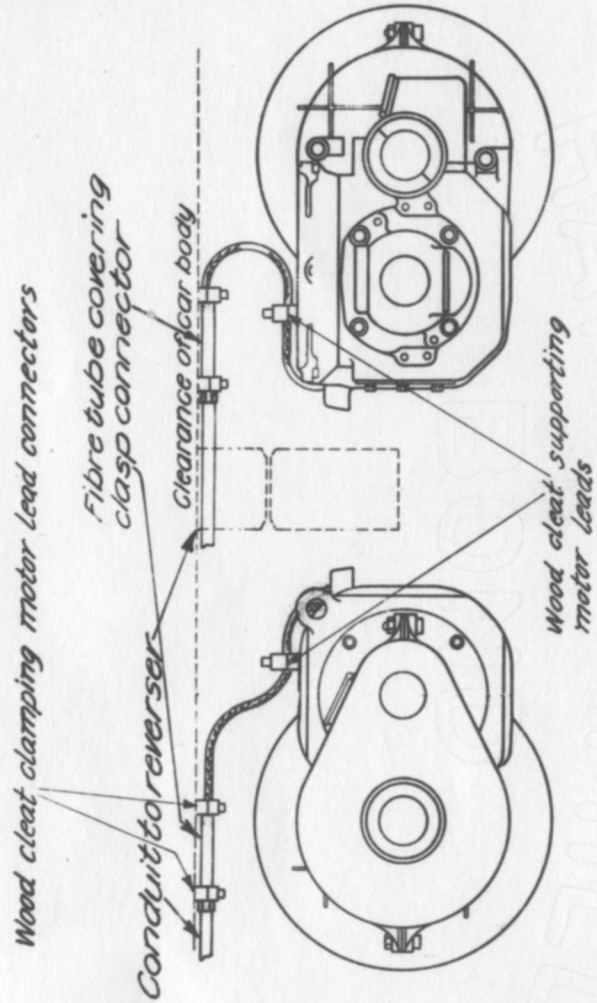
Supersedes { DS 25877 / DS 25878

ENGINEERING DEPT.
GENERAL ELECTRIC COMPANY

2m 5-3-18

Diagram of Railway Motor Connections to Car Body
for use with Type M Control





(2) REVISED APR. 25, 1910

Checked C.B.C.

Approved

12 Apr. 1911

Engineering Dept.
General Electric Company

DS 22426

1-2-5

84700-24

SEQUENCE OF PC CONTROLLERS

To reduce the burning of contactor arc chutes to a minimum, it is essential that there be a definite relation between the closing and opening of some of the contactors, though adjustment to maintain this relation is not required for normal wear. This relation of contacts should be noted when a contactor is installed in the controller or the contactor pins and bearings are badly worn. To obtain the relation of contacts, turn the cam shaft with a wrench and see that the sequence, as noted below is obtained.

SEQUENCE FOR PC-5 AND PC-6 CONTROLLERS.

When the cam shafts of the PC-5 and PC-6 controllers are turned on between points 2 and 3, the tips of the R-4 contactor should touch before the tips of the R1 and R3 open. Between points 5 and 6, the tips of P contactor should touch before the tips of R3, R4, R5 or S open and the tips of R5 contactor should be separated before the tips of R2 contactor touch. The tips of S contactor should be separated before the tips of G contactor touch.

SEQUENCE FOR PC-9 CONTROLLER.

When the cam shaft of the PC-9 controller is turned on between points 5 and 6, the tips of P contactor should touch before the tips of contactors R1, R3 or S separate and the tips of R3 and S contactors should be open before the tips of the G contactor touches.

SEQUENCE FOR PC-10 CONTROLLER.

When the cam shaft of the PC-10 controller is turned on, between points 5 and 6, the contact tips of the B contactor should touch before contact tips of the S, R12 and R22 contactors open. Between points 6 and 7, the tips of the P contactor should touch before the tips of B contactor open and the tips of the B contactor should be out of contact when the tips of the G contactor touch.

SEQUENCE FOR PC-12 CONTROLLER.

When the cam shaft of the PC-12 controller is turned on between points 2 and 3, the tips of the R3 contactor should touch before the contact tips of contactors R4 and R5 separate. Between points 4 and 5, also 8 and 9, the tips of the R5 contactor should touch before the tips of R3 separate. Between points 5 and 6, the tips of P contactor should touch before tips of S or R5 separate and the tips of the S contactor should be open before the tips of the G contactor touch.

SEQUENCE FOR PC-101 CONTROLLER.

When the cam shaft of the PC-101 controller is turned on between points 2 and 3, the tips of the R3 contactor should touch before the tips of either the R4 or R5 contactors separate. Between points 5 and 6, the tips of the P contactor should touch before the tips of R5, S1, and S2 contactors separate and the tips of contactors R5, S1 and S2 should be separated when the tips of contactors R3 and G touch. Between points 8 and 9, the tips of R5 contactor should touch before the tips of R3 contactor separate.

PC-5, PC-6 and PC-9 CONTROLLERS.

CONTACTOR UNITS, CONTROL DRUM AND CAM SHAFT.

The removal and replacement of these parts are exactly the same as for the PC-10 and PC-12 controllers. The description will be found on a following page.

LINE BREAKER.

The ARC CHUTE is removed by taking out two cap screws. These cap screws are accessible from the bottom of the controller and are located in the arc chute pole pieces, on the outside of the arc chute, adjacent to the contact tips.

To remove the line breaker PISTON PACKING, it is necessary first to take off the arc chute, then take out one of the transite barriers. This allows the pins thru the operating and contact levers and the levers to be taken out. The cylinder head may now be taken off and the piston packing removed.

REVERSER.

The reverse cylinder may be removed by disconnecting and removing the cutout switch and end bearing of the reverser. Then the reverse cylinder may be taken out thru the door that covers the cutout switch.

PC-10 and PC-12 CONTROLLERS.

CONTACTOR UNITS.

When a complete contactor is put in the PC-10 or PC-12 controller, its position may be located from its cam roller. Slotted holes in the contactor support provide means of adjustments. As all of the cam rollers are in line, a straight edge held against those in position will locate the one being put in.

The arc chute should be closed before the cap screws fastening the contactor in place are finally tightened, in order that the contactor may shift sideways until it takes its correct position.

CONTROL DRUM

In order to remove the control drum, take out the cap screws holding the bearing at the line breaker end of the cylinder. Then slip the bearing off the shaft and the drum can be easily disengaged from the clutch and removed.

It is possible to put the control drum in place 180° from its correct position, and to prevent this, the two parts of the clutch, between the drum and the cam shaft, are marked.

CAM SHAFT AND PINION

To remove the cam shaft, first take out the control drum, then take off the steel strap used as a stop for the covers. The cap bolts holding the cam shaft bearings can now be taken out and the cam shaft removed.

In order that the cam shaft and pinion may be correctly assembled in the rack, the best method is to mark the pinion and rack before taking these parts out. In case this is not done, the rack and pistons should be pushed toward the "on" magnet valve as far as they will go. The cam shaft and pinion are then put in place, so that none of the cams touch the cam rollers on the contactors.

LINE BREAKER

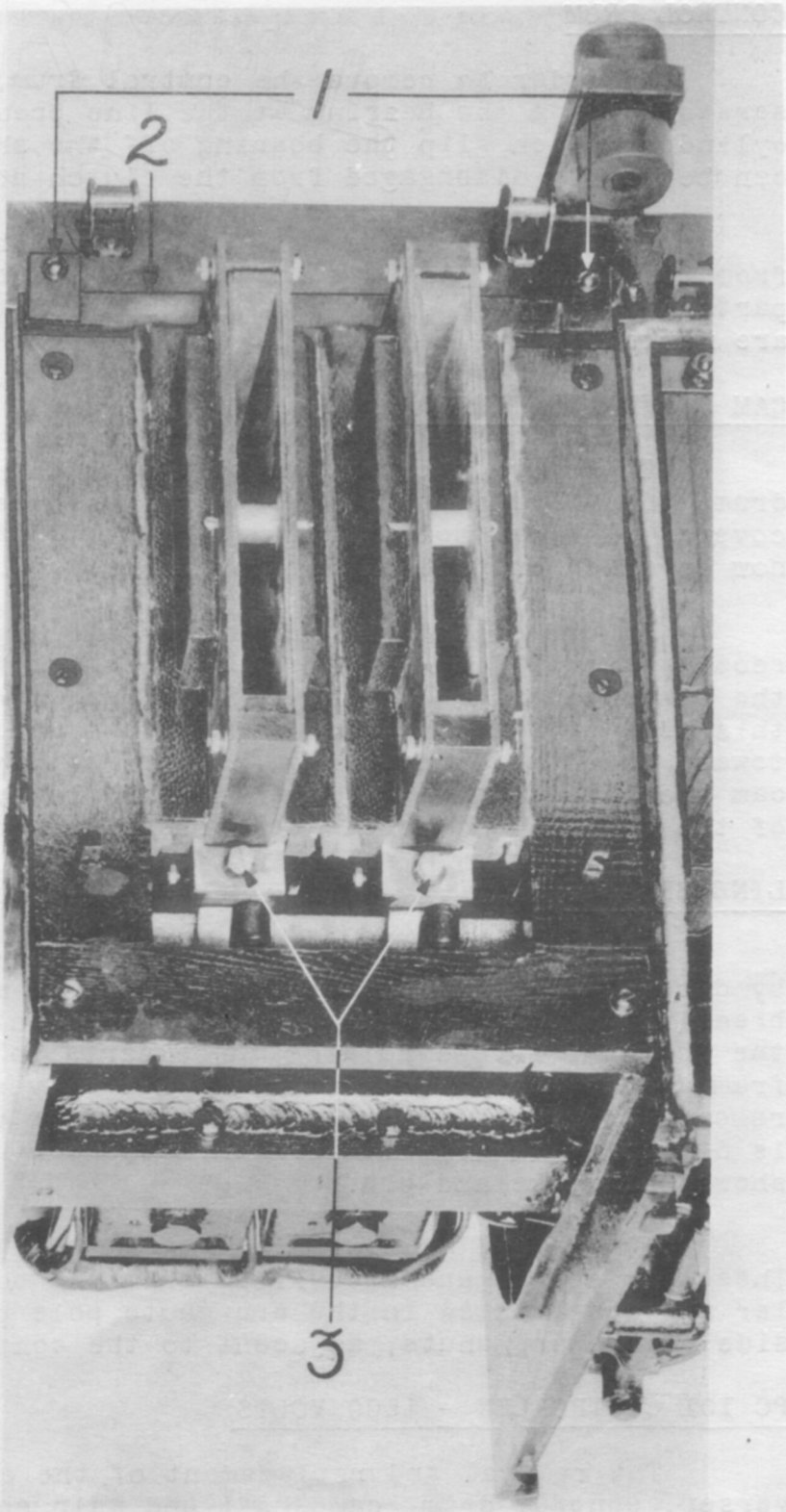
The PNEUMATIC PORTION of the line breaker is removed by disconnecting the control leads on the magnet valves, breaking the air connection at the pipe union and removing the four cap screws holding these parts to the controller frame. The air cylinders and magnet valves may then be removed toward the back of the controller until the yoke is disconnected from the pin thru the contact arm. Page 39 shows this yoke and pin.

The ARC CHUTE is removed by taking out two cap screws. These cap screws are accessible from the bottom of the controller and are located in the arc chute pole pieces, on the outside of the arc chute, adjacent to the contact tips.

PC 101 CONTROLLER - 1500 VOLTS

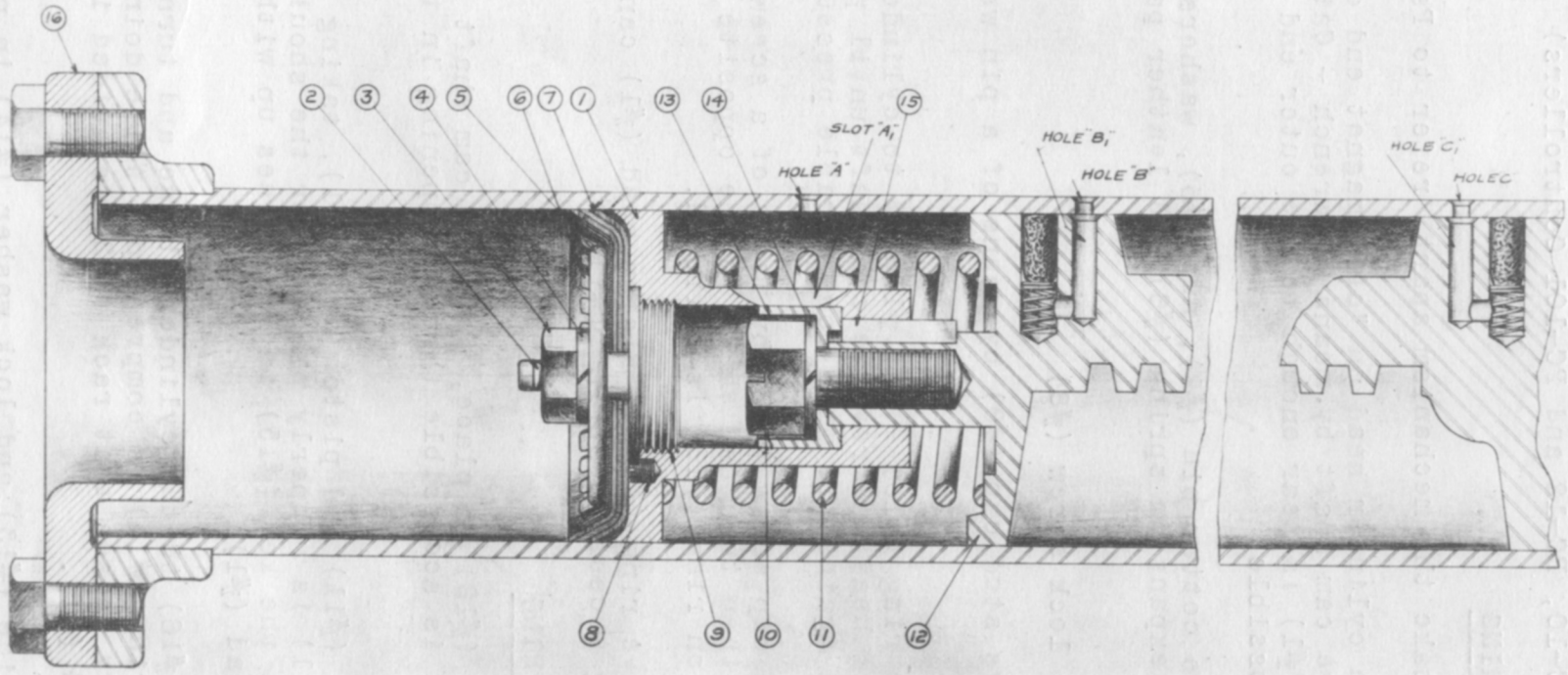
The removal and replacement of the contactor units, reverser, control drum, cam shaft and main engine parts are practically the same for the PC-10 and 12 controllers.

The Arc Chute is removed by taking out screw and parts as indicated by numbers 1, 2, and 3, on page 28.



316958 TYPE PC-101 CONTROLLER. PARTS TO BE DETACHED TO REMOVE ARC CHUTES OF LINE BREAKER.

INDEX E-353.7 12 7 17



Section Thru Main Engine Showing Piston for Types PC-10, PC-12 and PC-101 Controllers.

84700-29

MAIN ENGINE

(PC-10, PC-12 and PC-101 Controllers)

REMOVING PISTON SPRING

In order to take the mechanism apart, refer to Page 29.

First, remove cylinder head on "off" magnet end of main cylinder and revolve cam shaft by means of wrench - Cat.#176776 until piston head (#1) is near enough to the outer end of the cylinder to be accessible.

Second, remove cotter pin (#2), nut (#3), washers (#4), and follower (#5), expansion spring (#6) and leather packing cups (#7).

Third, remove lock screw (#8)

Fourth, remove stud cap (#9) by means of a pin wrench, Cat.#176775

Fifth, fasten ring (#16) - Cat.#176773 to cylinder flange, in place of cylinder head and revolve cam shaft until piston head (#1) is forced against it with considerable pressure.

Sixth, remove cap screw (#10) by means of a screw-driver, Cat. #189905, and, then turn cam shaft in the opposite direction until the pressure on ring (#16) is relieved.

Seventh, remove ring (#16). Piston head (#1) can now be slipped out, giving access to spring (#11).

REPLACING PISTON SPRING

With the rack (#12) in place, turn the cam shaft until the end of the rack is accessible thru the opening in the end of the cylinder.

Insert spring (#11) and piston head (#1), taking care that the spring (#11) is properly placed over the shoulder on rack (#12) and that the key (#15) in rack lines up with the keyway in piston head (#1).

Fasten ring (#16) to the cylinder flange and turn the cam shaft until spring (#11) is compressed. While doing this, it will be necessary to see that rack (#12) is guided into the hole in piston head (#1).

Put piston guide (#13) and lock washer (#14) in place and screw cap-screw (#10) down firmly on the washer by means of screw-driver - Cat.#189905.

Remove wrench from cam shaft, thus allowing spring (#11) to drive rack (#12) out until piston guide (#13) bears against the shoulder in the bore of piston head (#1). See that the parts which slide are perfectly free and that the spring forces rack (#12) back without hesitation.

Remove ring (#16).

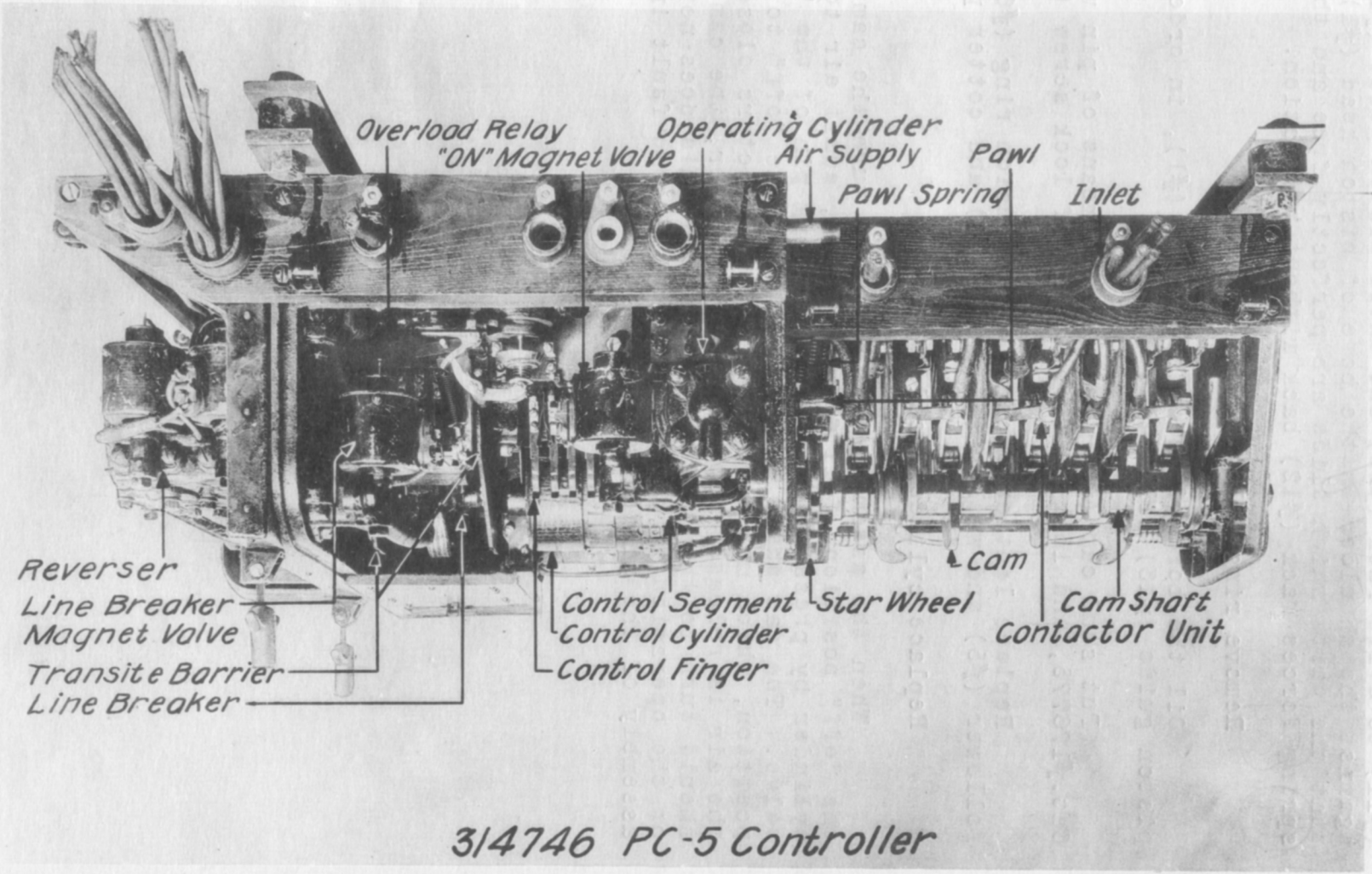
Oil the bore of the piston head (#1), in order that piston guide (#13) will slide easily.

Put stud cap (#9) in place, by means of pin wrench Cat.#176775, and lock it in by means of lock screw (#8).

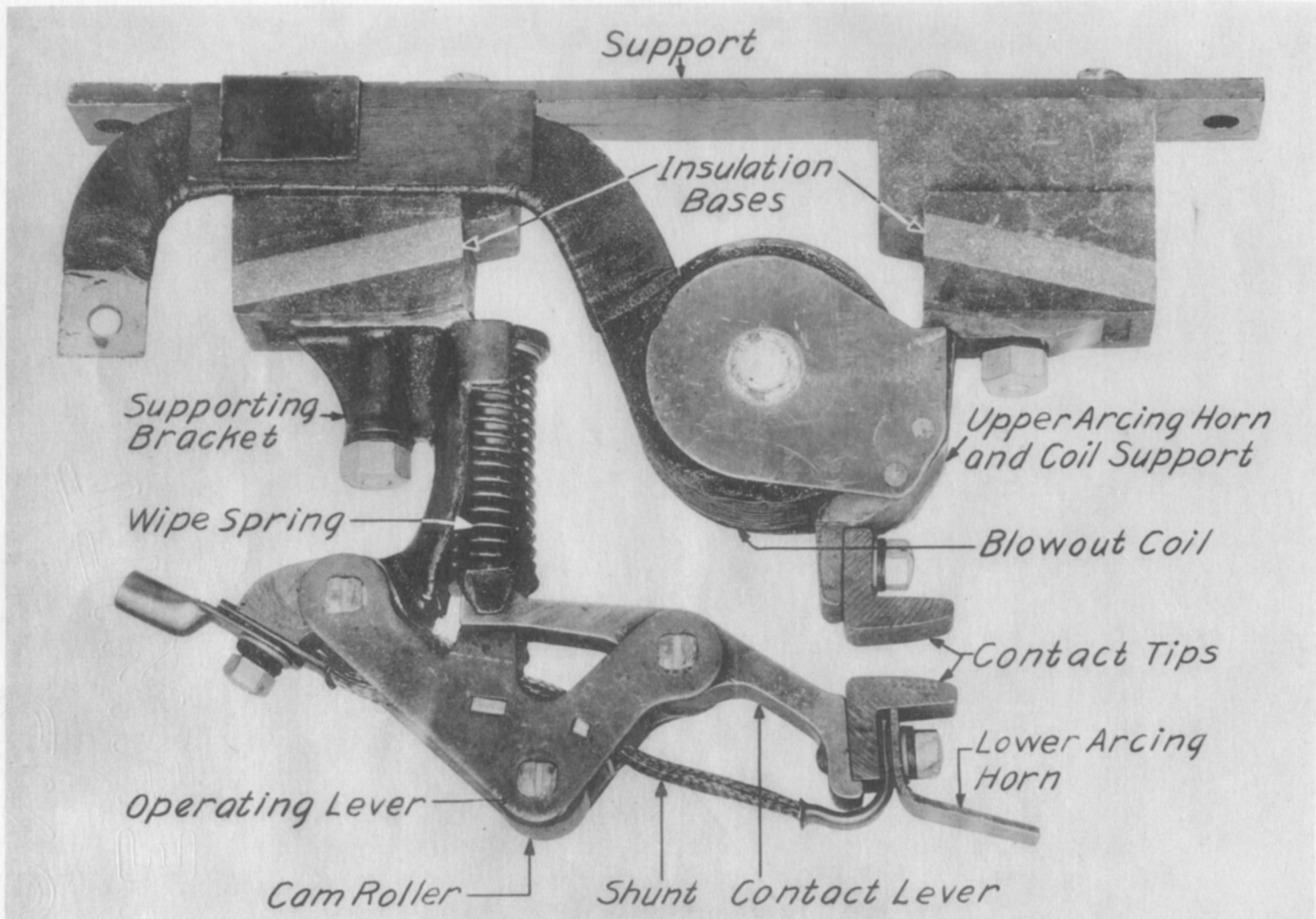
Replace leather cups (#7), expansion ring (#6), follower (#5) and washer (#4), nut (#3) and cotter pin (#2).

Replace cylinder head.

When the assembly is completed, turn the cam shaft to the "off" position, fill the air tanks, admit air to the "on" cylinder by pressing down the operating pin of the "on" magnet valve. The cam shaft should turn from the "off" to the first position, which may be noted by the contactors closed. When the air is released from the "on" cylinder, the cam shaft should turn to the "off" position. If this does not occur, or the operation is sluggish, there is some fault in the assembly of the piston spring.

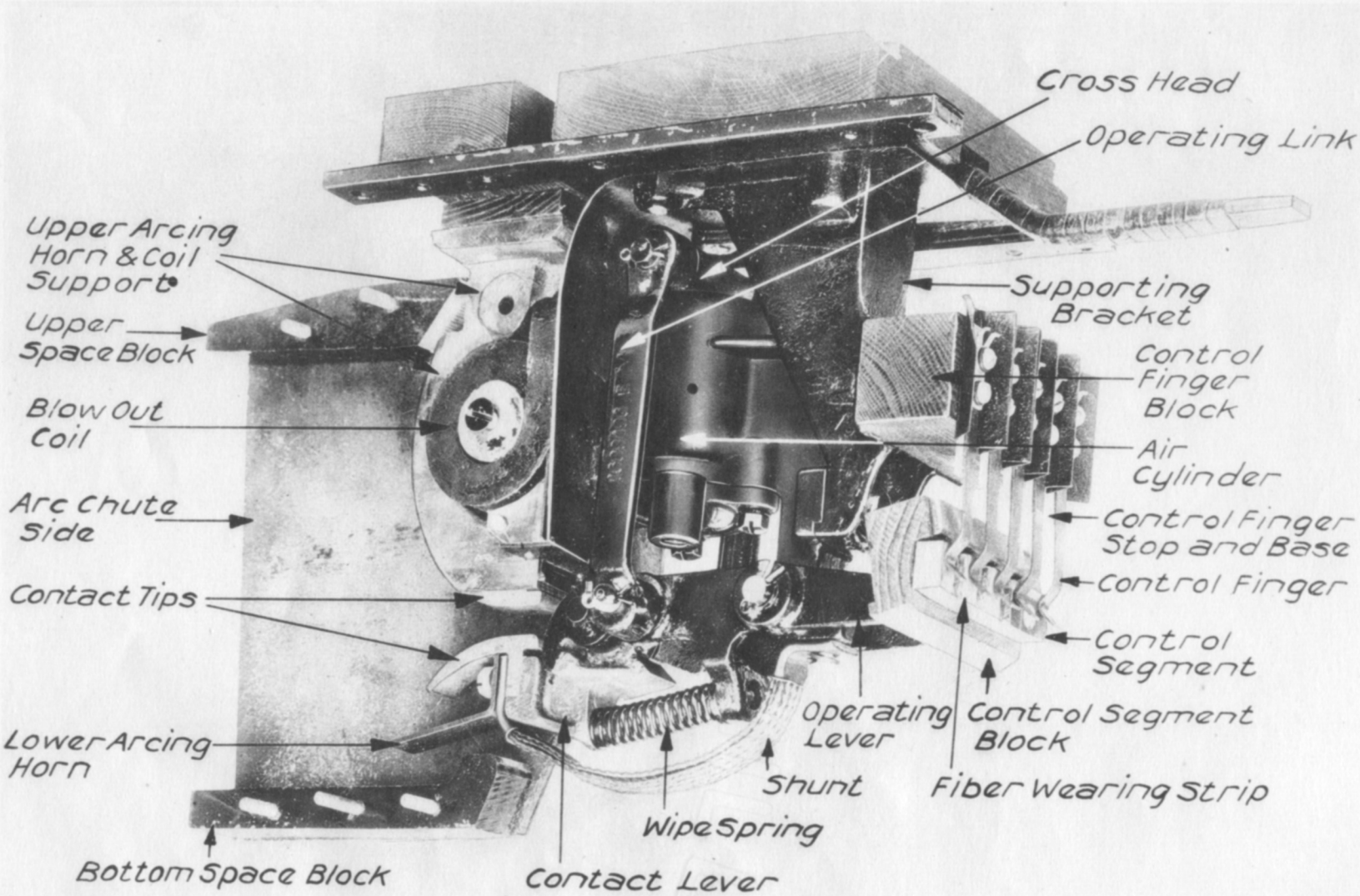


3/4746 PC-5 Controller



315355 Contactor Unit for Types PC5, PC6 and PC9 Controllers

84700-33



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314174 LINE BREAKER UNIT FOR TYPES PC-5, PC-6 AND PC-9 CONTROLLERS.

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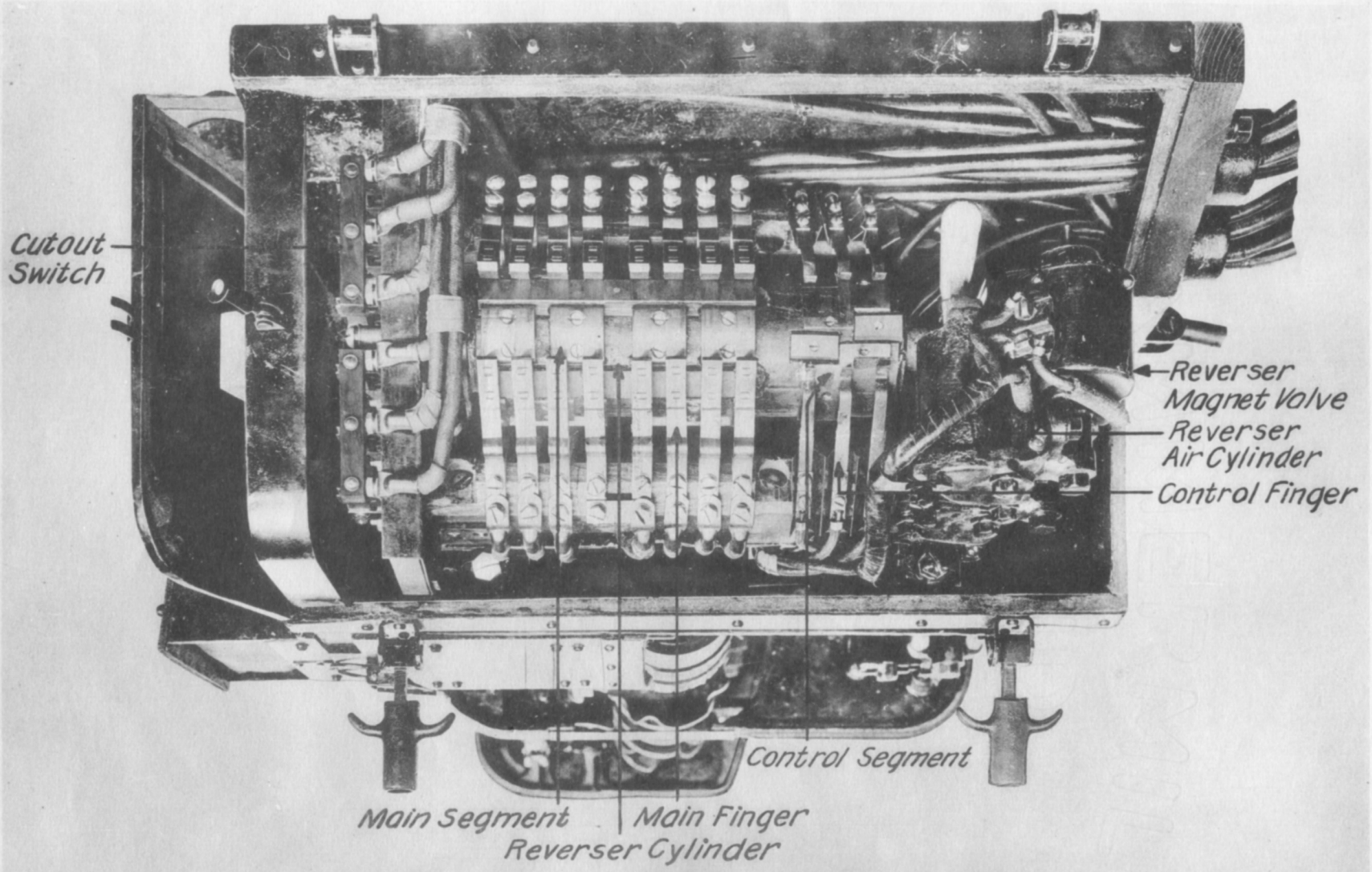
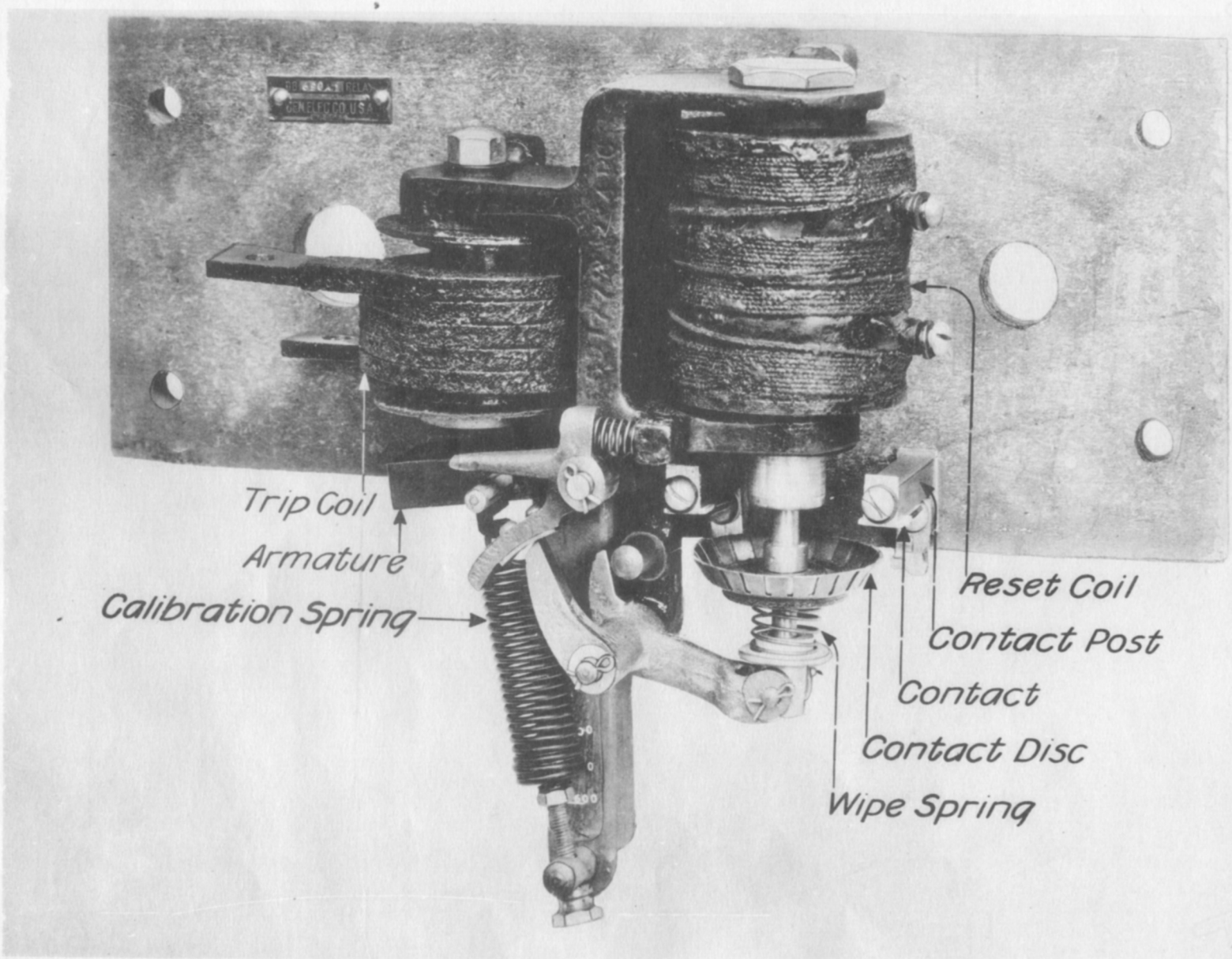


314745 PC-5 Controller (Reverser End.)

84700-35



314632 OVERLOAD RELAY FOR TYPES PC-5, PC-6 AND PC-9 CONTROLLERS.

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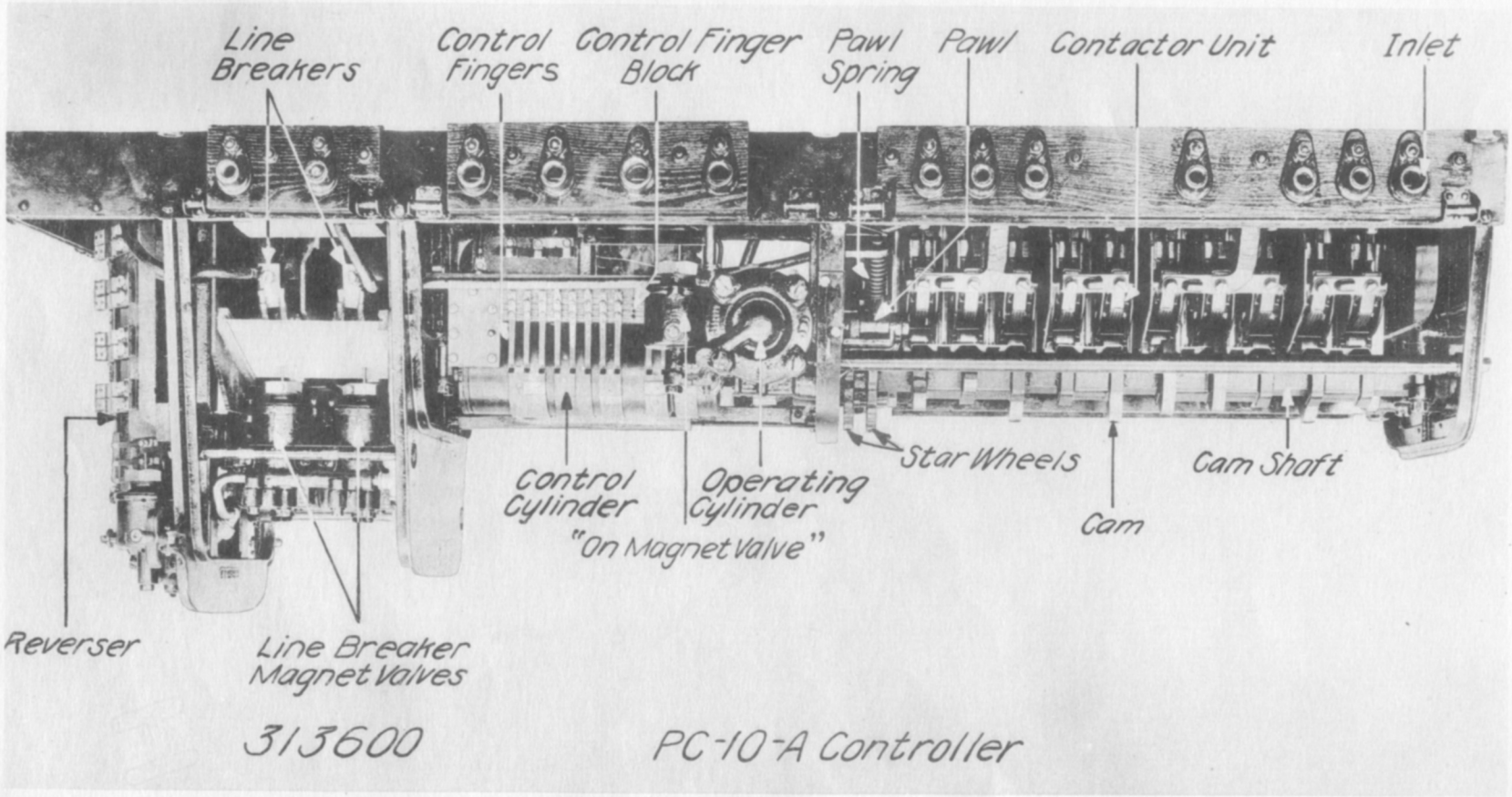
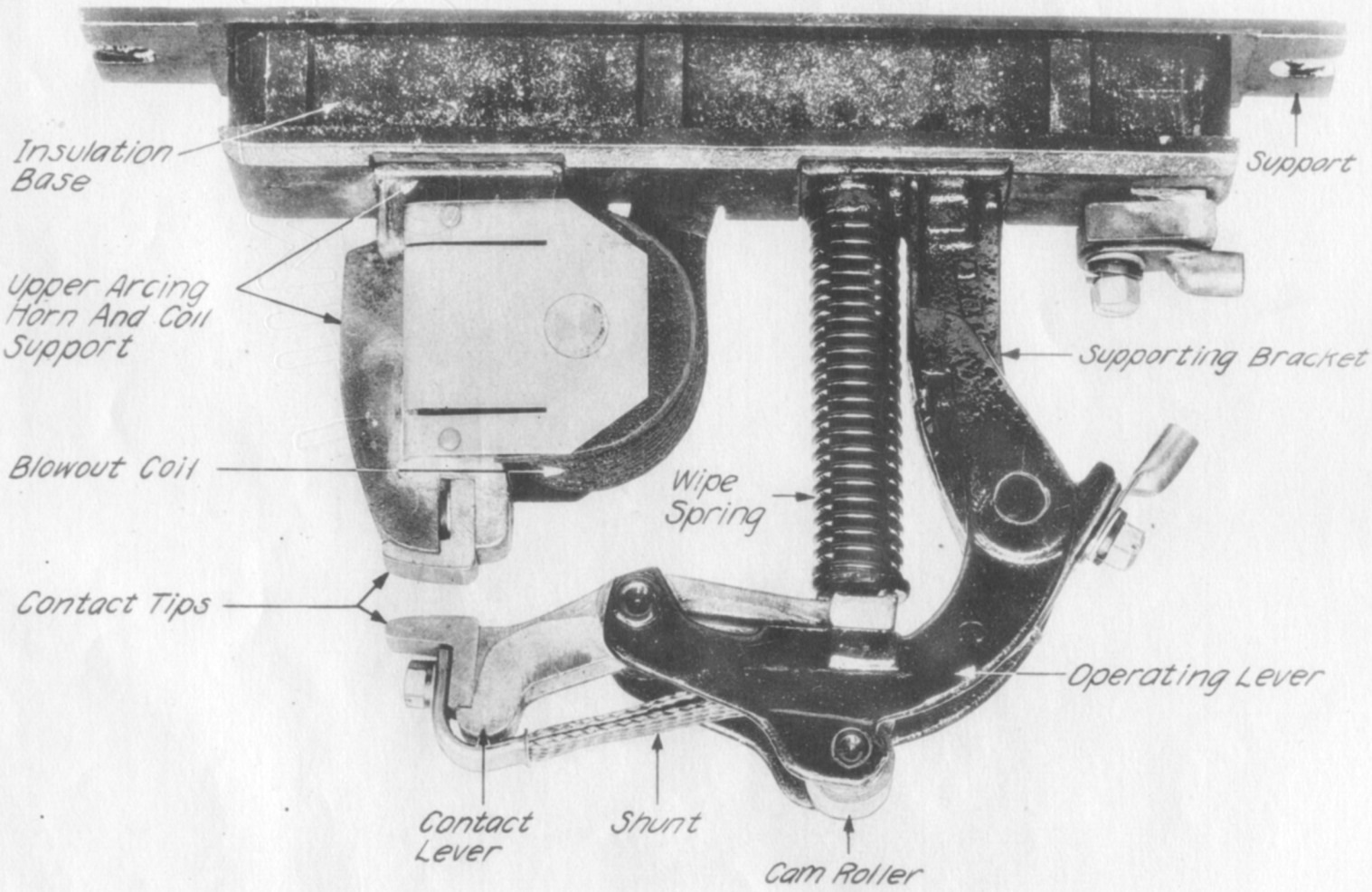


313600 PC-10-A Controller

84700-37



313601 CONTACTOR UNIT FOR TYPES PC-10 AND PC-12 CONTROLLERS.

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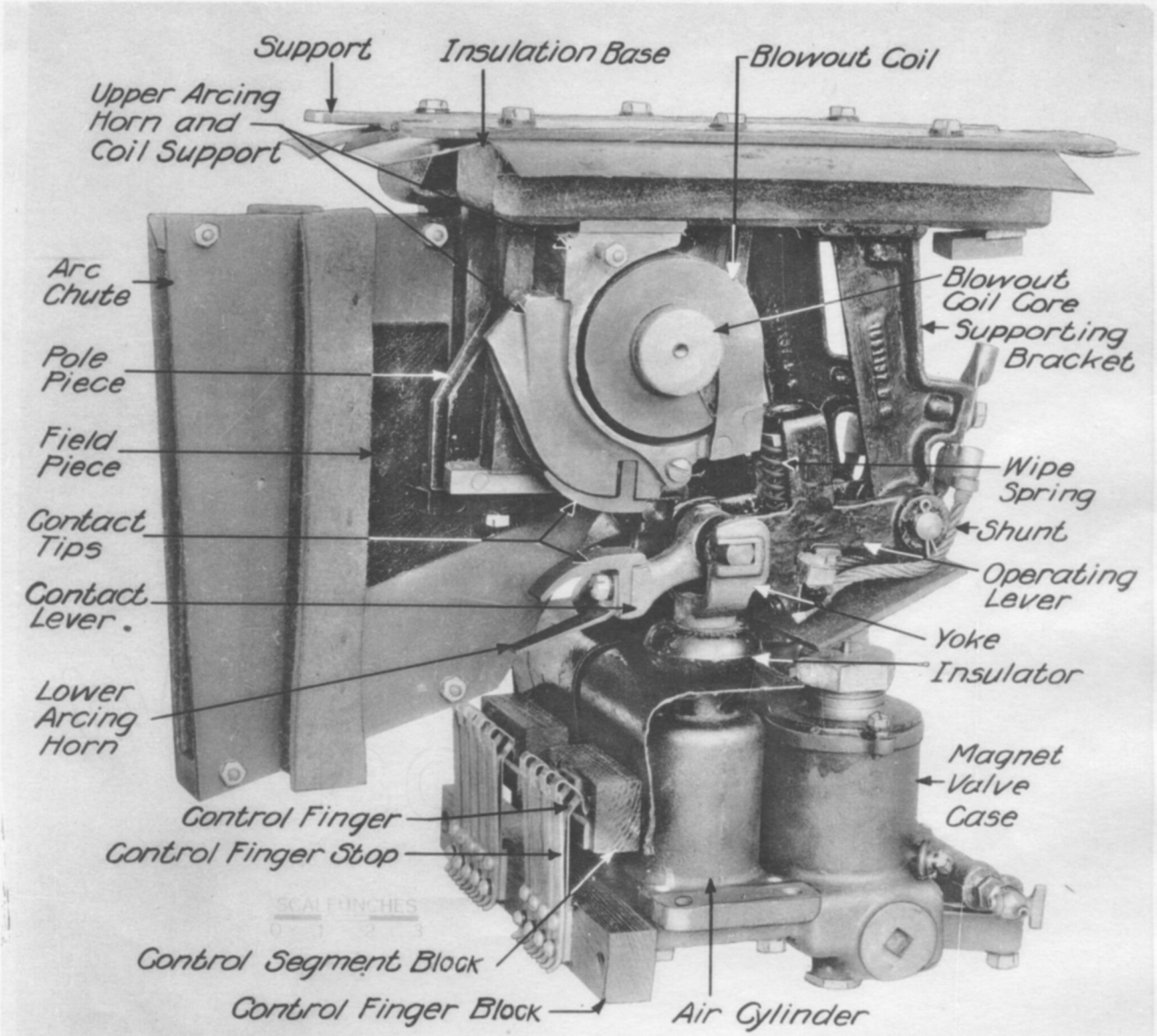

312493 LINE BREAKER UNITS FOR TYPES PC-10 AND PC-12 CONTROLLERS.

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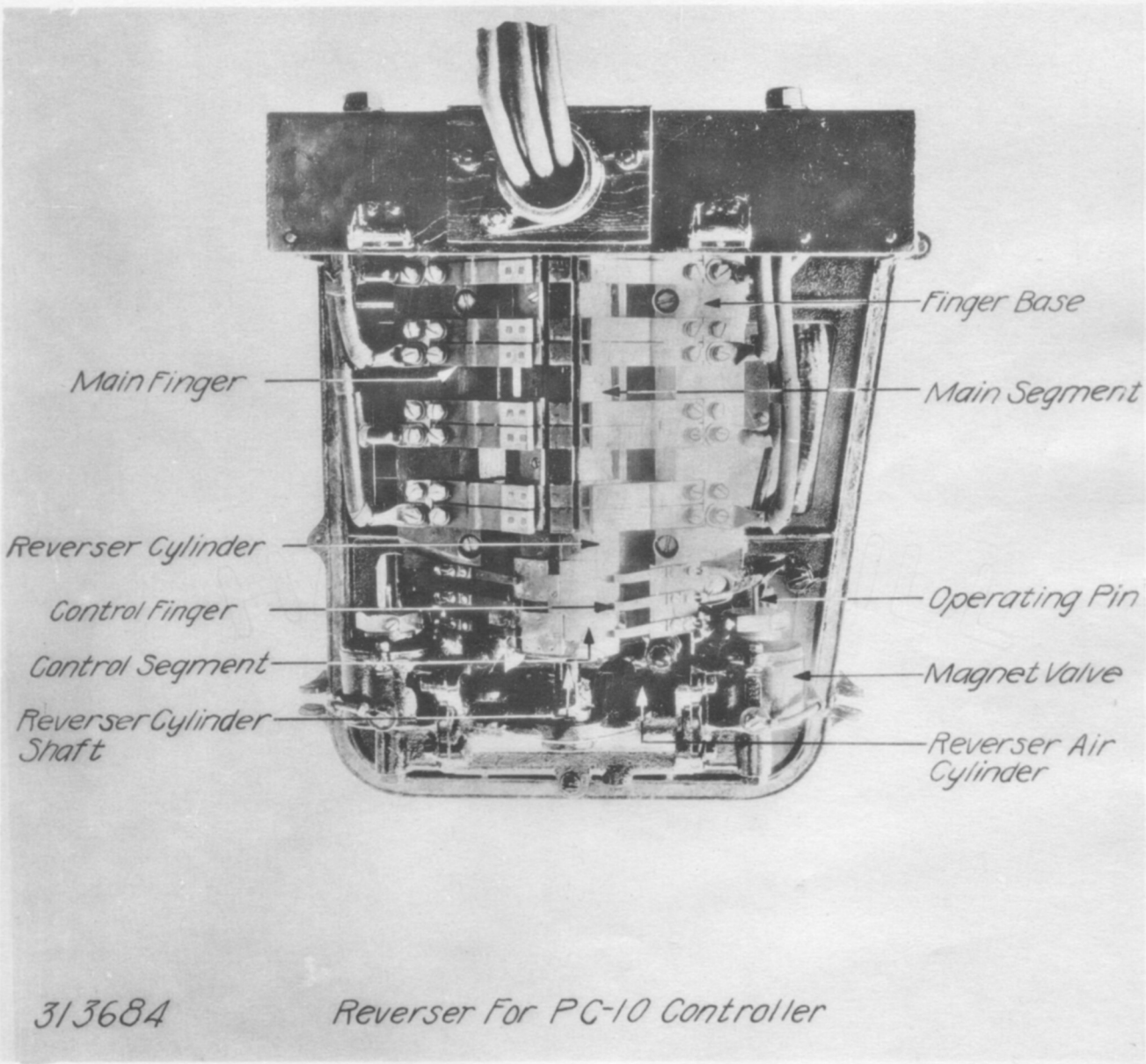
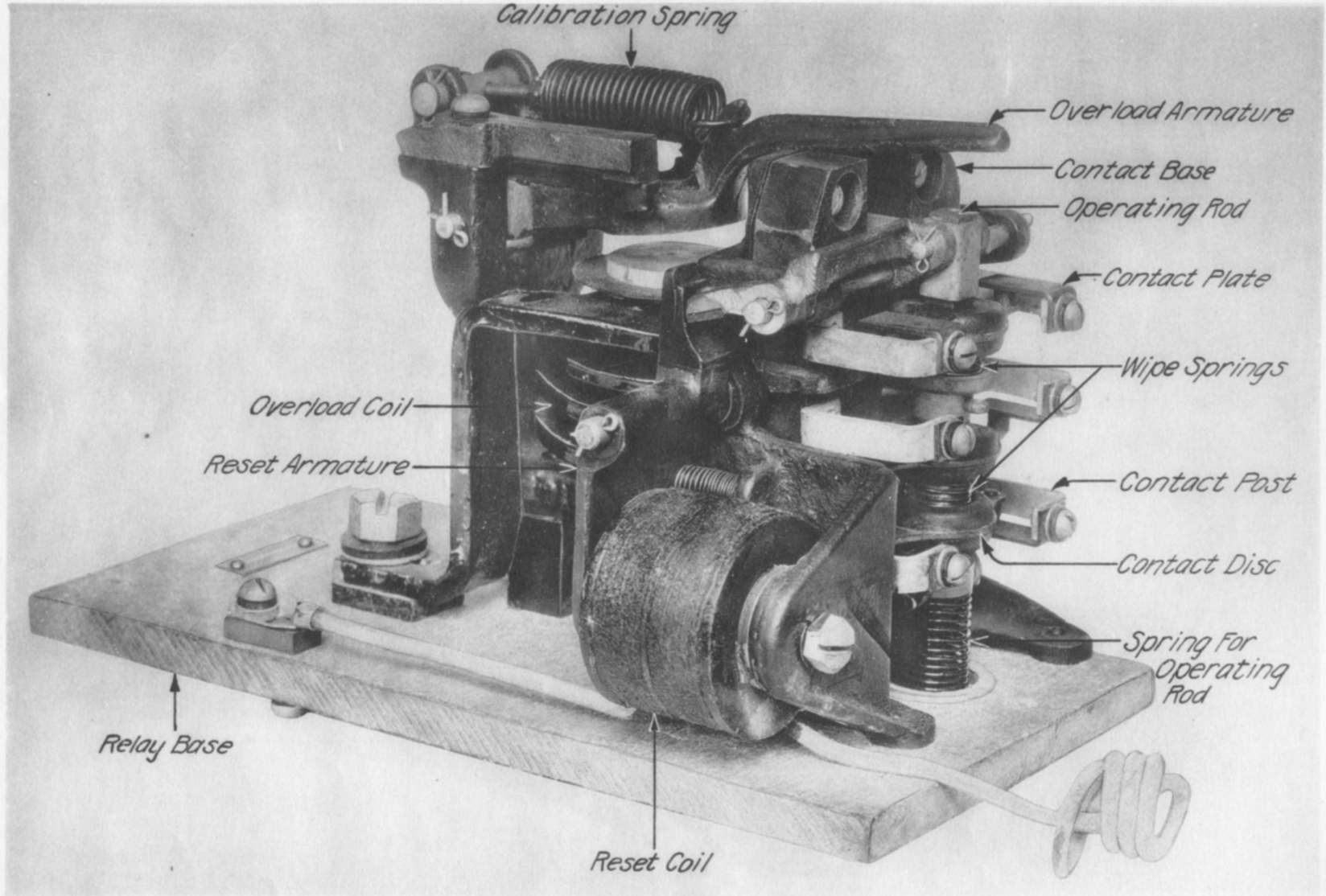


313684 Reverser For PC-10 Controller



313846 OVERLOAD RELAY FOR TYPES PC-10 AND PC-12 CONTROLLERS.

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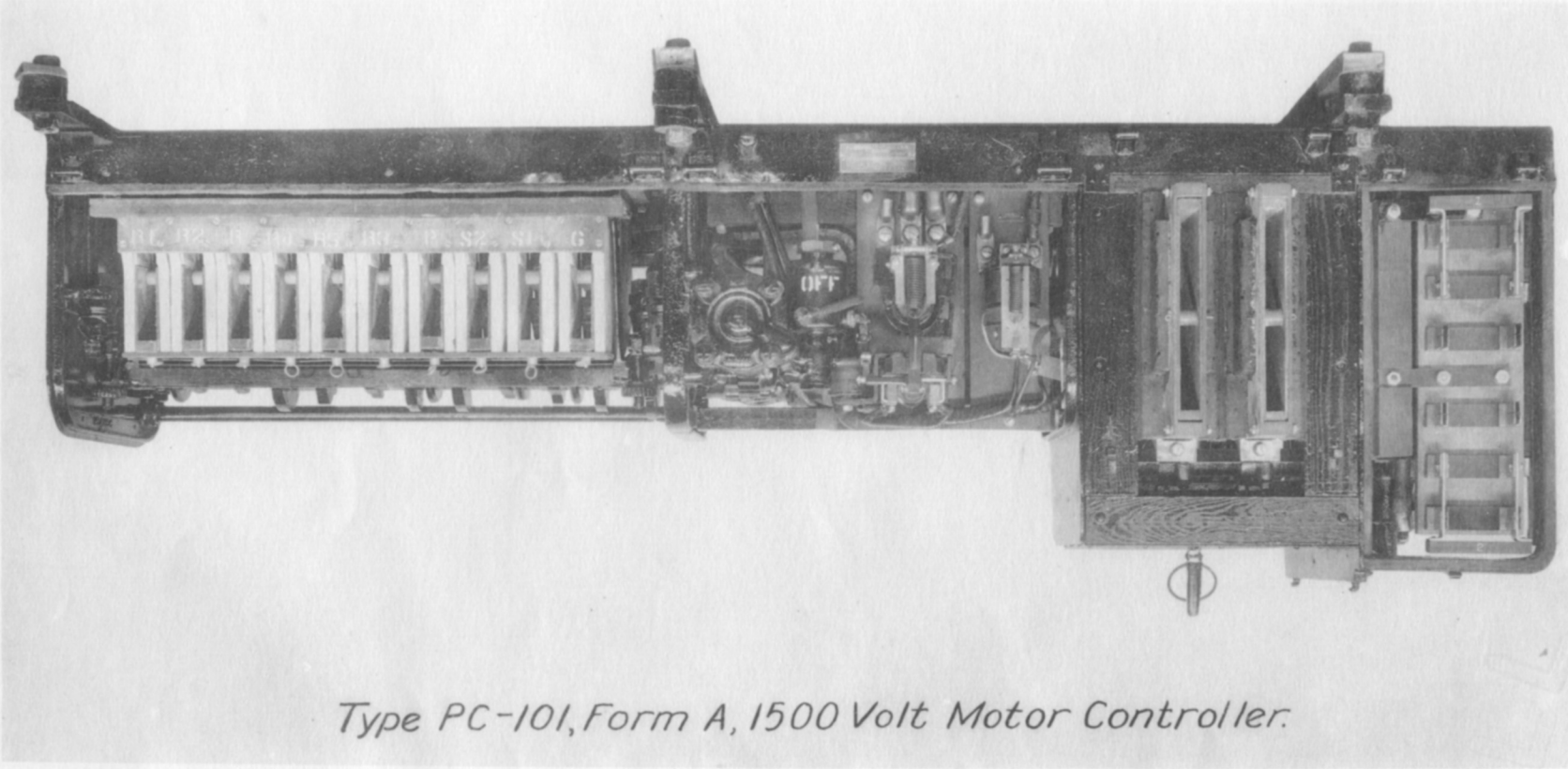

Type PC-101, Form A, 1500 Volt Motor Controller.

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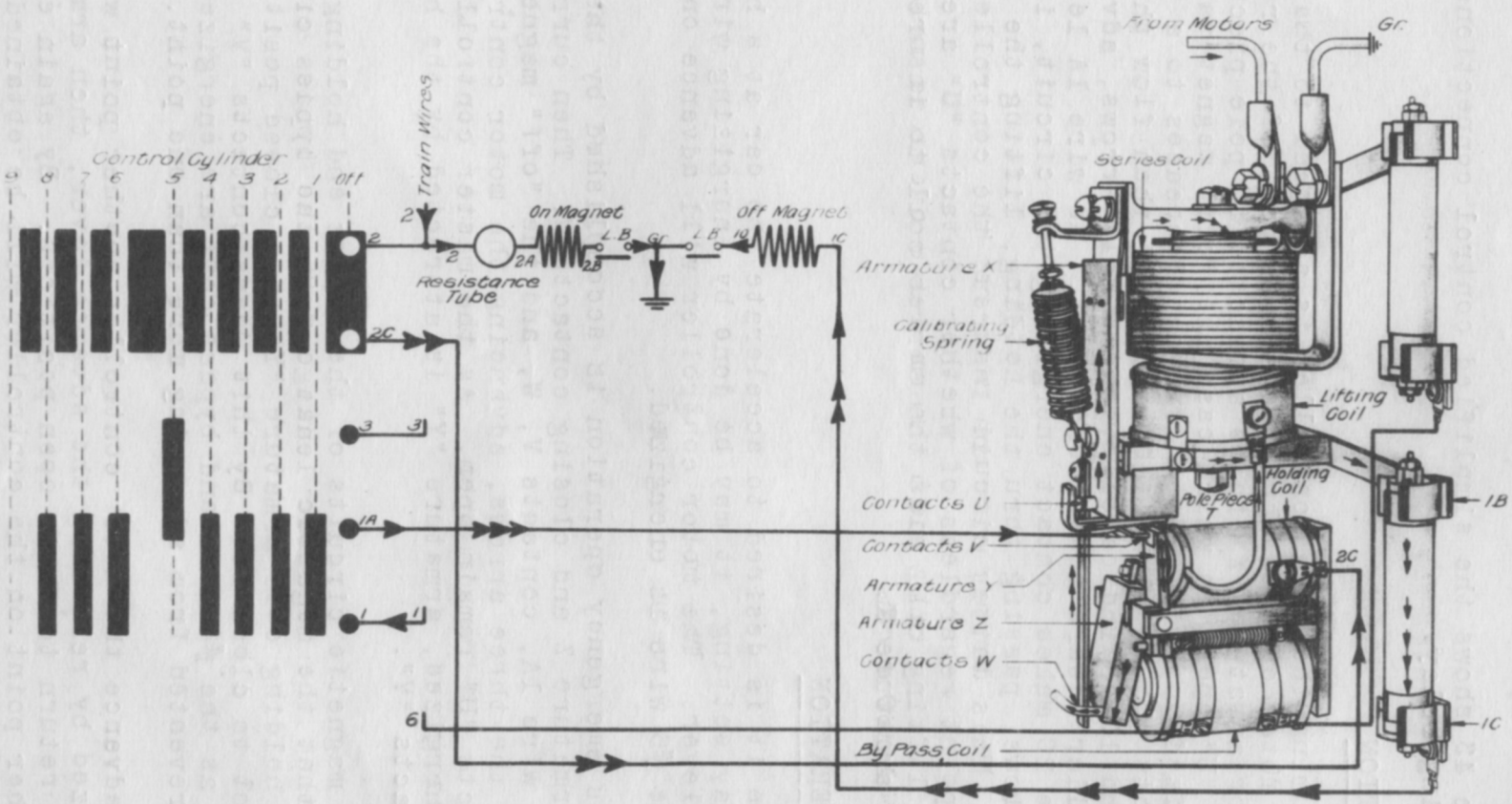

317831 TYPE DB-808 RELAY (CONTROL CONNECTIONS)

INDEX D 353 2 2 12 18

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OPERATION OF DB-808 NOTCHING RELAY

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Page 43 shows the simplified control connections of the DB-808 notching relay.

NORMAL OPERATION

Assuming the main controller is advanced to the first position and motor current thru the series coil of the relay is sufficient for armature "X" to be attracted to pole-piece "T" holding contacts "U" open, in which case the "off" magnet valve will not be energized until the motor current decreases to a value that allows contacts "U" to close. Current will then flow thru wires, 1, 1A, 1B, and 1C as indicated by the single arrows, advancing the motor controller toward the second point. As wire 1A leaves its segment, wire 2C makes contact energizing the circuit, indicated by double arrows, passing thru the holding, lifting the "off" magnet valve coils. This latter circuit insures; the controller advancing to the next point regardless of whether contacts "U" are open or closed. The lifting coil aids the series coil to insure positive operation of armature X.

EMERGENCY OPERATION

When it is desired to accelerate the car at a higher current than the relay setting, it may be done by energizing wire #6 with the advance lever. The motor controller will advance one point each time the #6 wire is energized.

This emergency operation is accomplished by the bypass coil attracting armature Z and closing contacts W. Then current will flow through wire 1A, contacts V, W, and the "off" magnet coil, as indicated by the three arrows, advancing the motor controller even though contacts "U" remain open. As the master controller advances wire 2C is energized, armature "Y" is attracted by the holding coil, opening contacts "V".

The magnetic circuits of the bypass and holding coils are so arranged that the magnetic leakage from the bypass circuit will maintain the holding coil armature "Y" in a closed position but is not sufficient to close it. By this means contacts "V" are held open as long as the #6 wire and bypass coil are energized and the controller prevented from advancing more than one point.

To advance the motor controller another point wire 6 must be de-energized by releasing the advance lever, then armature "Z" and "Y" will return to their open positions. By again energizing wire 6, another point on the controller will be obtained. Thus, any point on the control can be held by use of the advance lever.

MAINTENANCE

The work of maintaining equipments and the frequency of inspections necessary, depend greatly on local conditions, which are the real determining factors.

As a general rule, city equipments should be inspected every 500 to 1000 miles and interurban equipments from 1000 to 2000 miles.

OPERATING TEST

At each inspection the main switch should be opened and with an air pressure of not less than 60 lbs., the PC controller operated from each master controller, with the reverse handle thrown in the forward and reverse positions. This test immediately tells whether the pieces of apparatus are working. The PC controller will "notch up" in 3-1/2 to 4 seconds when properly lubricated and adjusted. This speed will decrease as the main engine piston leathers become dry. When the speed is 6 seconds, the cylinder should be lubricated.

The master controller should be held on points 1 and 2 long enough to insure that the PC controller definitely stops on the corresponding positions. The controller should be advanced a step at a time, the same as during acceleration, by using the "advance" lever on the master controller, or, by repeating the current limit relay by hand. The overload relay should be tripped by hand and reset from the cab.

INSPECTION

At each inspection the master controller, master control switches, main switch, fuse box and PC controller should be opened, examined, cleaned, adjusted or repaired if needed. The following points should be noted.

MASTER CONTROLLER:

(a) Inspect for weak fingers, imperfect contact and loose connections.

(b) When dirty, clean contacts and apply a small quantity of thin, lubricating oil to the contacts with a piece of cheese cloth.

CONTROL SWITCHES

(a) Inspect for poor contact.

(b) Clean and lubricate when needed.

MAIN SWITCH AND FUSE FOX:

(a) Inspect for loose terminals and poor contact.

PC CONTROLLER

At the first four or five inspections after the equipments are put in service, the cap screws fastening the main cable connections to the contactors, line breaker, reverser and relays should be examined to insure they are tight.

With the PC controller, the line breaker shunts and contactor shunts, contact tips and arc chutes as well as the control and reverse fingers and segments should be given particular attention. Valves and cylinders should be tried for air leaks. Relay contacts should be examined, and such parts as require it, lubricated.

Below is given a detailed description for the maintenance of these parts.

CONTACTORS AND LINE BREAKER:

(a) Examine contact tips and tighten screws holding them if loose.

(b) Renew contact tips when worn halfway through.

(c) When renewing a contact tip, if the surface against which it rests has become rough or pitted due to poor contact from a loose screw or similar cause, it should be smoothed up or else a new part installed.

(d) The contact tips of the line breaker and contactors close with a butting and rolling movement, which tends to remove any roughness caused by arcing. If, for any reason, the tips get extremely rough, they should be filed smooth.

(e) The screws holding the contactor and line breaker shunts should be examined to see that they are tight.

(f) The contactor and line breaker shunts should be examined for wear and breakage.

(g) Operate the line breaker by pressing the valve operating pin and note if the line breaker opens quickly. If it is sluggish, the operating cylinder and leather packings should be cleaned and lubricated.

(h) Examine the arc chute sides. When they are half burned through, they should be replaced by new ones.

REVERSER

(a) Inspect for weak fingers, poor contact and loose connections.

(b) When the contacts are dry or dirty, clean and lubricate with vaseline or lubricating oil.

(c) Operate the reverser by pressing on the valve pin. If the segments are clean and lubricated and the reverser is slow in operating, the air cylinders and packing leathers should be lubricated.

CONTROL FINGERS:

(a) At each inspection, the control fingers on the reverser, line breakers and control drum and their segments should be wiped clean with a piece of cheese-cloth that has been moistened with a thin lubricating oil. This is more essential when the control is operated from low potential (32 volts) than when trolley voltage is used.

(b) The control fingers when in contact with a segment should have sufficient pressure to make a good contact.

(c) The fingers should be replaced when worn half way thru, thereby, preventing delays to service from a broken finger.

OVERLOAD RELAY:

(a) Clean contacts when dirty.

(b) Trip the relay and see that the armatures move easily.

CURRENT LIMIT RELAY:

(a) Clean contacts when dirty.

(b) Move armatures by hand and see that they are free and move easily.

CONTROL DRUM

When segments are replaced on the control drum, they should be located with respect to the control fingers. This is quite necessary, as the circuit, which controls the stopping of the cam shaft for each controller point, is broken by these segments and control fingers.

Where other information is not available, it is suggested that measurements between the control finger and the old segment be made before its removal and used in locating the new segment.

STAR WHEELS.

The star wheels of the PC controllers, like those in a K controller, locate the controller notches. If the pawl springs are broken or become weak, the controller notches are not as definitely located as they will be when the spring pressure is normal. The pressure of the pawl roller against the star wheel, with the controller in the "off" position, for the PC-5, PC-6, and PC-9 controllers should be between 13 and 25 pounds, and for the PC-10, PC-12 and PC-101 controllers should be between 20 and 30 pounds.

MAGNET VALVES.

The general construction of the magnet valves used on the reverser line breaker and "on" cylinders is shown on Page 50, while the "off" magnet valve is shown on Page 51.

When the valves are sticky, wash with gasoline or kerosene, also pour a little gasoline thru the magnet core to clean the valve seats. WHEN VALVES ARE REMOVED, EACH MUST BE RETURNED TO ITS OWN SEAT, as each stem is ground to fit its own seat.

Whenever a new valve is installed, or a valve leaks, it must be ground in. After a good seat is obtained, blow out all grinding materials with air and wash with gasoline. When a large number of valves are to be ground in, the cost may be reduced by using special reamers on the valves and valve seats before the valves are ground in.

To grind in the INLET VALVE of the "off" magnet, remove the valve and its seat from the valve case and use the grinding jig - Cat.#1419139 (shown on Page No. 53). The screw threads in the jig form a holder for the valve seat, and the hole in the jig acts as a guide for the inlet valve. A thin paper gasket is used between the inlet valve seat and the valve case; be sure that this is in good condition before replacing the valve seat. The screw-driver - Cat.#189905 may be used for removing and replacing the inlet valve seat.

MEASURING AIR GAP AND TRAVEL.

The air gap and travel of the magnet valves should be measured once a year. This measurement is made by removing the magnet valve cover and armature. The .020" gauge - Cat. #1420997, is placed around the upper valve stem or plunger and the armature pressed on top of the valve stem. The exhaust valve of the reverser, line breaker and "on" magnet valves should seat (i.e., air should not escape thru the exhaust valve). For the "off" valve, this test should seat the inlet valve (i.e., air should not pass thru the valve). If air passes thru, new valves must be installed.

INSTALLING AND ADJUSTING NEW VALVES.

REVERSER, LINE BREAKER AND "ON" MAGNET VALVES.

First, place the .052" gauge (Cat.#1419137) around the exhaust valve stem. Then press down on the valve stem. When the exhaust valve seats (i.e., air does not pass thru the valve), the top of the valve stem should be flush with the surface of the gauge. If it is not flush, it should be shortened or lengthened until it is flush.

Second, place the .036" gauge (Cat.#1419136) on top of the .052" gauge. If the inlet valve stem is the proper length, the upper or exhaust valve stem will be just flush with the gauges, and, when the armature is pressed down, no action will result (i.e., air will not pass thru the inlet valve). If the upper valve stem is above the surface of the gauges, a small amount should be filed off the inlet valve stem. If the upper valve stem is below the surface of the gauges, a new inlet valve with a longer stem should be put in.

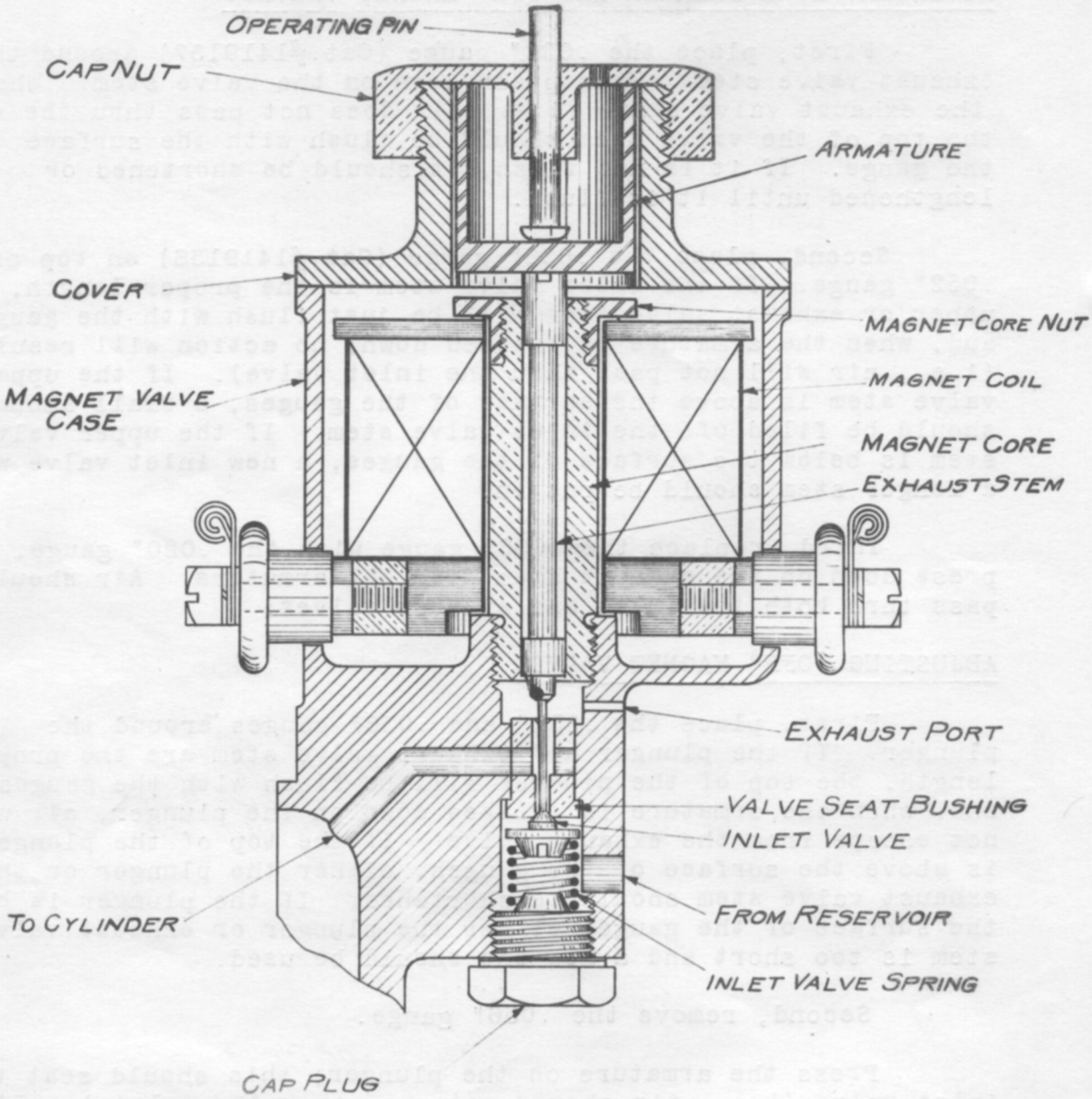
Third, replace the .036" gauge with the .020" gauge, and press down on the exhaust stem with the armature. Air should pass thru both the inlet and exhaust valves.

ADJUSTING "OFF" MAGNET VALVE.

First, place the .052" and .036" gauges around the plunger. If the plunger and exhaust valve stem are the proper length, the top of the plunger will be flush with the gauges, and, when the armature is pressed down on the plunger, air will not escape from the exhaust valve. If the top of the plunger is above the surface of the gauges, either the plunger or the exhaust valve stem should be shortened. If the plunger is below the surface of the gauge, either the plunger or exhaust valve stem is too short and a new one should be used.

Second, remove the .036" gauge.

Press the armature on the plunger; this should seat the inlet valve (i.e., air should not pass thru the valves). If the valves are the proper length, the top of the plunger will be flush with the surface of the .052" gauge. If the plunger is above the surface of the gauge, remove the inlet valve seat and place additional paper washers between the valve seat and valve casing until the top of the plunger is flush with the surface of the .052" gauge, with the plunger pressed down. If the top of the plunger is below the surface of the gauge, either use a new valve or make a metal washer, which should be placed between the inlet and exhaust valves, increasing the length between these valves.



234829 MAGNET VALVE FOR REVERSER. LINE BREAKER AND "CN" CYLINDER.

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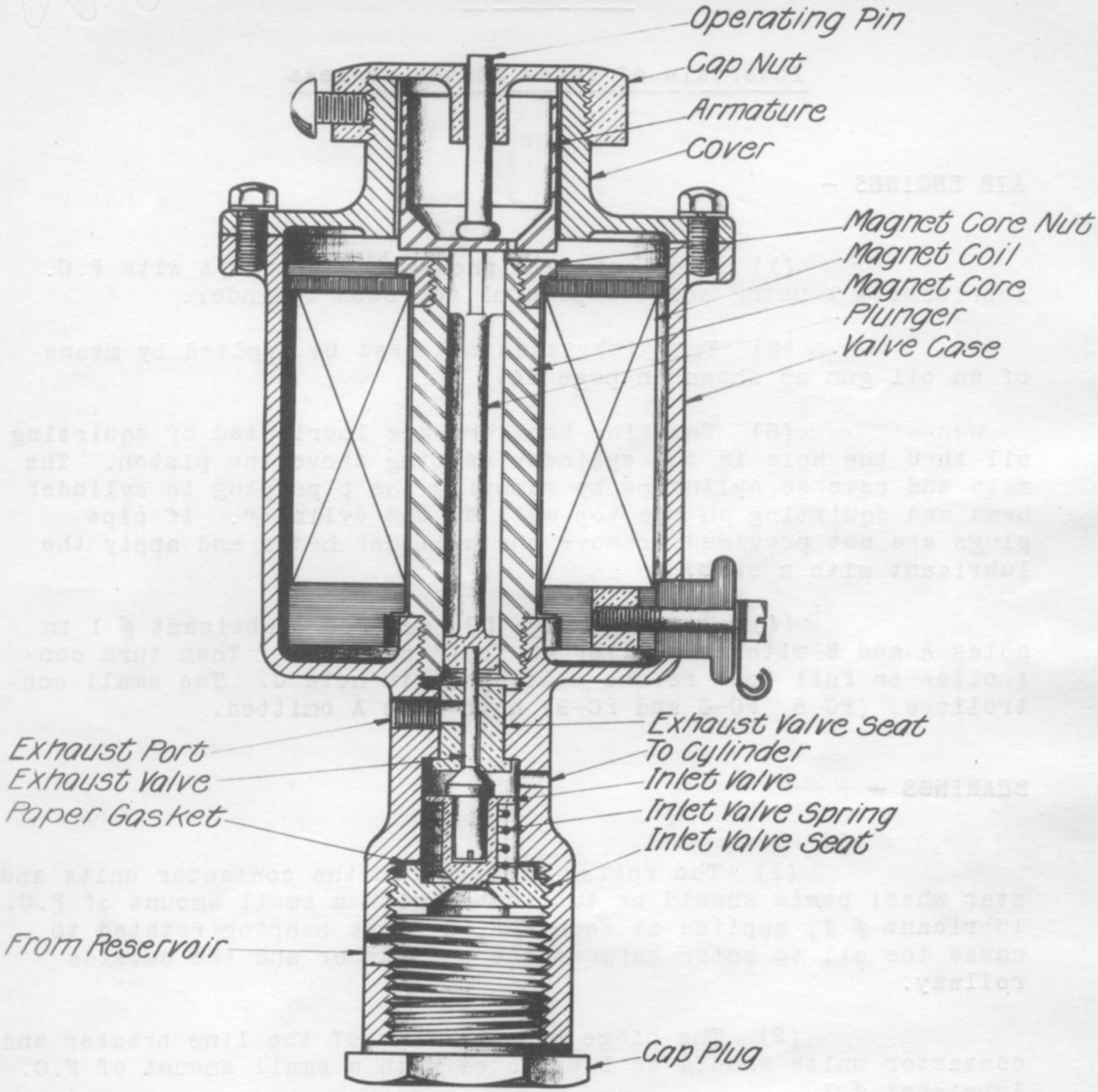

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MAGNET VALVE FOR "OFF" CYLINDER.

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8 11 16

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LUBRICATION

Intervals of Three Months or Less

AIR ENGINES -

(1) Lubricate all pneumatic cylinders with P.C. lubricant # 1 using one teaspoonful for each cylinder.

(2) This lubricant can best be applied by means of an oil gun as shown on page 54.

(3) The line breakers are lubricated by squirting oil thru the hole in the cylinder casting above the piston. The main and reverse cylinders by removing the pipe plug in cylinder head and squirting on the top wall of the cylinder. If pipe plugs are not provided, remove the cylinder heads and apply the lubricant with a swab.

(4) Refer to page 29, put P.C. lubricant # 1 in holes A and B with controller in "off" position. Then turn controller to full "on" before putting it in hole C. The small controllers, (PC-5, PC-6 and PC-9) have hole A omitted.

BEARINGS -

(1) The roller bearings on the contactor units and star wheel pawls should be lubricated with a small amount of P.C. lubricant # 1, applied at each end, and the bearing rotated to cause the oil to enter between the end washer and the outside rollway.

(2) The hinge pin bearings of the line breaker and contactor units should be lubricated with a small amount of P.C. lubricant # 1.

(3) Lubricate the reverser main bearings and also the sliding bearing and pin between the piston and the crank, if the controller is of the PC-10-11-12 or 101 type, with a small amount of P.C. lubricant # 1.

Overhauling Period, or at least once a year.

AIR ENGINE –

(1) Dismantle the air operating cylinders sufficiently so that the cylinder walls and piston parts may be thoroughly cleaned. This should include for the large PC controllers, (PC–10, PC–11, PC–12 and PC–101) removing and cleaning the spring and piston head in the "off" end of the main air engine as indicated on pages 29, 30 and 31. When re-assembling, lubricate with P.C. lubricant # 2. The three leather washers constitute a single packing and even when soaking them in oil should never be separated.

(2) If the leather packing is soft and pliable rub it over with P.C. lubricant # 2. If the packing is dry and hard, soak it for several hours in P.C. lubricant # 1. Do not knead the leather to soften it as it distorts the packing with the possibility of leaking when reassembled.

(3) Apply to the clean cylinder walls with a swab or brush an even film of P.C. lubricant # 2. For cylinders 3–1/2" diameter use 1/5 ounce (heaping teaspoonful). For cylinders 1–3/4" and 2–1/4" diameter use 1/8 ounce (level teaspoonful).

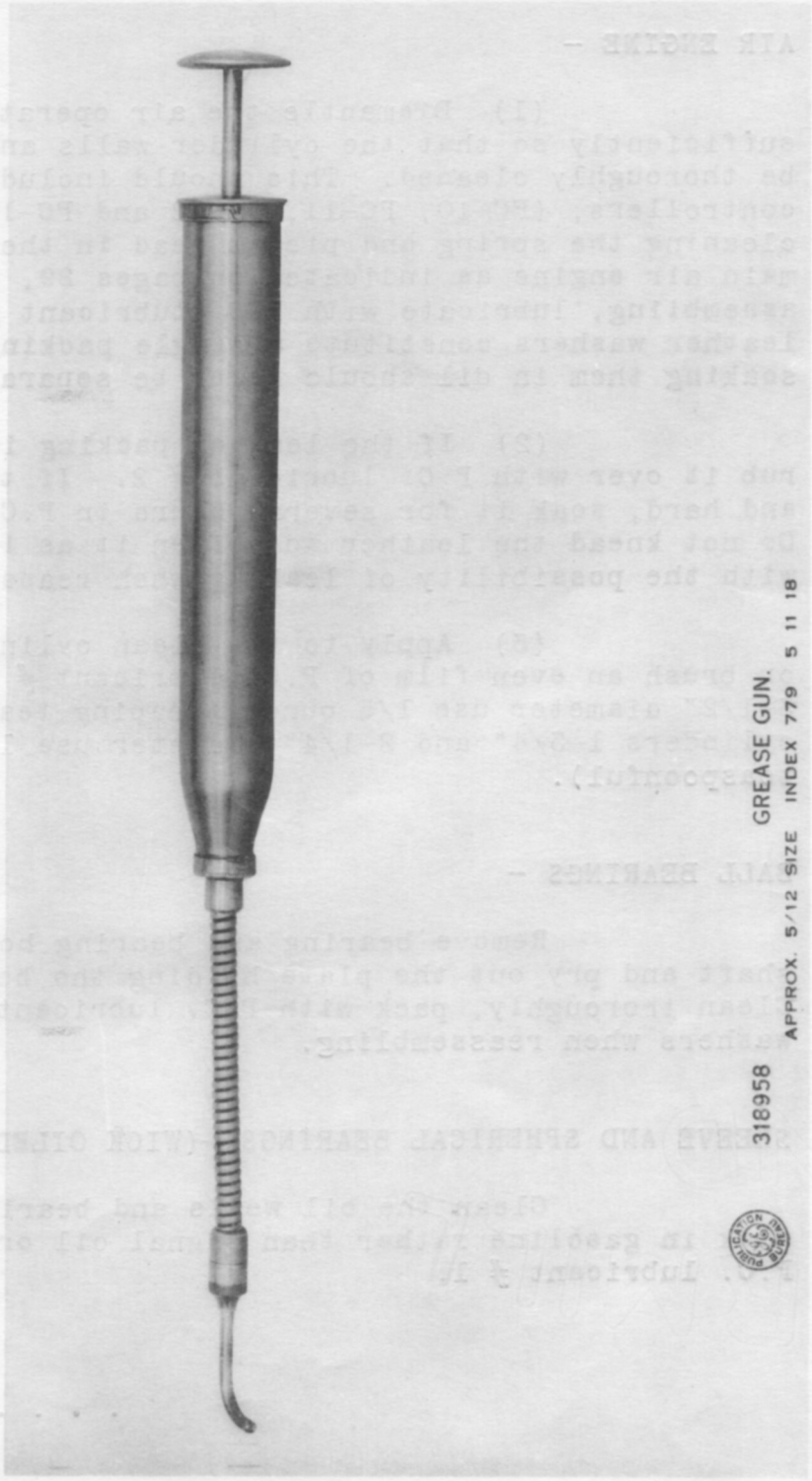
BALL BEARINGS –

Remove bearing and bearing housing from the cam shaft and pry out the plate holding the bearing in the housing, Clean thoroughly, pack with P.C. lubricant # 2 and use new felt washers when reassembling.

SLEEVE AND SPHERICAL BEARINGS––(WICK OILED)

Clean the oil wells and bearings, wash the felt wick in gasoline rather than signal oil or kerosene. Fill with P.C. lubricant # 1.

. . . . . .



318958 GREASE GUN.

APPROX. 5/12 SIZE INDEX 779 5 11 18

GAUGES AND WRENCHES - PC EQUIPMENTS.

Cat.#89996 (Page 53) wrench for turning cam shaft PC-5, PC-6 and PC-9 controllers.

Cat.#149761 - wrench for adjusting contact of reverser fingers.

Cat.#176773 is ring (#16 - Page #29) used when removing or replacing the piston spring (#11 - Page #29) in the main operating cylinder PC-10, PC-12 and PC-101 controllers.

Cat.#176775 is a pin wrench for the stud cap (#9 - Page #29)

Cat.#176776 is a wrench for turning cam shaft PC-10, PC-12 and PC-101 controllers.

Cat.#1419139 is a jig for grinding the inlet valve and seat or the "off" magnet.

Cat.#1420997 is a .020" gauge for measuring movement of the magnet valves.

Cat.#1419136 is a .036" gauge for measuring movement of the magnet valves.

Cat.#1419137 is a .052" gauge for measuring movement of the magnet valves.

Cat.#178416 is a spanner wrench for the magnet core nut in the magnet valves.

Cat.#178419 is a double open end wrench, one end for 1/4" nuts and the other for 5/16" nuts.

Cat.#189905 is a screw-driver for the cap screw (#10 - Page #29) holding piston spring, and also, for the inlet valve seat of the "off" magnet valve.

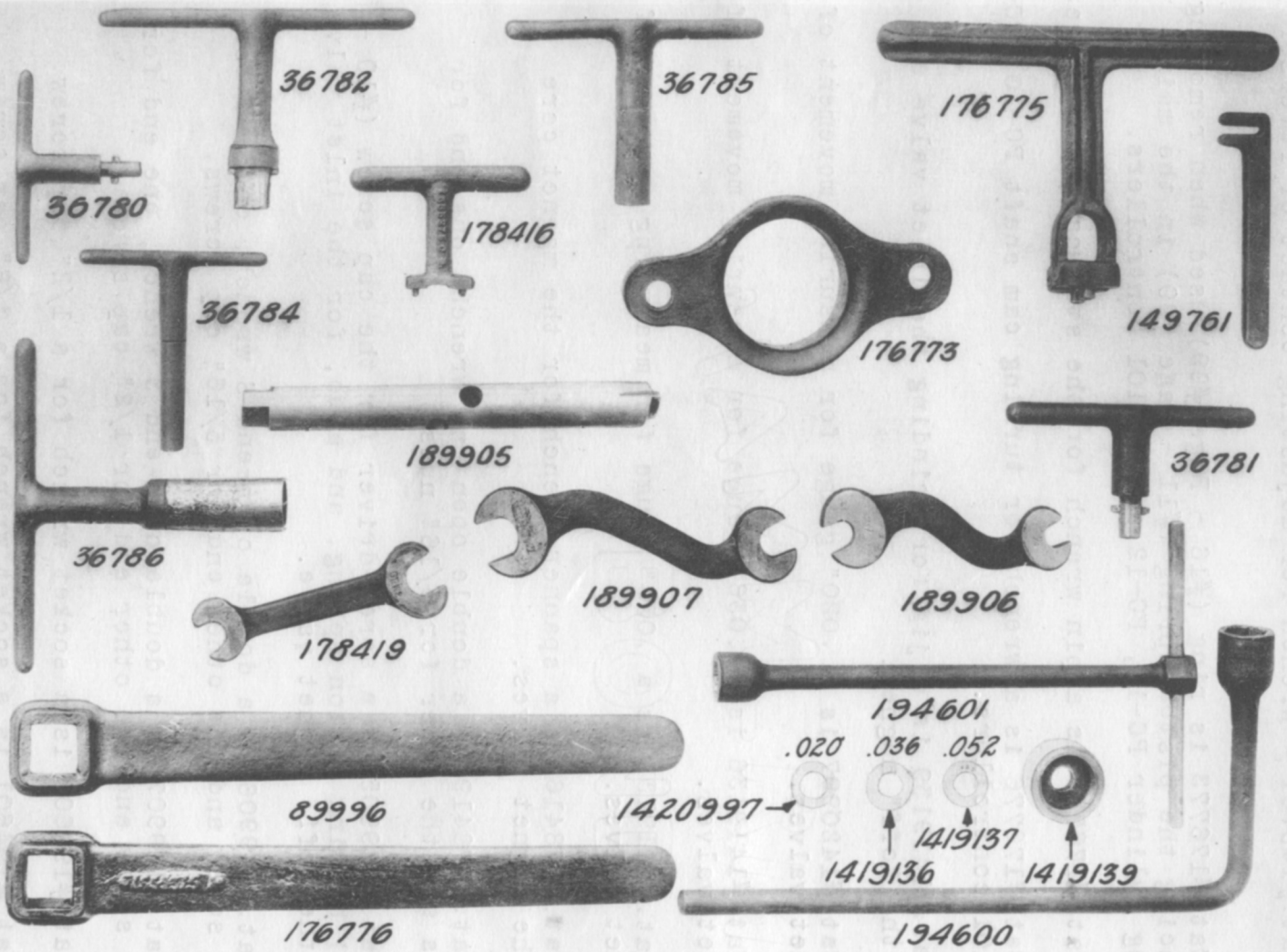
Cat.#189906 is a double open-end S wrench, one end for 1/4" cap screw and the other end for 5/16" cap screws.

Cat.#189907 is a double open-end S wrench, one end for 3/8" cap screw and the other end for 1/2" cap screw.

Cat.#194600 is a socket wrench for a 1/2" cap screw.

Cat.#194601 is a socket wrench for a 3/8" cap screw.

84700-56



239443 WRENCHES FOR PC CONTROL EQUIPMENT.

INDEX E-353.7 3 30 17

COUPLER SOCKET WRENCHES.

Cat.#36780 is for contact socket of train line couplers.
Cat.#36781 is for contact socket of 1/2" bus line couplers.
Cat.#36782 is for contact socket of 3/4" bus line couplers.
Cat.#36784 is for contact plug of train line couplers.
Cat.#36785 is for contact plug of 1/2" bus line couplers.
Cat.#36786 is for contact plug of 3/4" bus line couplers.

CONDUIT SIZES

Nominal Size	Outside Diam.	Inside Diam.	No. of threads per in. of screw	Nominal wt. per ft.
1/2"	.84"	.62"	14	.85
3/4"	1.05"	.82"	14	1.12
1"	1.31"	1.04"	11-1/2	1.67
1-1/4"	1.66"	1.38"	11-1/2	2.24
1-1/2"	1.90"	1.61"	11-1/2	2.68
2"	2.37"	2.06"	11-1/2	3.61

MULTIPLE CONDUCTOR TRAIN AND JUMPER CABLE
600 VOLTS. EACH CONDUCTOR 19/25

	TRAIN CABLE			JUMPER CABLE	
No. of conductors	Diam. over all	Conduit size	Approx. wt. per 100 ft.	Diam. over all	Approx. wt. per 100 ft.
7	.75"	3/4"	32	.97"	54
9	.875"	1"	43	1.03"	64
10	.906"	1"	48	1.06"	70
12	1.06"	1-1/4"	55	1.28"	89

GENERAL ELECTRIC COMPANY CAR CABLES FOR CONDUIT INSTALLATION.

STANDARD STRAND

Size B&S	No. Wires in Strand	C.M.	Bare Diam.	600 Volts Diam. over all.	600 Volts Approx. Wt. per 100 ft.	1500 Volts Diam. over all.	1500 Volts Approx. Wt. per 100 ft.
14	7		.073"	.263"	4.2	.33"	6
7	7		.165"	.385"	12.	.45"	14
6	7		.184"	.404"	14.	.47"	17
5	7		.208"	.425"	17.	.49"	20
4	7		.232"	.462"	20.	.52"	23
3	7		.263"	.493"	25.	.55"	27
2	7		.292"	.523"	29.	.58"	33
1	19		.332"	.594"	38.	.62"	39
0	19		.375"	.637"	45.	.67"	47
2/0	19		.419"	.681"	53.	.71"	57
3/0	19		.470"	.732"	67.	.76"	69
4/0	19		.528"	.790"	82.	.82"	85
250000	37		.576"	.875"	98.	.90"	99

EXTRA FLEXIBLE

19/25	19	6080	.09"	.278"	5.1	.34"	8.1
800/25	800	256000	.67"	1.05"	111.	1.05"	111.
900/25	900	288000	.70"	1.08"	122.	1.08"	122.
1000/25	1000	320000	.715"	1.10"	133.	1.10"	133.
1250/25	1250	400000	.845"	1.23"	163.	1.23"	163.
1500/25	1500	480000	.90"	1.28"	191.	1.28"	191.

BUS LINE JUMPER CABLES

100/25	100	32000	.25"	.50"	19.6	.665"	25.
400/25	400	128000	.46"	.875"	64.9	.870"	66.
500/25	500	160000	.51"	.937"	77.	.915"	78.

TYPE C-6 FEED VALVE

This valve is used to maintain a constant pressure in the control pipe.

DESCRIPTION OF VALVE:

A slide valve, operated by a piston, controls a port leading from the low pressure or control pipe side of the valve to the valve chamber. See Diagram on Page 60. The valve chamber is in communication with the main reservoir or high pressure side of the valve. The piston which carries the slide valve is fitted loosely in the valve casing, allowing air to leak around it, so that any difference in pressure between the two sides is quickly equalized. A small pilot valve, actuated by a brass diaphragm, governs a port leading from the piston chamber at the back of the slide valve piston to the chamber on the pressure side of the diaphragm, the latter being connected to the low pressure or control pipe side of the valve.

A regulating spring acts against the pressure on the diaghragm. Its compression, which determines the control pipe pressure, can be readily changed by means of an adjusting screw.

OPERATION:

When the valve is closed the pressure in the main reservoir and piston chamber is equal and the pilot valve is closed by its spring, the diaphragm being deflected by the control pipe pressure. If the pressure in the control pipe falls, thereby reducing pressure on diaphragm, the pilot valve opens and reduces the pressure on the piston chamber side of the piston. The piston then moves, opening the supply port and making connection between the main reservoir and control pipe. This connection continues until the pressure in the control pipe is sufficient to deflect the diaphragm and allow the pilot valve to close. The pressure then quickly equalizes on both sides of the piston and the supply port is closed by the action of the slide valve spring.

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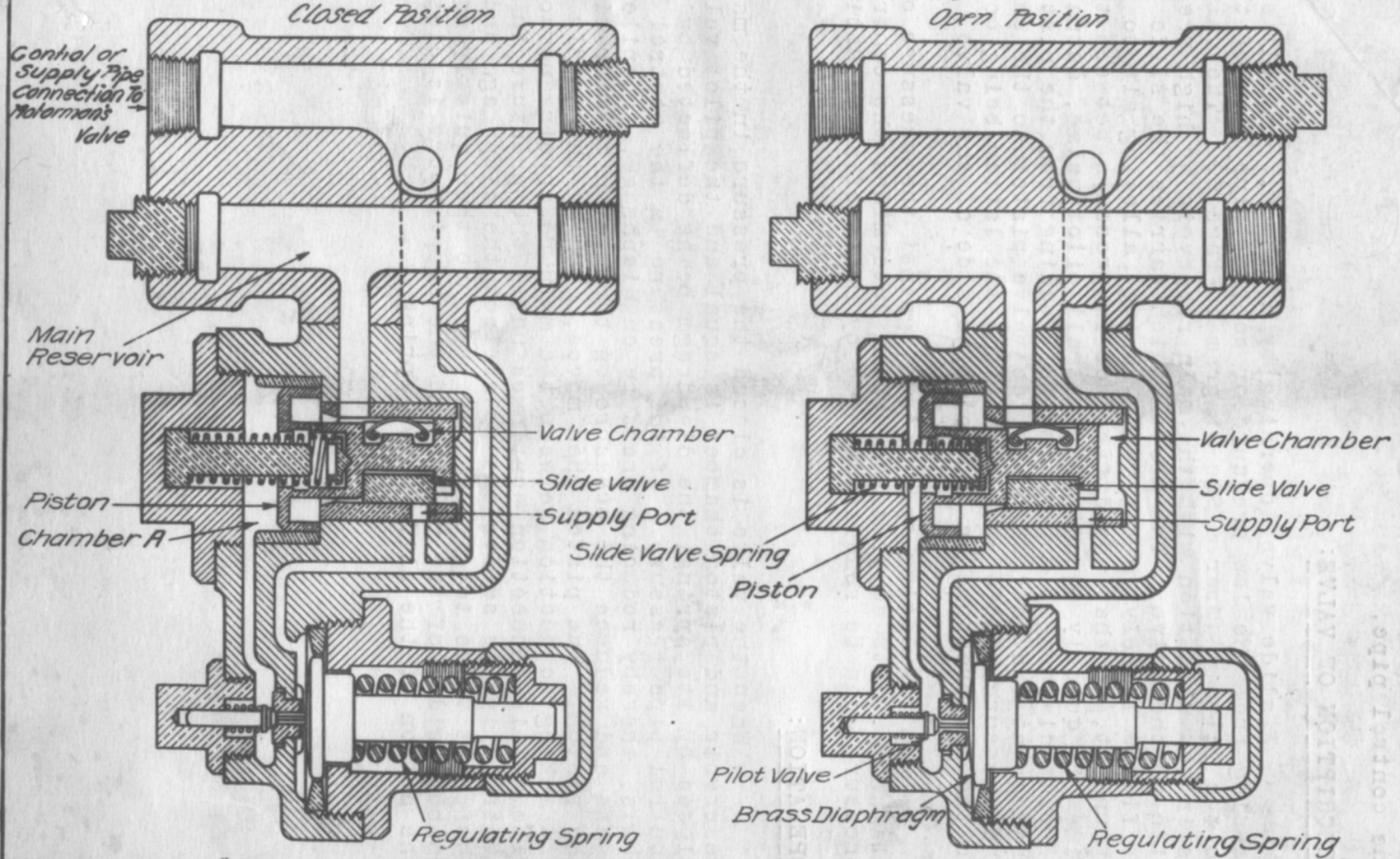
Instruction Diagram of Slide Valve Feed Valve
Mounted on Combined Straight and Crossed Passage Pipe Bracket



Checked G. M.

Approved

5 Sep. 1912

Engineering Dept.
General Electric Company

D.S.28276

Changed
24 Mar. 1913
27 Apr. 1915
7 May. 1915
6 Dec. 1917

1 – 2/5