# CONTROL SECTION

## INSPECTION

It is suggested that regular inspection periods be set up for inspecting the control equipment.

The following schedule is recommended until such time as it is found by experience to be inadequate or too frequent.

### INSPECTION PERIODS

1. Initial or Overhauled Car
2. Every 2 months or 10,000 miles
3. Every 3 years or 160,000 miles for Overhaul

### INITIAL OR OVERHAULED CAR INSPECTION

1. General

A new or overhauled car presents an entirely different problem than one which has been in service for a period of time. When examining a piece of apparatus which has been in service for some time, more attention is given to parts which may wear or get out of adjustment. When the car has not been in service nothing will be worn but there is much more chance that parts may not be properly assembled or adjusted or that parts may be loose or even some extra loose parts may have become wedged in some moving part.

In making a final inspection start at one end of the car and go over everything carefully, making a visual inspection and feeling all moving parts for freedom of motion and all connections for electrical and mechanical clearance and tightness. Before getting into detail on specific parts of a car, consider first the following:

a. Electrical Clearance

Installation of supports, cables, and terminals should not effectively reduce any creepage or striking distances provided in the design of the apparatus.

b. Mechanical Clearances

Parts such as contactors, relays, controllers, etc. should be inspected and if possible observed during operation. Be sure there is no interference.

c. Wiring Harness

A neat wiring job is usually a good job. Look especially close for small wires which may be holding up a cable. Cables should not be subject to vibration.

d. Paint

Painting of wiring harness and other parts is advisable but paint on fingers, interlocks, etc. will insulate and should be removed.

e. Contact Wipe and Break

A "kiss" contact or insufficient "break" will eventually cause trouble.

f. Tightness of Connections

For good electric contact a connection must be tight mechanically, and stay tight. Spring-steel lock washers should not be ommitted where required. In checking connections for tightness, consider the size of the bolt or screw. You can usually tighten a 10-32 screw a little each time it is tried. If several people do this, failure may occur due to breakage.

2. Apparatus

a. Gang Switch

(1) Look over connections to see that they are tight and properly made, as there are many connections in a small space.

(2) Check each switch for proper action. Loosening holding screws at each end allows switch to be swung down for inspection.

b. Pedals

(1) Pull-off springs must be adjusted to overcome all controller and rod friction to return the pedal to OFF position with some pull to spare. In turning on, the operator must provide the force to wind up this spring and overcome TURNING ON controller, rod and linkage friction.

(2) Check pedals for abnormal or tight operation and eliminate abnormal friction.

c. Foot Interlocks

(1) See that travel adjustment, contact wear allowance and contact break are correct, as these are essential. Both power and brake are interlocked in this one switch.

d. Brake Operating Mechanism

(1) See that there is clearance between moving parts, particularly the pull rod and truck structure.

(2) Observe band pull rod adjustment and compare with recommendations.

(3) Examine electric connections for ground clearance.

e. Line Breaker

(1) Examine both power and control connections for routing and clearances.

(2) Check main and overload armatures for free movement.

(3) Contact surfaces of overload interlocks must be in good condition.

(4) Trip overload relay by hand and check operation of holding coil.

f. Master Controller

(1) Examine mounting.

(2) Measure controller position at FULL ON and FULL OFF.

(3) 1/16-inch clearance between operating lever stop surface and supporting bar gives correct travel and allows pedal stops to absorb shocks.

(4) Check reverser positions.

(5) Check operation of reverser and interlocking with power and brake pedals.

(6) See if the operation of the brake controller follows depressing the brake pedal.

(7) See if the operation of the accelerating controller follows depressing the power pedal.

(8) Examine rod connections to operating levers. See that connections are tight and locked.

(9) Inspect wiring and note that cover when installed has clearance to all live circuits.

(10) Observe that rate coil rheostats are properly installed and that rheostat brush contacts are satisfactory.

(11) Check finger pressures.

g. Motor Reverser

(1) Manually operate reverser to insure freedom of motion.

(2) Make sure no loose pieces of magnetic material (screws, nuts, washers, etc) are on or near armature. These can be drawn into armature gap and prevent reverser from throwing completely to either operating position.

(3) See that brass cap screws are used at end of diagonal bars.

(4) Inspect interlock for correct wipe and break.

h. Control Group

(1) Note arrangement of wiring harness as regards connections to interlock studs which may be supporting weight.

(2) See that there is clearance to brush arm at left end of group.

(3) Do not let leads to operating coils interfere with contactor armatures or interlocks.

(4) Heavy cables coming from top of group should be back out of the way to eliminate interference for arc chute removal.

(5) Examine to see if there is sufficient space to remove arc chute.

(6) There should be transite barrier at all points where arc may strike conducting surface and cause possible flashover. (Arc blowout will drive arc upward, then it will spread out.)

(7) Note that arc chutes are in the proper places after working around contactors before operating car. A quick check can be made by noting relative location of arc chutes. If one is higher or lower than the rest, look for incorrect assembly.

(8) Inspect interlocks for contact condition, mechanical interferences, wear allowance and break. In checking wear allowance on the 17CM42 contactors, be sure armature is pushed all the way in when checking wear allowance of normally-open interlocks. If the armature can not be pushed in directly, remove arc chute, take hold of the movable tip and rock it back, at the same time pushing in on the armature.

(9) Examine transfer switch. On normally-closed contacts, the gap should be 1/32 inch to 1/16 inch, when normally-open contacts touch in closing.

i. Commutator Controller

(1) Be sure the oil level in gear box is up to small pipe plug.

(2) Contact arm should move freely over the entire travel. Rubber bumpers should be in place at stops. Clearance at all points should be noted.

(3) Ballast lamps should be screwed in tight.

(4) Look for rough or dirty spots on commutator resulting from handling or storage. Smooth or clean with fine sandpaper (0000) if necessary.

(5) Check contact-arm brushes for freedom of motion and pressure.

(6) Examine pilot motor to see if brushes are making proper contact on commutator.

j. EWF Resistors

(1) Examine the mounting for electrical clearance.

(2) Lead arrangement should provide maximum clearance to grids at allpoints. Never depend on insulation on wire to keep leads in place mechanically.

(3) Note assembly of connections to be sure all parts are properly installed.

(4) Air deflectors and barriers should conform to recommended arrangement. A careful check of the first one or two cars on a new order should be made.

k. Auxiliary Control Panel

(1) Examine in a manner similar to item h, Control Group.

(2) Observe operation of generator contactor GC. It should pick up in starting and drop out when MG is shut off. Do not expect it to operate instantly as it is operated from motor voltage. With starting resistance, voltage builds up with speed and in shutting off, motor will generate as it has a shunt field.

(3) Set voltage regulator 35-35 1/2 volts cold, 36-36 1/2 volts hot with no load on generator after generator commutator is in good condition.

l. Sequence Check

(1) See General Maintenance.

m. Run Test

(1) Sufficient running should be done to assure that car is correct in all details. Some of the most important things to be checked are:

(a) Both pedals down - brake predominates.
(b) Safety interlocking, deadman, door interlock, etc.
(c) Smooth application and release of power or brake.
(d) All brakes functioning.

n. Rate Adjustments

(1) Factory settings are per PCC specifications, approximately 250-amperes maximum acceleration and 180-amperes maximum brake. Some slight adjustment will probably be required to get correct rates on actual run test.

o. General

(1) Look over each equipment as it is being installed and wired. It will save trouble later on.

p. Checking Car Sequence (Car at Standstill)

In order to observe operation of control devices without moving car, it is necessary to open main motor power circuits. This may be accomplished by:

(1) Opening motor cutout switches (if used),
or (2) Insulating reverser fingers,
or (3) Disconnecting main power wire at LB1, moving contact side,
or (4) Opening main switch (if used), and providing a 600-volt feed for C1 coil.

The usual method is to have one man operate the control with another to observe operation of devices with convenient signalling system. With both men in place and control turned on, check the following: Refer to simplified connection diagram.

(1) Complete Coasting Cycle
Both pedals off - coasting set up - C2, B1, B2 and FS1 closed. To get complete coasting cycle close B3 interlock B6 to 8B circuit (second from left side) which will close B3 switch, setting up high speed combination and allowing control to make complete coasting cycle. To slow down or stop progression of control to closely observe operation, work armature of ABR by hand.

(2) Power Application - Brake Off - Power Pedal Down
The operation of contactors at the instant of applying power is fast, but by careful observation the sequence as given in the table can be noted. Note the different

sequence for "low" and "high" rates. Low rate is obtained by moving pedal just far enough to get power and high rate is obtained by moving pedal all way down quickly.

(3) Low Rate Acceleration (Switching) Cycle
Depress power pedal as above for low rate and follow sequence chart.

(4) High Rate Acceleration (Run) Cycle
Depress power pedal for high rate and follow sequence chart.

(5) Cushioned Power Release
Release power pedal quickly after completing cycle given in step (4) above.

(6) Complete Braking Cycle
Braking cycle differs from coasting cycle in that FS1 is out and track and friction brakes apply.

EVERY 2 MONTHS OR 10,000 MILES..

a. General

(1) Remove covers and blow out each piece of apparatus with clean dry compressed air. Remove gang switch holding screws and drop switch to clean.

(2) Remove arc chutes, clean and if burned, repair or replace them.

(3) Examine all contacts, clean and replace, if necessary.

(4) Measure contact gaps, wipes and pressures and adjust them to their proper values.

(5) Examine all shunts for wear, fraying, and breakage. Replace if there is any indication of possible breakage.

(6) Examine wiring and tighten any loose connections.

(7) Operate contactors, motor reverser, line breakers, relays and switches by hand to see if they have free movement and do not bind.

(8) Examine all springs to see if they are in their proper places. If broken or have a permanent set, replace them with new ones.

b. Commutator Controller

(1) Examine commutator for burning, roughness or loose segments. Repair defects.

(2) Move brush arm by hand to insure free movement.

(3) Replace carbons in brush-arm finger tips if worn to within 1/8 inch of copper.

(4) Replace brushes of pilot motor if worn to 3/4-inch length. Clean commutator with fine sandpaper and if too rough, or has flat spots, remove for turning.

(5) Examine resistor elements to see if they are warped, damaged, or broken. Warping is caused by some abnormal condition which should be investigated.

(6) Clean commutator string band and when necessary, paint with Glyptal® No. 1201 red enamel. This should be kept clean and painted to prevent creepage.

(7) Check timing of brush arm.

c. Master Controller

(1) See that segments are tight on the reverser cylinder. Clean these segments with a fine file. Touch up with Glyptal No. 1201 red enamel, any spots on the drum slightly burned. Replace short brushes on rheostats and see that brush pressure is not too low.

d. Accelerating and Braking Relay

(1) Do not attempt to make adjustments on car, and do not attempt adjustments, under any circumstances, without instruments. If the relay does not operate correctly, replace with a spare.

(2) Have sufficient clearance between terminals.

(3) Operate armature by hand to see that relay controls speed of brush arm on controller and operates freely.

e. Regulating Relay

(1) Test voltage and adjust, if necessary.

f. Gang Switch

(1) Check operation of each unit to make sure it snaps properly if desired, or return positively if spring return.

(2) Test units with blowouts at 600 volts, 10 amperes to make sure arc blows out around arcing horn.

g. Resistors

(1) Examine for broken or cracked insulators and tubes and nicked, broken, or short-circuited windings. When defective, install new parts. Tighten tie rods.

h. Trolley Stand

(1) Check bearing for wear.

i. Sequence of Control

(1) Remove trolley pole from wire.

(2) Make operation and sequence test. Make complete operation test from power and brake controllers. See that line breakers and contactors open and close in proper order.

j. Pedals

(1) While making sequence check, check the travel adjustment and freedom of movement. Any binding or improper travel should be corrected.

k. Underneath the Car

(1) Check motor bellows for damage (usually caused by splitting a switch).

(2) Inspect motor leads for clearances at the friction or drum brake shaft.

(3) Inspect ground wires for damage.

l. Car Body Interior

(1) Operate all switches to determine if M-G set, all lights, track brake, and other accessories are working properly.

m. Electric Shoe Brakes

(1) Inspect space between renewable shoes and remove any foreign particles.

(2) Dress up bottom edges of renewable shoes that tend to burr, especially burrs on the inside edges which tend to decrease the air gap between the renewable shoes.

(3) With current applied to each track brake shoe, place a small piece of steel across one end and see that it is attracted to the shoes.

## OVERHAUL

The control should be overhauled every three years or after 160,000 miles.

## GENERAL MAINTENANCE

All apparatus should be blown out using clean, dry compressed air, and accessible parts should be wiped off with dry waste or clean wiping rags. Washed wiping rags are preferable to cotton waste as they are less liable to leave lint. When using air for cleaning in the vicinity of exposed mica insulation, care should be taken not to use too high pressure or get the nozzle too close or small flakes of mica will be blown off, finally resulting in complete destruction of the insulation.

Oil is very destructive to insulating materials as it collects dust and dirt, causing them to break down electrically. When lubricating apparatus, extreme care should be taken to prevent the lubricant from getting on insulated parts and commutators. If this should occur, wipe off lubricant with clean wiping rags.

All screws, bolts and nuts which secure electric connections should be kept tight to insure good contact. When making a ground connection, the surface to which connection is to be made should be thoroughly cleaned of all dirt, paint or rust to assure good electric contact.

Cement may be used to advantage in repairing burned insulation such as sides of arc chutes. One of these that has been used with considerable success is G-E No. 12-G compound. Another good cement is Sauereisen INSA-LUTE high temperature cement No. 7, manufactured by Sauereisen Cement Company, Pittsburgh, Pennsylvania, or equivalent.

Glyptal No. 1201 red enamel is recommended for all cables exposed to dirt or moisture, especially where creepage is important. It has high insulating qualities and gives a smooth surface which is easily cleaned.

When painting control apparatus, use a good quality of insulating varnish such as G-E No. 458 or Glyptal No. 1201 red enamel.

Be sure that tools, bolts, nuts, etc. are not left on or around the frames of the electrical equipment. Serious damage may result from an oversight of this nature.

a. Arc Chutes

Renew side plates or repair them with special cement if burned three-quarters way through. One of these is G-E No. 12-G compound. Another good cement is Sauereisen INSA-LUTE high temperature cement

No. 7 (Sauereisen Cement Company, Pittsburgh, Pa.) or equivalent. Renew fiber end pieces if they are burned close to the rivets.

b. Ground Connections

Surface to which connection is made must be thoroughly cleaned of dirt, paint, or rust.

c. Copper or Alloy Contact Tips, Segments and Fingers

Smooth up roughened or beaded surfaces by filing lightly with a fine file. It is not necessary to remove small pits. Be sure that full contact is obtained across and between the contact surfaces after filing.

Install new parts when contacts are badly pitted or worn halfway through at the contact surface, or when wear is sufficient to cause poor contact.

d. Silver-Faced Contacts and Fingers

Clean surfaces preferably with a clean, lintless cloth moistened with carbon tetrachloride, or use a fine file. Do not use sandpaper or emery cloth as they leave grains embedded in the silver that will insulate the contacts. If serrated contact surfaces are worn, resharpen them with a small triangular file.

To determine if silver facing is worn through or almost through, run a fine file over the surface, and that will indicate when steel backing has been reached.

When renewing a contact tip, smooth up, or install a new part, if the surface against which it rests has become rough or pitted due to poor contact.

e. Contact Gaps, Wear Allowances and Pressures

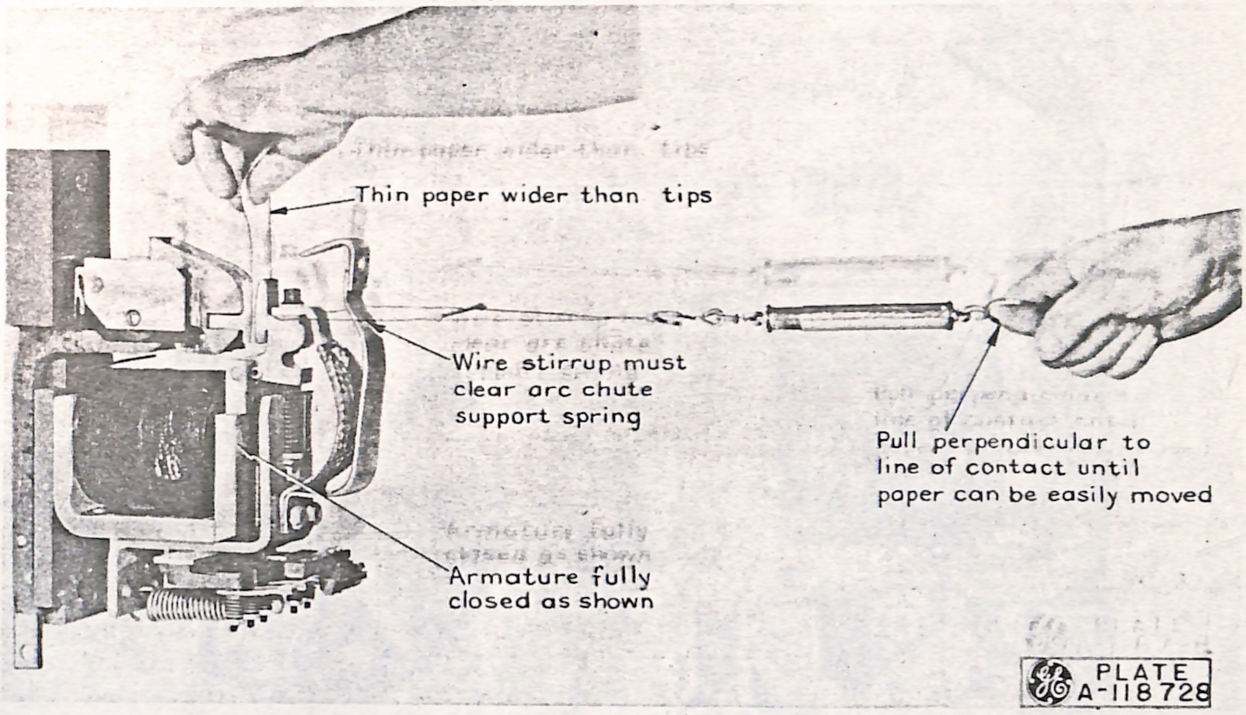
(1) Check these during inspection, and after the device has been torn down and reassembled. Correct values are given under each device on INSPECTION DATA.

(2) Contact gap is the distance between contact surfaces with device fully open and with old contacts will be greater than that given under each device by the amount of wear on the contact surfaces. Low gap may be caused by worn contact-tip lever or bent armature stop. If tip lever is worn, the gap will be high. High gap at heel on contactors with double-pivoted contact levers may be caused by worn stop on brass tip lever or on intermediate lever. Low gap at heel may be caused by bent intermediate lever stops or worn tips. High gap at the toe may be caused by bent intermediate lever stops or lack of spacers under frame next to base. Low gap at toe may be caused by

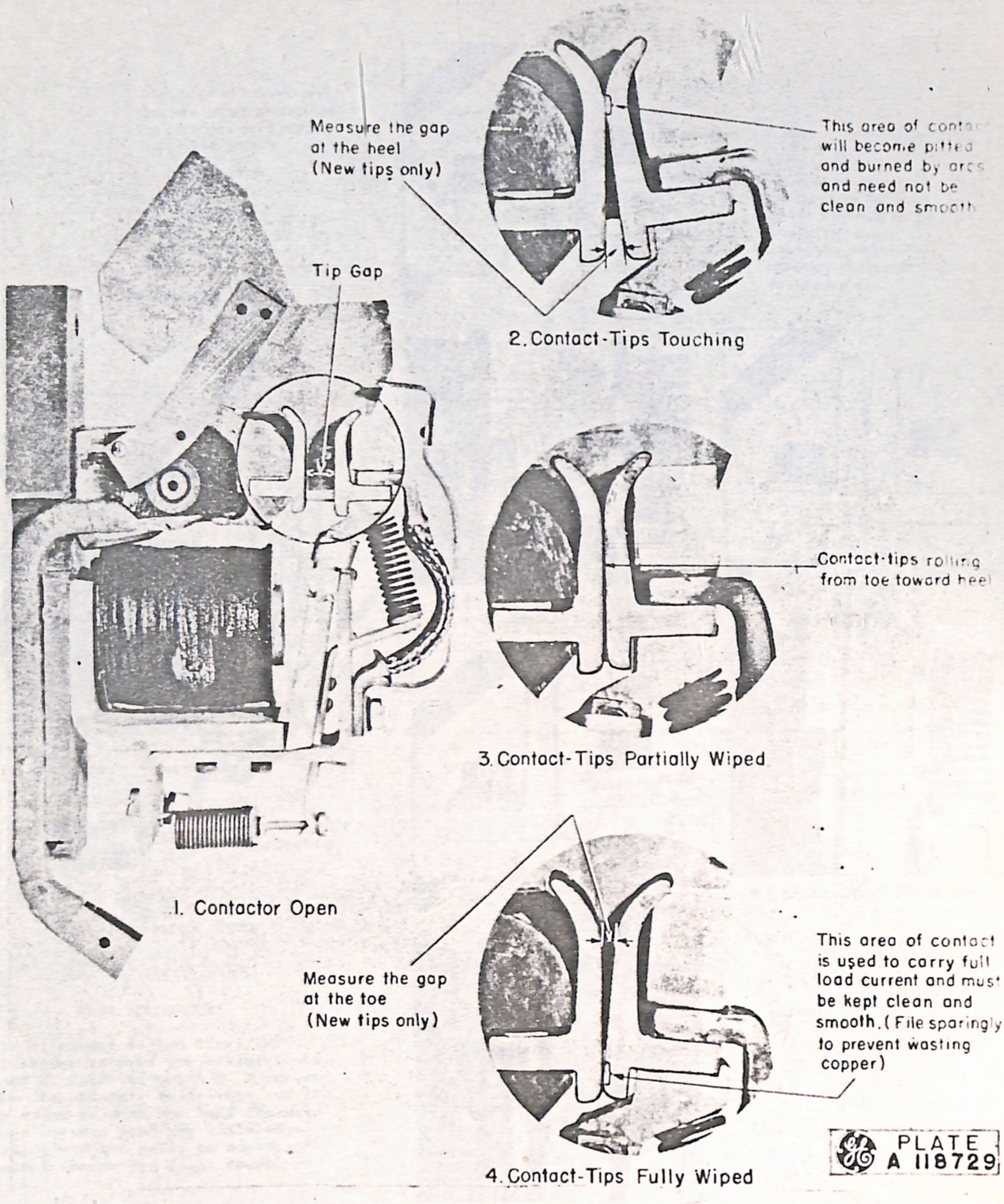
worn tips, worn or bent intermediate lever stops or by too many spacers under frame. Intermediate tip lever stops should be adjusted very carefully and only after checking all other possible causes of defective operation.

(3) Wear allowance is the maximum distance by which electric contacts would overlap if they were mounted side by side instead of contacting. Low wear allowance is caused by badly worn or bent contacts, insufficient armature travel, or bent stationary contact supports. High wear allowance is due to bent contacts, or worn stop on contact-tip lever. Repair or replace defective parts. Plate A-118727 shows method of measuring wipe.

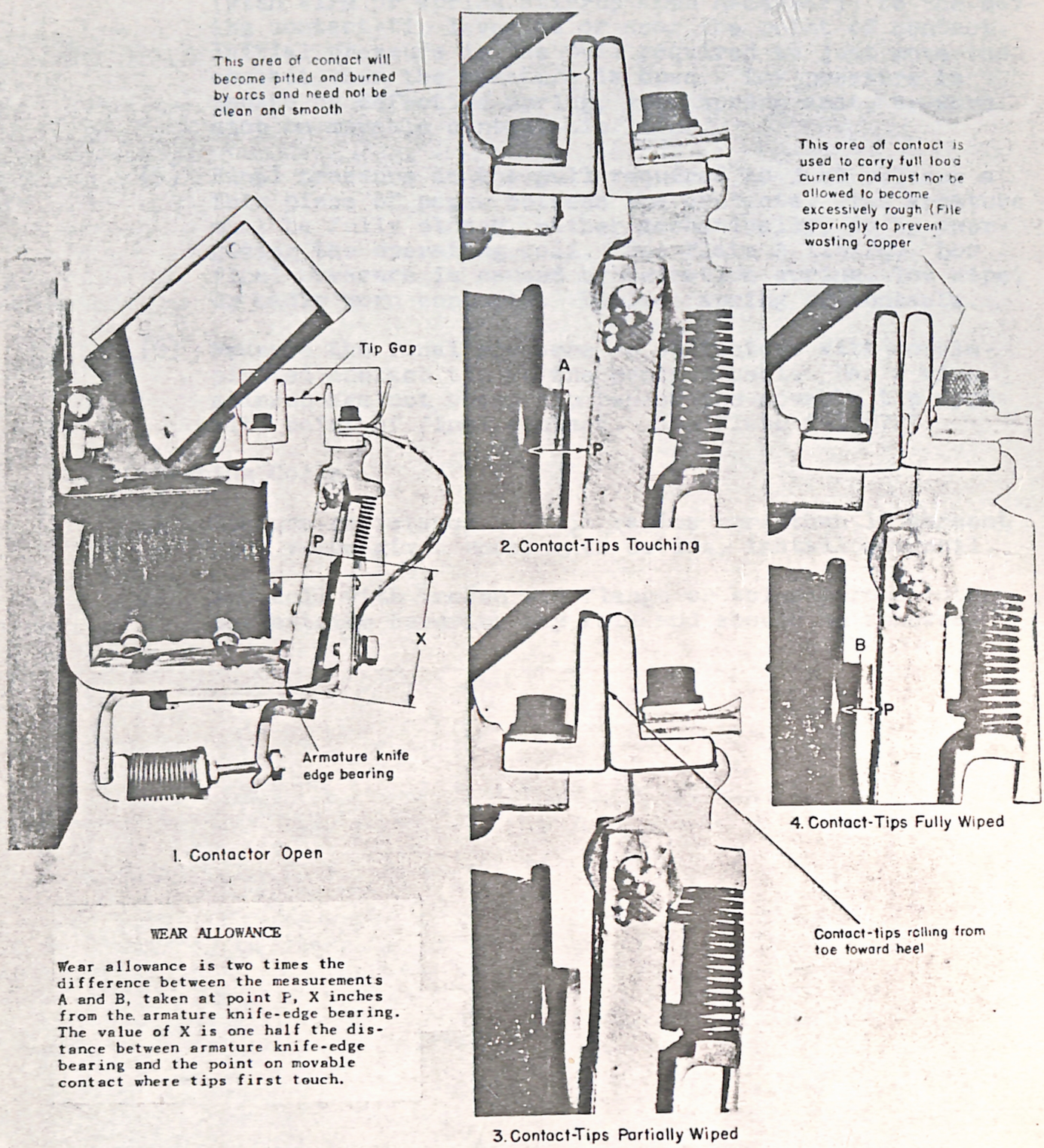
Contact wear allowance as such is not usually measured on contactors with double-pivoted contact levers. Instead, the gap at the heel as the contact tips just touch and the gap at the toe when the armature is fully closed are measured (see Plate A-118729). This is the proper measure of correct contact tip closing action. Check with new tips only.




G-E transportation magnetic contactor. Type 17CM. Showing method of measuring final contact-tip pressure. Spring balance may be obtained from a hardware store.




G-E TRANSPORTATION MAGNETIC CONTACTOR TYPE 17CM SHOWING TIP OPERATION
(FORMS WITH DOUBLE PIVOTED CONTACT-TIP LEVER ONLY)




1. Contactor Open

2. Contact-Tips Touching

3. Contact-Tips Partially Wiped

4. Contact-Tips Fully Wiped

WEAR ALLOWANCE

Wear allowance is two times the difference between the measurements A and B, taken at point P, X inches from the armature knife-edge bearing. The value of X is one half the distance between armature knife-edge bearing and the point on movable contact where tips first touch.

PLATE A-118727B

TIP OPERATION OF G.E. MAGNETIC CONTACTOR

(4) Measure contact pressures by attaching a spring balance (with wire or spring stirrup when necessary) to the moving contact-tip lever at or near the point of contact. Initial pressure is the pull required to just move the contact when the armature is open. Low pressure is caused by defective spring, worn spring seat, or worn stop on movable contact-tip lever.

(5) Final pressure is the pull required to just release a thin piece of paper between the contacts. The armature must be fully closed, either mechanically, or by energizing the operating coil. See Plate A-118728. Low final pressure is caused by defective spring, low wipe, or badly worn contacts. Replace spring or contacts.

(6) Measure the final pressure on contactors with double-pivoted contact tip at the contact heel. Use a wire stirrup against brass tip behind the movable tip opposite point of final contact. See Plate A-118729.

f. Operating Coils

(1) Measure resistance. If it varies more than 10 percent from value given under each device, install new coil.

(2) Any coil with broken end flange or holes burned into the outside covering may fail and should be renewed.

# TYPE 17CM MAGNETIC CONTACTORS

## 1. DESCRIPTION

The type 17CM contactor is a magnetically-operated power switch. The forms used in this equipment have a bent-up frame construction and a knife-edge armature bearing. The contactor is mounted with its supporting base in a vertical plane and with its contact tips up.

Where necessary, the contactors are provided with blow-out coils and arc chutes to assist in rupturing the arc. The arc chute is easily removed, thus making the contact tips readily accessible.

## 2. INSPECTION AND DATA

See Inspection Section and Inspection and General Maintenance in CONTROL SECTION.

## 3. ELECTRICAL SETTINGS

The contactor is provided with an adjustable armature spring to obtain positive opening when the operating coil is de-energized. This spring was properly adjusted at the factory and should not require any further adjustment. In the event a contactor is disassembled or the adjustment is otherwise disturbed, the operating coil should be connected to variable voltage source and the spring adjusted so that the contactor will pick up at the current specified under INSPECTION DATA.

## 4. OPERATING COIL

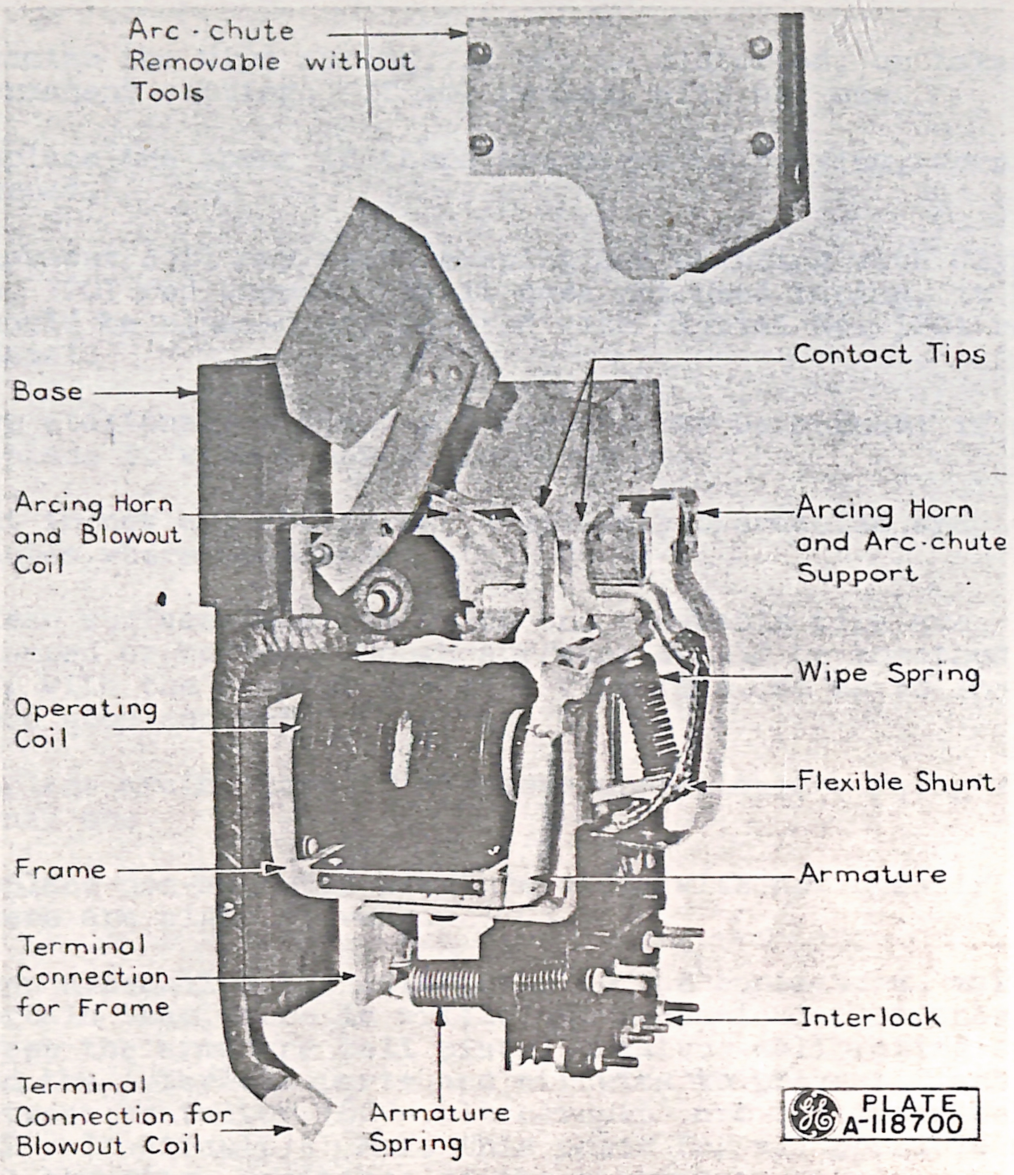
Any coil with broken end flange or holes burned into the outside covering may fail and should be renewed.

## 5. TO RENEW COIL

All coils are mounted on the contactor core. To renew a coil, it is necessary to disassemble the contactor frame from the base and remove the screw from the back of the frame holding core. In doing this, it might be necessary to grip the core head with pliers or other suitable tool to prevent rotation. Remove the two screws holding coil to frame where used.

In some forms of the contactors, the coil is prevented from rotating or vibrating by a sponge-rubber washer cemented to the end of the coil, next to the frame. On these forms the coil must be rotated for proper terminal position before tightening coil in reassembly.

After a coil has been assembled in the contactor, the pick-up setting should be checked. If the two parts of the frame have not been separated, the pick-up setting may not have changed.




Type 17CM42A Contactor.

## 6. OVERHAUL

With the contactor removed from the car and on the bench, the following operations should be performed.

1. Examine the tip lever for wear, especially the stop surface and bushing. If badly worn, replace with new lever, or new bushing.

2. Tighten operating coil, if loose.

3. The non-magnetic stop plate on armature may be worn and should be replaced.

4. Examine the wipe spring, it may be distorted, or taken a permanent setting. If so, replace with new one.

5. Replace the shunt if there are signs of fraying, worn or burned.

6. Blow-out coil may need retaping and painting with Glyptal No. 1201 red enamel. If it does not need taping, it should be cleaned and painted with Glyptal No. 1201 red enamel.

7. The stationary contact-tip support may be burned; if so, replace it with a new or built-up one.

8. Put in new arc chutes, or completely overhauled arc chutes where necessary.

9. Clean surfaces against which the renewable tips are clamped or bolted. Rough surfaces should be smoothed off with the careful use of a fine file, so as to insure good contact.

10. Replace arcing horn if it shows appreciable burning with a new one.

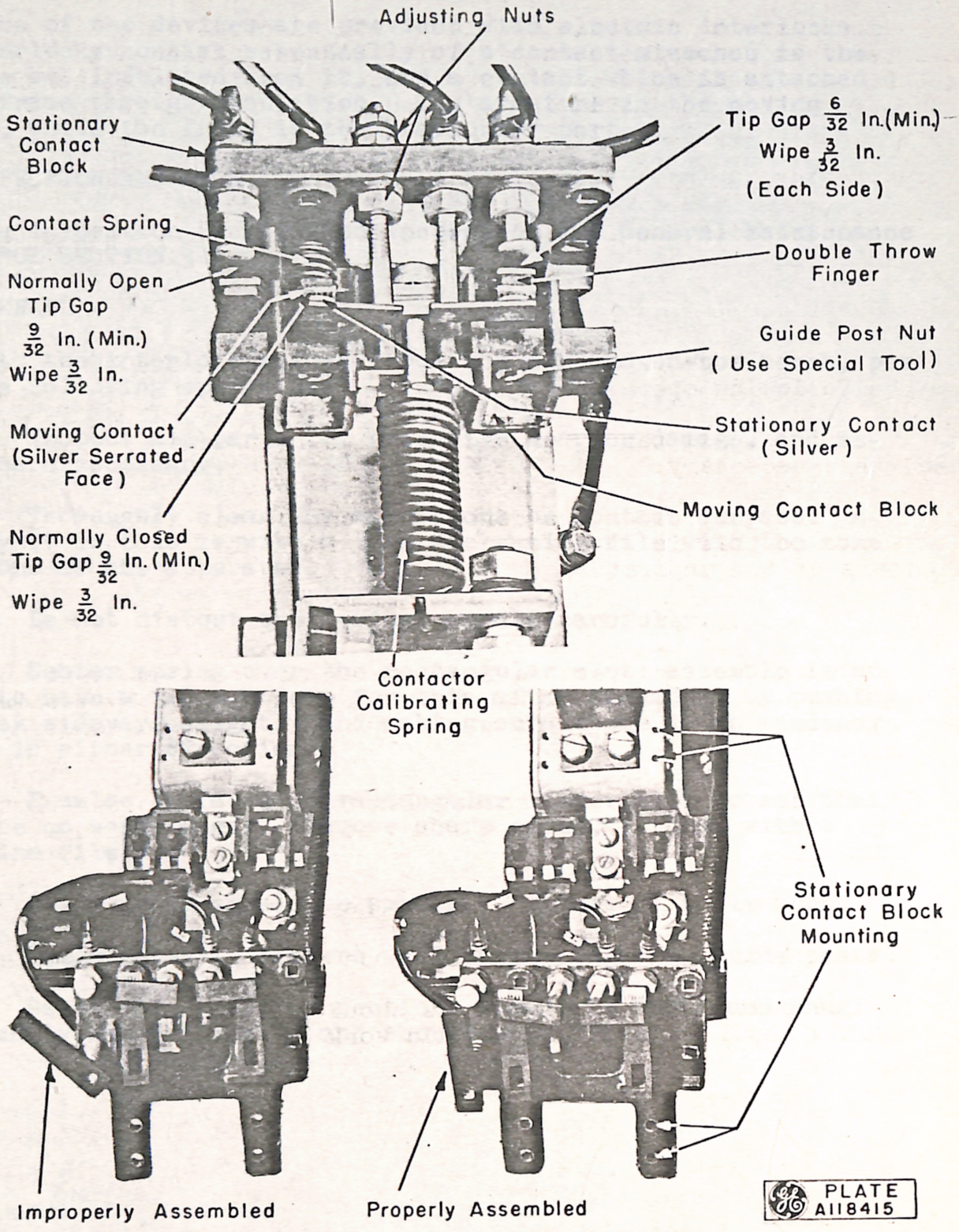
11. Replace non-magnetic armature stops with new ones if there are signs of wear.

12. When assembling the interlocks to the contactors, make certain that there is sufficient mechanical clearance between the armature tail piece, armature calibrating spring and the interlock parts and circuits to prevent flashover between contactor (600-volt circuit) and the interlock (32-volt circuit). Make this check for all possible normal operation positions of the armatures.

13. Make a high-potential test with the contactor completely assembled. Give the 600-volt circuit 1500 volts a-c between contacts except field-shunting contactor which should be given 500 volts across contacts. Make high-potential test of 1500 volts a-c between the 32-volt and the 600-volt circuits.

14. Check the wear allowance, gap, and pressure. See Inspection Section for method and values. The resistance of the coils should be within 10 percent of the values given.

15. Clamp contactor in a vertical position similar to normal position on car. Connect operating coil to a source of variable d-c voltage corresponding to coil voltage, with suitable size of ammeter in circuit to measure coil amperes. Adjust armature spring to obtain specified operating current.




TYPICAL TYPE 17AF20 INTERLOCK

1. DESCRIPTION

Some of the devices are provided with electric interlocks. The interlocks consist essentially of a contact attached to the armature but insulated from it, and a contact which is attached to the frame through insulation. The armature is the moving element, while the frame is the stationary part.

2. INSPECTION AND DATA

See Inspection Section and Inspection and General Maintenance in CONTROL SECTION.

3. OVERHAUL

With the interlock removed from the car and on the bench, perform the following operations:

1. Inspect all parts for excessive wear or damage, and replace where necessary.

2. Thoroughly clean the serrations on contact surface. A good way to do this is with a thread cleaning file with the same serrations as the apparatus.

3. Do not distort the spring, handle carefully.

4. Center spring over the rectangular slot; assemble it so as not to have a twist. Test for this after assembly, by pushing interlock sideways slightly and making sure there is no tendency to turn in either direction.

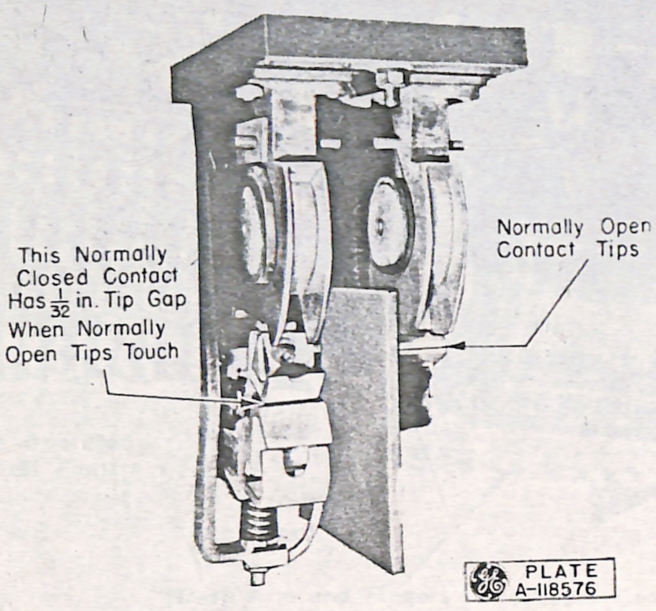
5. Examine surfaces of rectangular finger slot to see that there are no sharp edges. Remove sharp edges, if any, with a small fine file.

6. Guide posts should be smooth. Replace if badly worn.

7. Rough edges in fingers will cause ridges on guide posts.

8. Reassemble - all connections should be tight and snug; the assembly should line up and should work freely.

## TYPE 17GM8A1 POWER SWITCH




TYPE 17GM8A1 POWER SWITCH

On this switch, work armature by hand and note gap between normally-closed contacts when normally-open contacts touch. This gap should measure 0 to 1/32 inch. As the tips wear, this gap will increase but it should never be allowed to become more than 1/8 inch. To prevent this, adjustment should be made when the gap reaches 1/16 inch by moving the adjustable tip on the normally-closed contact in towards the movable tip one notch. Keeping the adjustment 0 to 1/32 inch will result in smoother operation and maximum tip life. This can be done whenever necessary until the end of the adjustment is reached and then new tips should be installed and the contacts readjusted. With parts new and full wipe in normally-closed contact, armature spring must pull armature fully and positively open. Adjustable tip must never be moved far enough in to increase wipe so that armature will not fully open in this manner. Set armature spring tension so that switch will operate at 2.5 amperes. See Plate A-118576.

## TYPE 17KM12 COMMUTATOR MOTOR CONTROLLER

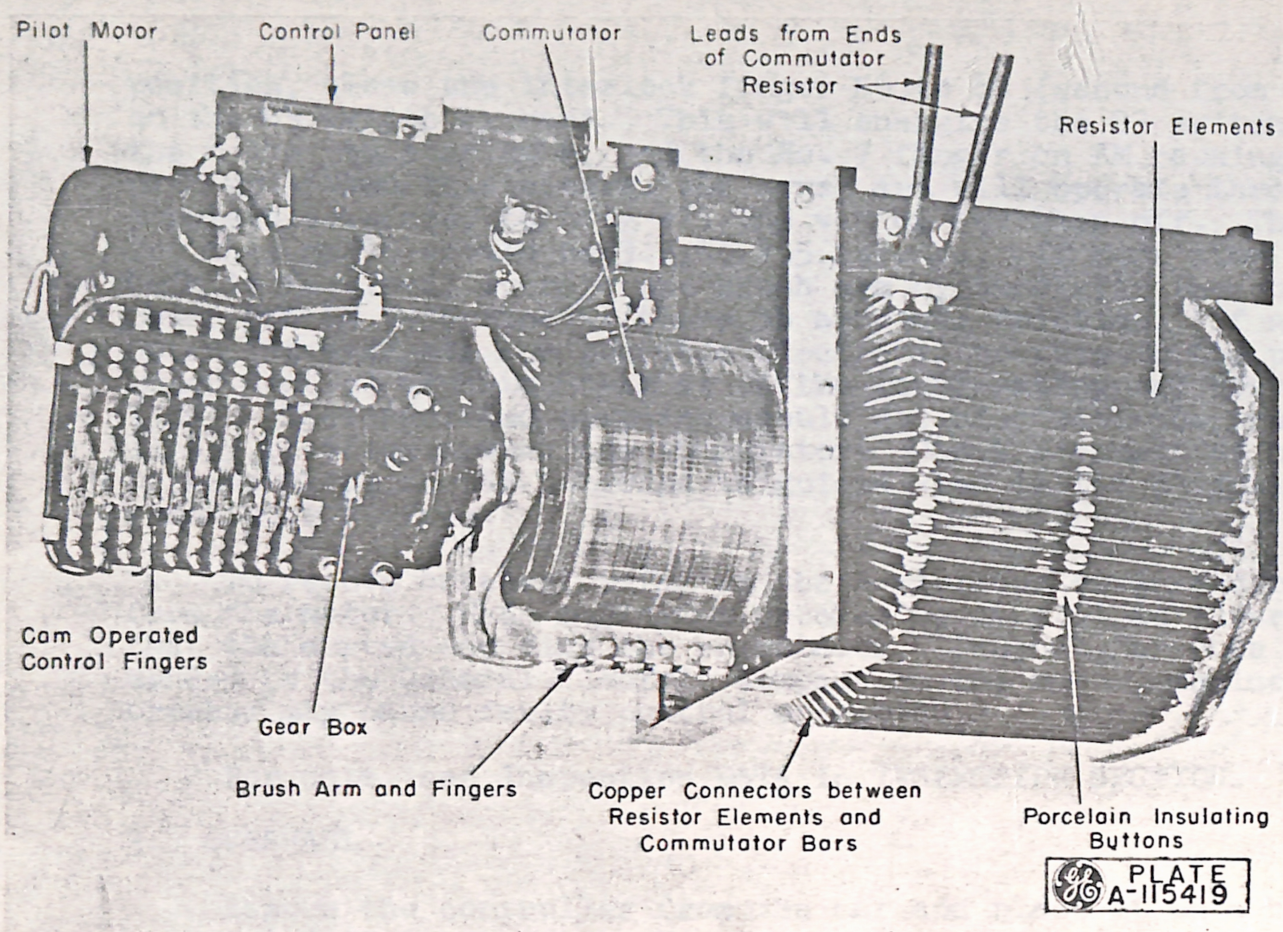
### 1. DESCRIPTION

The motor controller consists of a stationary commutator, the bars of which are connected to resistor sections, and a rotating brush arm driven by a small electric motor. This type of controller provides a large number of steps during acceleration and braking.

It is mounted in frame supported by two angle irons lengthwise along top. Motor is geared to main shaft. A shaft extension beyond commutator operates ten roller-type hinge fingers for control and interlocking. A brush contact arm has six fingers in multiple, each with one-inch wide copper tip and copper insert which rests on the commutator. It has a barrier between commutator and resistors to allow grids to be ventilated.

### 2. INSPECTION AND DATA

To make inspection and minor repairs it is not necessary to remove the controller from the car. In such cases, first remove




G-E TRANSPORTATION CONTROLLER, TYPE 17KM12
OBLIQUE SIDE VIEW WITH PARTS NAMED

the cover of the controller. This will enable inspection and repair the control fingers and contact main fingers, gear housing, commutator and resistor.

Be removing the four screws (3/8 in. - 16) which hold the two insulation bases to the bearing housing, the two bases can be spread apart, so that inspection of the cams and camshaft can be made. The panel can be removed, thereby giving access to the pilot motor.

(1) When carbon inserts in finger tips on brush contact arm need replacement, the copper finger tips may be used again by removing the worn carbon and pressing in a new piece. When pressing in a new carbon, applied pressure should come within 160 pounds minimum and 500 pounds maximum.

(2) Burning of commutator may be caused by short-circuited commutator bars, resistor sections short circuited by foreign matter between resistor elements, operating with short carbons, badly worn rubber bumpers, badly worn brush-arm bearings or rough spots on commutator. If burning is indicated, clean the commutator with fine sandpaper, locate and repair the cause of burning.

(3) Check timing of brush arm with motor-generator set running to provide normal voltage and brake pedal latched in parking

position, close the interlock finger B6 to 8B (second from left) on the B3 switch by hand. This will energize the B3 switch through the 8-ohm resistor tube, and the No. 7 finger on KM causing B3 to pick up. When this occurs, the brush arm will operate through a complete sequence, turning all the way on and then off. The time for this cycle should be 3.5 to 4.5 seconds. If more time than this is required, operate the brush arm by hand with the control power off to determine if there is abnormal friction. If none is noted, investigate for possible electrical trouble in the pilot-motor control circuit, such as in the accelerating and brake relay (ABR). The insulated coupling should not bind with the brush arm in any position around the commutator. Check movement of main fingers which should not bind in guides when lifted slightly off commutator surface.

To remove brushes, unfasten the commutator cover and remove from the motor. When replacing brushes be careful to insert so that the curved end fits the commutator. Use only brushes recommended by the General Electric Company in the motor, as incorrect brushes may cause faulty control operation.

For data, see Inspection DATA in INSPECTION SECTION.

3. OVERHAUL

Remove the controller from the car and place it on a bench.

Examine every part carefully. It might not be necessary to completely disassemble every part of the controller, but it should be disassembled enough so as to be able to tell that every part is in good working condition.

Special attention is called, however, to the following:

1. Examine all wiring to see that the insulation is in good condition, not worn off or frayed. If not in good condition, replace it with new wire.

2. If cams are worn, renew them.

3. Replace all bearings with new ones if they show excessive wear.

4. Examine and thoroughly clean pilot motor and replace worn parts with new ones.

5. Clean and polish commutator with sandpaper and paint the bead ring with Glyptal No. 1201 red enamel. If the grooving in the commutator is deep, it may be necessary to turn it and undercut the mica.

6. Straighten resistor elements and if necessary renew the defective ones.

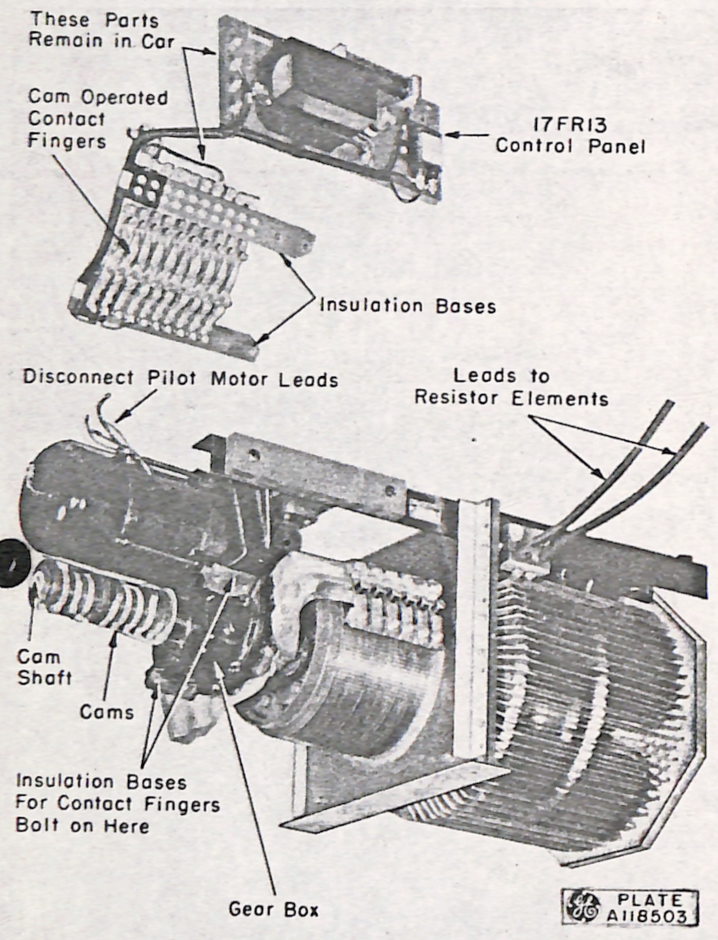
7. Open the gear box and examine the gears. If these show excessive wear, replace the gears with new ones. The cause of the excessive wear should be determined. It might be lack of lubrication or misalignment.

4. DISASSEMBLY

A complete disassembly requiring removal of the controller from the car is seldom necessary, but if such work is required, the following procedure is recommended:

a. Remove controller cover.

b. Disconnect main leads to resistor elements and remove the two insulation bases supporting the control fingers and contacts. These bases are removed by taking out the two screws (3/8 in. - 16) holding each base to the gear-box housing. Disconnect pilot motor leads at the type 17FR13 control panel and unbolt the panel from the frame angle. The panel and insulation bases, together with the fingers, contacts and wiring can therefore be left in the car when the controller is removed for repairs or overhaul.




TYPE 17KM12 CONTROLLER, PARTLY DISASSEMBLED, AS REMOVED FROM CAR

c. Remove air baffles around the resistor elements, being careful not to damage the transite.

d. Remove bolts holding controller barrier to car structure.

e. Place hoist under controller and in proper position for supporting the controller weight.

f. Remove four bolts holding controller frame to car supports.

g. Slowly lower the controller, being careful not to damage any parts.

h. If work is to be done on the motor and drive assembly this complete assembly should be removed from the main controller.

i. Main Drive Unit

(1) Remove four screws (3/8 in. - 16) holding motor to

gear housing, allowing motor and pinion to be withdrawn.

(2) Pull the motor armature out by removing the long through screws with heads at the pinion end allowing the framehead and armature to be withdrawn.

(3) To remove cams, take out the screw (3/8 in. - 16) and two washers, at the end of the cam shaft and pull cams off along the shaft. Be sure to identify for easy reassembly.

(4) Take the gear housing assembly apart by remove the 11 screws (5/16 in. - 18) holding the cover to the gear housing.

(5) Remove the brush contact arm with shaft, key, shunt fingers, and pipe plug by first removing the shunt connection at the terminal which is at the center of the far end of the resistor. Pull the arm away from the commutator, pulling the shunt through the hollow shaft running through the center of commutator and resistor assembly.

(6) Remove the top half of the barrier with guard by taking out the four screws (1/4 in. - 20) fastening barrier to connecting angle or channel and knocking loose the filling compound.

(7) By taking out the two screws (5/8 in. - 11) fastening supporting plate to insulated stud the resistor is freed from the frame angle. By taking out the four screws (3/8 - 16) fastening commutator support to the insulation base, the commutator assembly is freed from the frame angle. Take off cable cleat from frame angle. The commutator and resistor assembly can now be lifted out of the frame.

5. REPAIRS

a. To Replace Shunt

If shunt is worn, frayed, or burned, renew it. Detach the defective shunt from the shaft by taking out the pin which fastens the terminal and then unscrewing the terminal. Screw the new shunt into the shaft and then pin to fasten it. In reassembly, arrange shunt for minimum twist over range of brush arm travel.

b. To Replace Brush Arm or Shaft

The shaft is pressed in the brush arm with a minimum pressing of two tons so that the end of the shaft is flush with the far surface of the arm. A slot is then cut in the end of the shaft to match with the slot in the surface of the arm. The key is then put in this slot and pinned with two pins. The shunt is then fastened to the other end of the shaft. See that the oil holes in the shaft are not plugged.

c. To Renew Commutator Bars

If it becomes necessary to put in new commutator bars, unsolder resistor connection and take out the clamping bolts (1/2 in. - 13) of the commutator, removing commutator cap and support. Take out commutator cone. Take out the damaged bar. Cut or file the new bar to the correct size and then put in place of the damaged one. If the side mica is damaged, replace it. Put in the mica cone and bolt on the commutator cap and arm. This should be put on with 13 tons pressure cold. If it is possible, the commutator should be heated to 140 C for ten hours and then cooled to 100 C and tightened up again with 13 tons pressure. The commutator should then be turned and the mica undercut.

d. To Turn Commutator

Put the commutator and resistor element assembly, including commutator support in a 24-in. or over lathe with 4-in. or over extension centers. An offset cutting tool is required to clear the commutator support in turning. The shape and size of this tool will vary with the lathe used.

After turning, undercut the commutator mica to a depth of 1/32 in. Use a circular saw 0.025-in. thick. It may be necessary to turn the assembly end for end in the lathe to completely undercut the mica on account of the commutator support. Clean the slots with dry compressed air.

Polish the commutator with coarse (No. 1) and then fine (2-0) sandpaper.

Clean and paint the string bands with Glyptal No. 1201 red enamel.

Some grooving of the commutator will appear after several years service. A reasonable amount will not impair proper operation. If the grooving is too bad, turn the commutator.

e. To Renew a Resistor Element

Chip away the cement over the soldered connection of the element to be renewed. Loosen the soldered connection by driving the end of the resistor element out of the commutator slot with a drift. Take the defective element out and clean the slot. Fit the new element in the end support, and solder the end in the commutator slot. Use pure tin solder if these connections have to stand high temperatures. Put General Electric filling compound No. 805 over the connection and then paint with Glyptal No. 1201 red enamel.

f. Repairs to Pilot Motor

(1) If commutator is badly grooved, turn and polish it.

(2) If grease has collected on the field coils, clean it off with carbon tetrachloride or a good grease solvent.

(3) Renew bearings if badly worn.

(4) Examine oil seal between motor and gear box. This may need to be renewed.

6. ASSEMBLY

a. Assemble frame and commutator and resistor assembly.

(1) Fasten resistor supporting bracket with bushing, supporting plate and insulated stud to frame angle with four screws (5/16 in. - 16).

(2) Fasten commutator cap and support to insulation base with four screws (3/8 in. - 16).

(3) Assemble top half of barrier with guard around the commutator by fastening it to the connecting angle with four screws (1/4 in. - 20). Fill space between barrier and resistor and also over the soldered connections with General Electric filling compound No. 805 and then paint with Glyptal No. 1201 red enamel.

b. Assemble brush contact arm on commutator.

(1) Draw the shunt through the hollow shaft running through the center of commutator and resistor assembly.

(2) Make the connection of the shunt at the terminal which is at the center of the far end of the resistor. Refer to Item 1 of REPAIRS.

(3) Fit the shaft in the center of commutator and the brush holder with fingers on commutator.

(4) Line up fingers and see that they have the right pressure.

c. Fit coupling disk on key on the contact arm.

d. Assemble drive unit.

(1) Start with cam shaft with end disk and key.

(2) Place oil seal and cover with bushing on cam shaft. Press main gear on shaft with from two to five tons pressure leaving 1/16-in. clearance.

(3) Place auxiliary gear and pinion on shaft for auxiliary gear and fit in hole in cover with oil seal so that the auxiliary pinion will mesh with the main gear.

(4) There is a locking plate with dowel pin and gasket which must be fastened on the outside of cover with screw (10-32).

(5) Fasten gear housing to cover with gasket and oil seal with 11 screws (5/16 in. - 18). The gear-housing assembly is now ready for the motor.

(6) Assemble motor so that the pinion meshes with the auxiliary gear. The motor is fastened to gear housing with gasket and four screws (3/8 in. - 16).

e. Assemble cams on cam shaft.

(1) Put washer on shaft.

(2) Put first cam on shaft. Be careful to match "0" on shaft with "0" on the cam, so as to be sure that the cam is on the right way.

(3) Put on each of the cams in the correct order.

(4) The cams are held on by two washers and screw in the end of the cam shaft. The drive unit is now ready for assembly on controller.

f. Assembly of drive unit to controller.

(1) With brush arm in "A" position, assemble coupling disk to brush arm. If disk is badly worn, a new disk should be used.

(2) Place drive unit in place and bolt gear box to angle iron support; at the same time, locating the cam shaft so that with the coupling disk engaged, the No. 9 cam (second from end) is in position to just lift the finger.

g. Before assembling complete controller on car preliminary tests are recommended as follows:

(1) High-potential 600-volt circuits with 1500 volts.

(2) High-potential 32-volt circuits with 500 volts.

h. Add oil to gear box and lubricate brush arm.

i. If possible, give controller an operational test, using a test circuit similar to that on the car. With 2.4 ohms in series with the motor across 36 volts, the time required for the brush arm to travel from "A" to "B" or "B" to "A" should not exceed 1 1/2 seconds. A single-pole double-throw switch may be used to reverse the motor for tests. It is easier to remove any controller friction before it is mounted on car.

j. Install controller in its place on the car body.

(1) Place controller on hoist, and roll the hoist under the car. Raise the hoist so that the controller is in the correct place for installation on the car body, and fasten the four screws holding the controller frame to the car supports.

k. Install panel on frame angle.

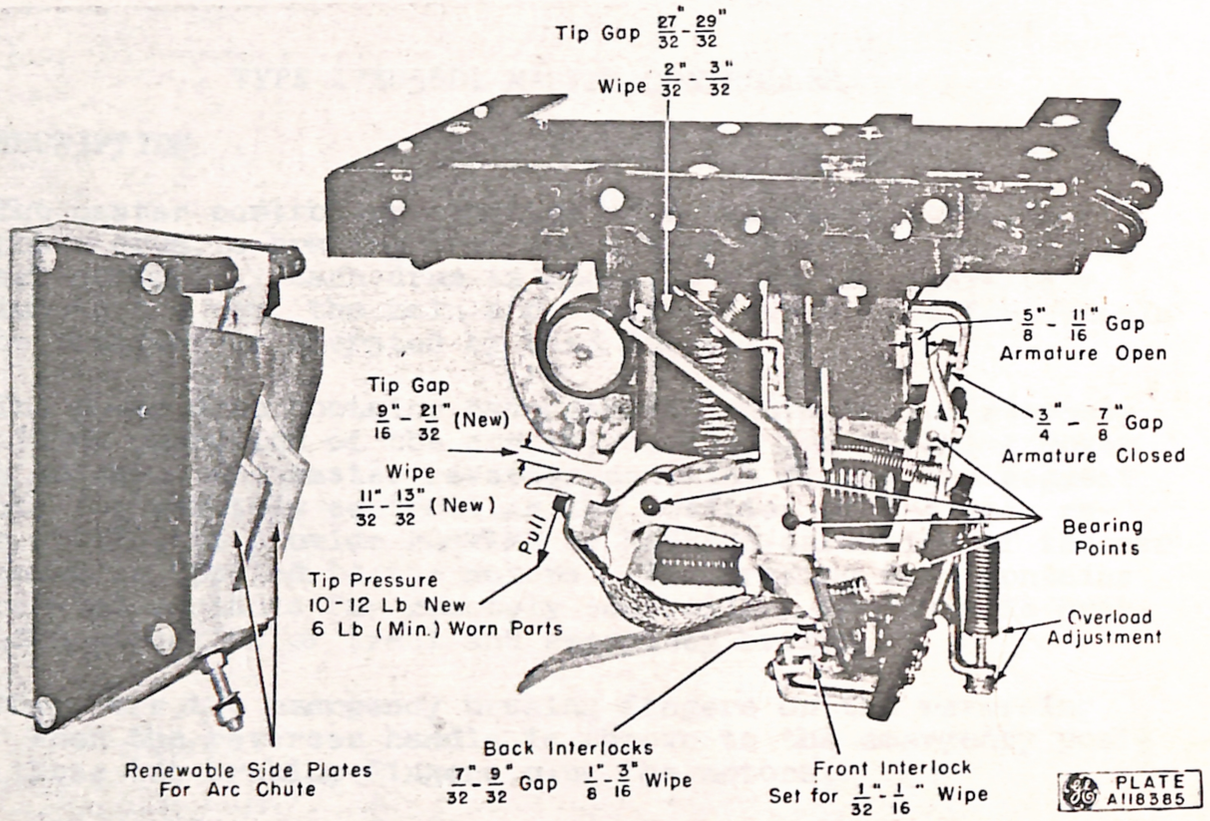
l. Connect pilot motor leads.

m. Assemble insulation bases with contact fingers and stationary contacts on bearing housing with two screws (3/8 in. - 16) each. Line up fingers and contacts so that proper contact is made when the cam shaft is turned. Be sure that the fingers have the proper gap, wipe and pressure.

n. Make all necessary electric connections and make operational tests similar to those given in INSPECTION in CONTROL SECTION.

o. Install cover.

TYPE DB-1805 LINE BREAKER



1. DESCRIPTION

The DB-1805 line breaker consists of a magnetically-operated contactor with overload attachment and interlock, mounted in a sheet-steel box.

2. OPERATION

The line breaker is used to rupture the power circuit when the operating pedal or lever is released during normal operation or when the overload relay trips due to overload or short-circuit conditions. When the overload relay operates, a holding coil maintains the armature in the tripped position until the master controller is returned to the off position, which automatically resets the overload relay.

3. INSPECTION AND DATA

For adjustments see Plate A-118385. For further information refer to INSPECTION SECTION and Inspection and General Maintenance in CONTROL SECTION.

4. OVERHAUL

The same information given under CONTACTORS will apply to line breaker.

## TYPE 17KC56D1 MASTER CONTROLLER

1. DESCRIPTION

The master controller consists of a framework mounting a main power drum, a braking drum and a drum operating the master reverser controls. Each drum is operated from the operator's position in the car, the main and braking levers from foot pedals and the reverser is operated by hand lever.

The power drum contains cam-operated contacts for remotely controlling operation of the control devices for applying power to the motors. The master reverser contains finger and segment contacts for remotely controlling the position of the main reverser 17DM1A, to provide FORWARD or REVERSE direction of the car when power is applied to the motors. The braking drum contains cam-operated contacts for remotely controlling the dynamic braking and application of track and emergency brakes.

There are two emergency braking fingers on the reversing drum. When the reverser handle is thrown to the emergency position, these two braking fingers plug the motors.

On the inner end of both the power and braking drums there is mounted a rate-control rheostat, the one on the power drum controls

the acceleration rate, the one on the braking drum controls the rate of dynamic braking.

2. INTERLOCKING

There is no mechanical interlocking between power and brake levers. Interlocking between reverse and power levers and between reverse and brake levers is as follows:

| | | |
|---|---|---|
| a. | Reverse lever in FORWARD or REVERSE positions. | Power lever may be operated.<br>Brake lever may be operated. |
| b. | Reverse lever in OFF position. | Power lever is locked in OFF position.<br>Brake lever is locked in PARKING position. |
| c. | Power lever NOT in OFF position. | Reverse lever is locked in FORWARD or REVERSE positions.<br>Brake lever can be operated. |
| d. | Brake lever NOT in PARKING position. | Reverse lever is locked in FORWARD or REVERSE positions but can be turned to EMERGENCY position.<br>Power lever can be operated. |
| e. | Brake lever in PARKING position. | Reverse lever can be turned to FORWARD or REVERSE positions. |
| f. | Power lever in OFF position. | Reverse lever can be turned to FORWARD or REVERSE positions. |

3. OPERATION

Main Controller

The first movement of the power drum, as controlled by the power pedal, opens the circuit for dynamic braking by opening B1 and B2 contactors. As soon as B1 opens, its interlock closes the reverser circuits causing the main reverser to adjust itself to agree with the position of the operator's handles. This is followed by the closing of the line contactors LB1 and LB2 and the cushioning contactor C1 which closes the pilot motor circuit and starts the progression of the KM controller. This corresponds to the switching position.

Movement of the power pedal further to the RUN position closes the cushioning contactor C2 to provide shunting of the motor fields and resulting increase in speed. Remaining movement of the camshaft operates the rate control rheostat to vary the resistance

in the rate control circuit through the ABR relay and thus control the rate of acceleration; the rate of acceleration increases in proportion to the distance the pedal is depressed.

The body of the rate control rheostat is adjusted so that the brush arm contacts the rheostat winding at the camshaft position where contacts PC4 and PC5 overlap. This is necessary to prevent arcing between brush arm and winding (also applies to brake controller where BC1 and BC11 overlap).

Brake Controller

With the brake drum in the "off" position, FS1 contactor is closed so that the dynamic braking circuit is set up as soon as the main controller returns to the "off" position causing the braking contactors B1 and B2 to close. The rate control coil in the ABR relay is energized through BC11 contact, thus providing a small amount of dynamic braking while in the "coasting" condition.

On depressing the brake pedal further to the "Dynamic Braking" position the FS1 contactor drops out and control of the braking rate is transferred to the rate-control rheostat mounted on the brake drum. Additional pressure on the brake pedal cuts in resistance in the rheostat, increasing the braking rate until at maximum dynamic braking no current flows through the rate-control coil in the ABR relay.

Further depression of the brake pedal energizes the track brakes to provide additional braking.

4. INSTALLATION

Definite stops should be included as part of the pedal mechanisms to limit the movement of the controller shafts to the angular rotation shown on the outline print. The stops included in the controller are emergency stops only.

The operating rods for the camshafts should be installed in such a manner as to require the least amount of effort to operate consistent with positive operation. The return spring must have enough tension to return the pedal positively to the off position when released from any operating position and still not require excessive effort to operate.

5. INSPECTION AND DATA

(1) Check for excessively worn brushes and low brush pressure on rheostats.

See "Inspection Section" and "Inspection" in CONTROL SECTION.

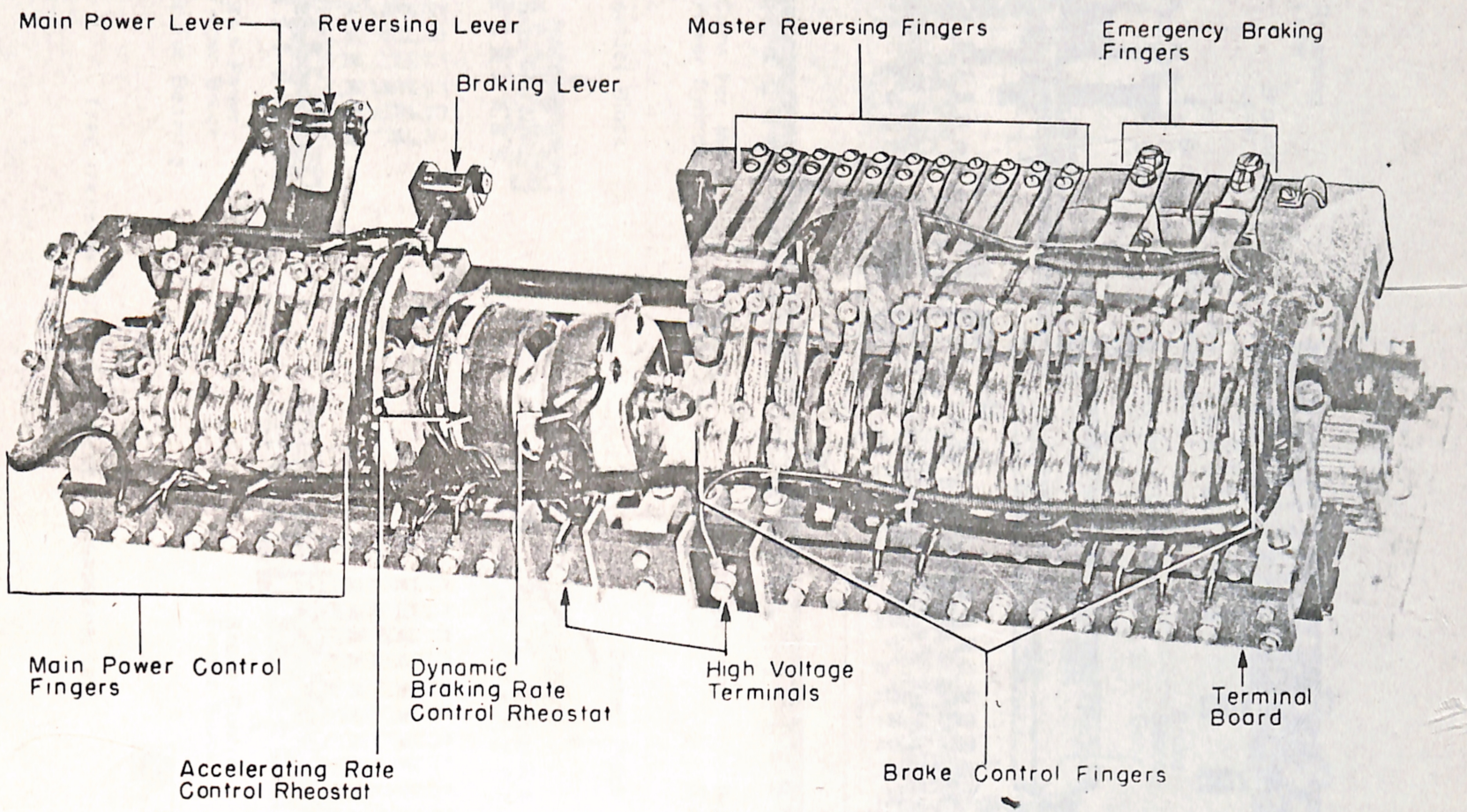
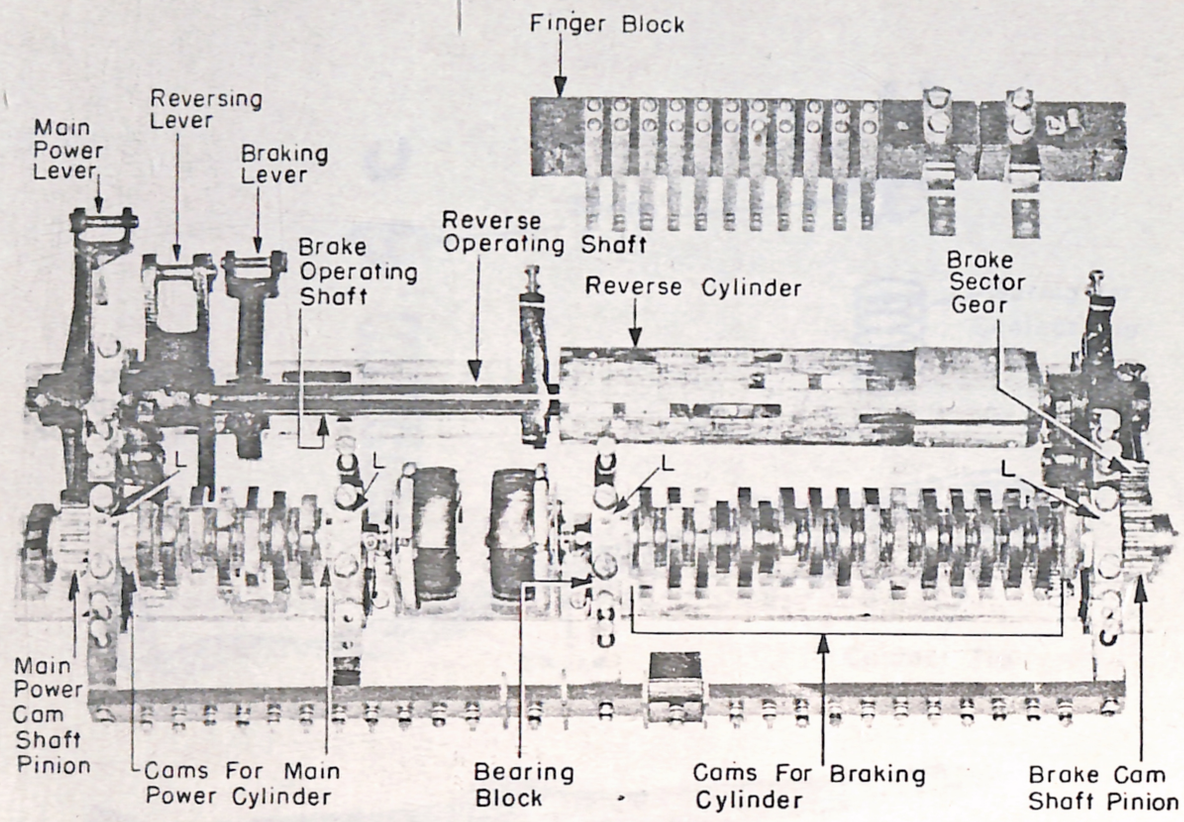
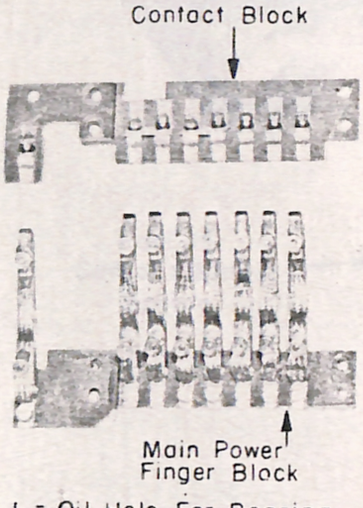



PLATE A-125182

TYPE 17KC56BI MASTER CONTROLLER




L = Oil Hole For Bearing

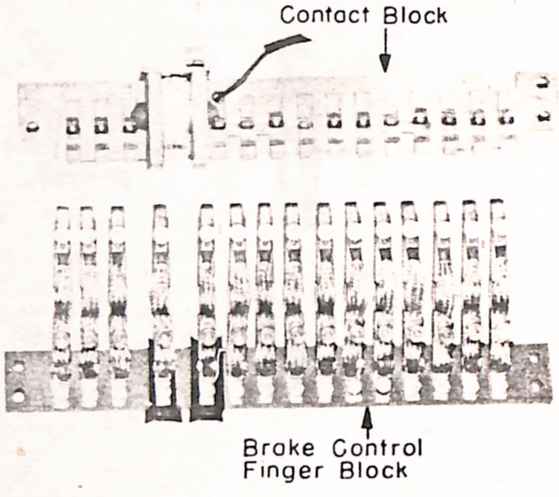
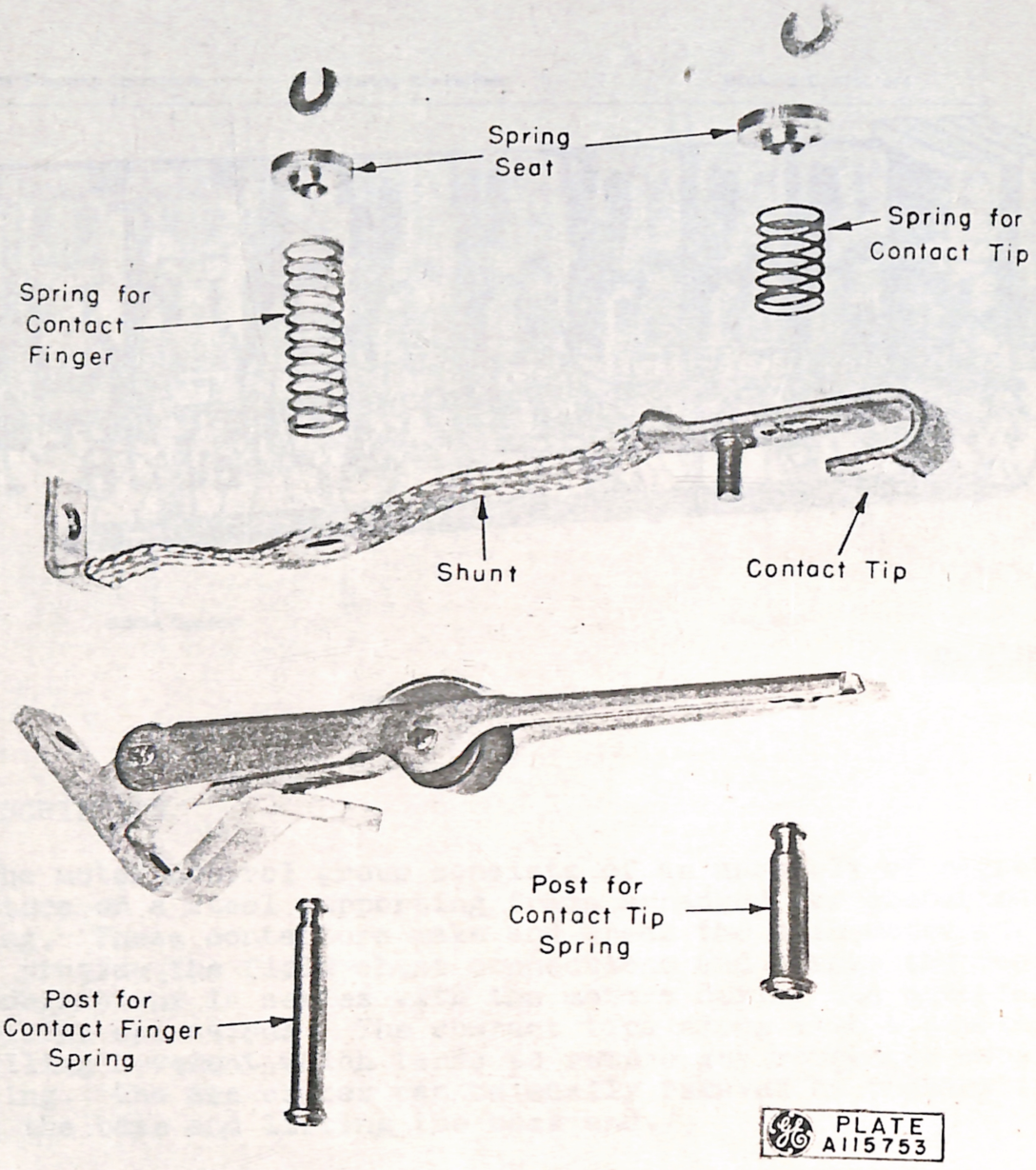


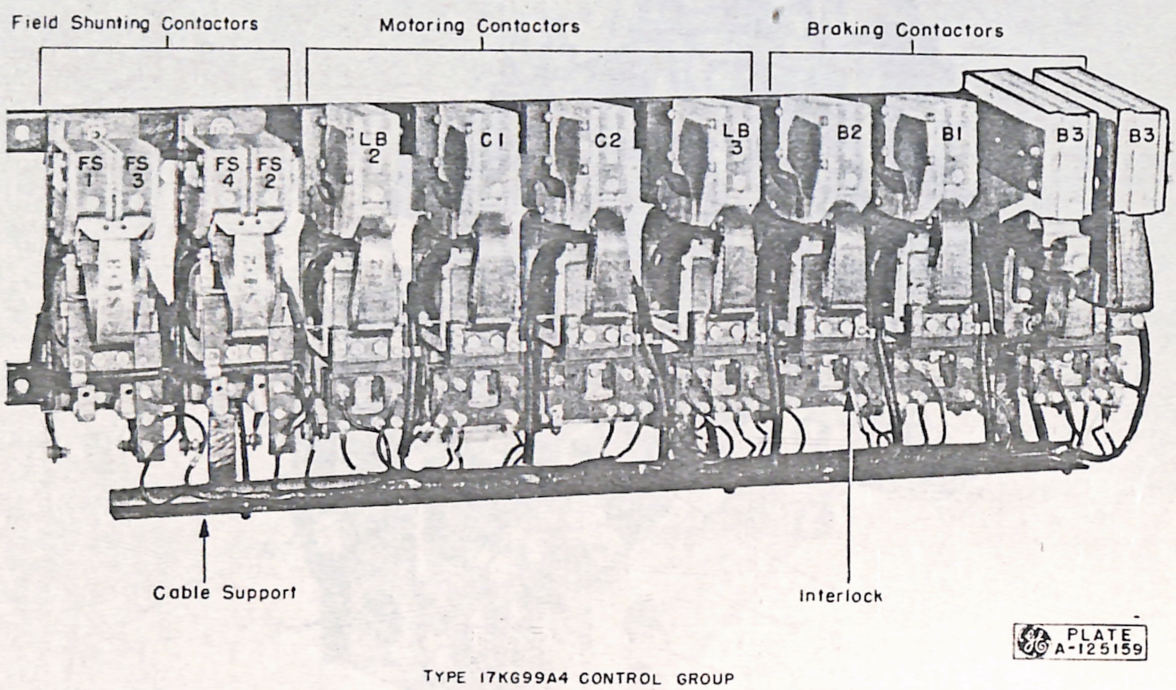

PLATE A-125187

TYPE 17KC56B1 MOTOR CONTROLLER (DISASSEMBLED)




ROLLER TYPE CONTACT FINGER, DISASSEMBLED

# TYPE 17KG99 MOTOR CONTROL GROUP




TYPE 17KG99A4 CONTROL GROUP

## 1. DESCRIPTION

The motor control group consists of an assembly of magnetic contactors on a steel supporting frame arranged for compartment mounting. These contactors make and break the main motor circuits, provide the field shunt connections and change the resistor combinations in series with the motors during the motoring and braking operations. The contact tips close with a butting and rolling movement which tends to remove any roughness caused by arcing. The arc chutes can be easily removed by pushing in toward the base and lifting the back end.

## 2. INSPECTION AND DATA

See INSPECTION in CONTROL SECTION.

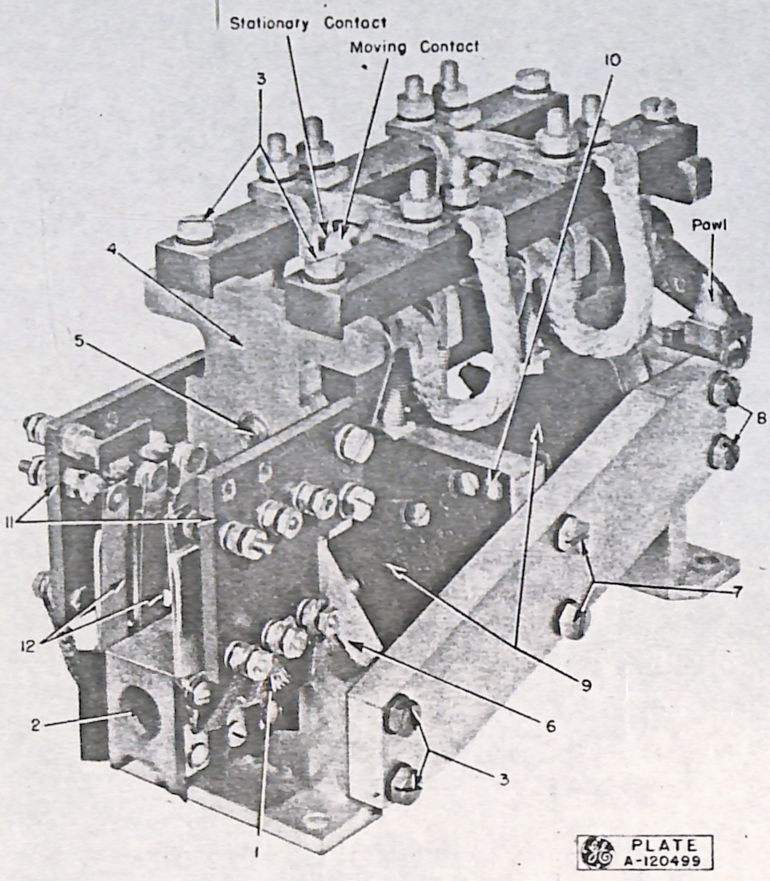
## 3. DISASSEMBLY AND ASSEMBLY

The contactors can be removed from the frame angle by taking out the holding bolts at the back and disconnecting the cables. The information for contactors will be found under TYPE 17CM MAGNETIC CONTACTORS.

## 4. OVERHAUL

The same information given under TYPE 17CM CONTACTORS will apply here.

# 17DM1A MAGNETIC MOTOR REVERSER




TYPICAL 17DM1A1 MAGNETIC MOTOR REVERSER

## 1. DESCRIPTION AND OPERATION

This reverser controls the direction of car movement by reversing the traction motor fields.

The 17DM1A1 reverser is a magnetically-operated reverser with four double-throw main contacts. These contacts have silver contact surfaces and are not designed to interrupt or close on any appreciable current.

Two operating coils are used which operate a double-ended rotating armature. One coil rotates the armature to the right; the other coil rotates the armature to the left. These coils are short-time rated; namely, they are energized only momentarily at full current in order to operate the reverser and will not stand full operating current for long periods of time.

Eight interlocks are provided, six of which are used in the operating coil circuits, and the remaining two are for associated control circuits.

These main contacts are actuated by means of a cam and roller arrangement, the cam being on the end of the rotating armature shaft.

2. ADJUSTMENTS

No adjustments are provided for the operating coils and rotating armature.

Interlocks may be adjusted to operate at any desired point by adjusting the length of the fixed contact by means of the nuts which hold the contact posts. The two pairs of interlocks nearest the frame are used in the operating coil circuits. These interlocks should be adjusted to close before any of the interlocks operate. This can be checked as follows: With power off and the armature starting from the extreme end position, rotate the armature slowly toward the center and observe the interlock action. The end pair of interlocks should close before any of the other interlocks close or open. This same condition should exist with the other end pair of interlocks when the armature is slowly rotated from the opposite position.

The main contacts have no adjustments and should not require much attention.

## DISASSEMBLY
(Refer to Plate A-120499)

1. Remove reverser from car.

2. Disconnect braided shunts (1) on interlock assembly.

3. Remove retaining spring and washer in interlock block (2) and remove interlock fingers (12) and block from reverser frame.

4. Unscrew the six hex bolts (3) out of end frame (4).

5. Remove end frame. The moving contact shaft (5) will drop down slightly, but can be wired up so it will not interfere with disassembly.

6. Using the tapped holes provided, jack the armature (6) off the main shaft.

7. Unscrew the four bolts (7) out of the side frames.

8. The complete coil assembly including both coils and separator may be removed from frame. It may be necessary to loosen the four bolts (8) slightly in case the side frame binds.

9. Both coils (9) may be removed from the shaft after the four screws (10) are taken out.

## ASSEMBLY

To reassemble this reverser, reverse the process of disassembly.

CAUTION: Before tightening the four bolts (7) in the side frames, make sure that there is uniform clearance between the main shaft and the coils, otherwise there may be some binding present which will prevent proper operation of the reverser.

The two coils of the reverser are interchangeable. Care must be exercised in reassembly to make sure the armatures are replaced in the same manner as before disassembly.

## TYPE 17LC29C4 ACCELERATING AND BRAKING RELAY (ABR)

### 1. DESCRIPTION

This relay consists of a frame mounting, a series coil, a shunt coil, a regulating (wiggle) coil, a rate coil, an armature operating a set of five movable contacts and three variable resistors for adjusting the shunt and rate coil circuits.

### 2. OPERATION

The function of the accelerating and braking relay (ABR) is to regulate the speed of the pilot motor (PM) and the commutator motor (KM) brush arm motion in response to current flowing in the traction motor circuit. During motoring and braking, the current flowing through one pair of traction motors passes through the series coil of ABR. Current in this coil tends to close the five relay contacts in sequence when its magnetic pull on the armature overcomes the tension of the armature spring. Wound about the same core and assisting the series coil are a shunt coil, a regulating coil and a rate coil. The shunt coil is energized by the voltage appearing across a pair of motor fields; the regulating or wiggle coil is energized by the voltage appearing across the pilot motor armature; and the rate coil is energized directly from the battery through master controller contacts. See Plates A-123796 and A-123797.

During acceleration, the pilot motor runs at full speed cutting out resistance in series with the propulsion motors until current through the ABR series coil rises and causes ABR to pick up. At this point, the pilot motor speed is regulated to hold current through the propulsion motors at the value set by ABR. The value of current at which ABR regulates is raised by decreasing the current through the rate coil. This is done by depressing the power pedal and increasing the resistance in the rate control rheostat at the end of the master controller power drum. Regulating action is obtained in the relay by means of the regulating coil. This coil tends to be shorted out each time the

relay picks up, and therefore the loss of its magnetic pull on the armature acts to immediately drop the relay out again. This results in a fluttering action which makes the relay very sensitive to slight changes.

When accelerating with the master controller in the switching position, the shunt coil across the traction motor fields is energized through a resistor. Its pull added to the pull of the rate coil results in the ABR regulating at a relatively low current value.

Operation of the relay during coasting and braking is the same as for acceleration, except that the shunt coil is energized at all times to assist the series coil. During coasting, the shunt coil is connected directly across the traction motor fields so that the relay regulates at a very low ampere value. During braking, the shunt coil is connected across the traction motor fields, but it is in series with ballast resistors, resulting in the relay regulating at a low value of braking current. Here again, higher current settings or higher braking rates are obtained by decreasing the current through the rate coil with the brake pedal. Progressive pressure on the brake pedal cuts in resistance in the rate control rheostat on the end of the master controller brake drum, increasing the braking rate until at maximum dynamic braking no current flows through the rate coil of ABR relay.

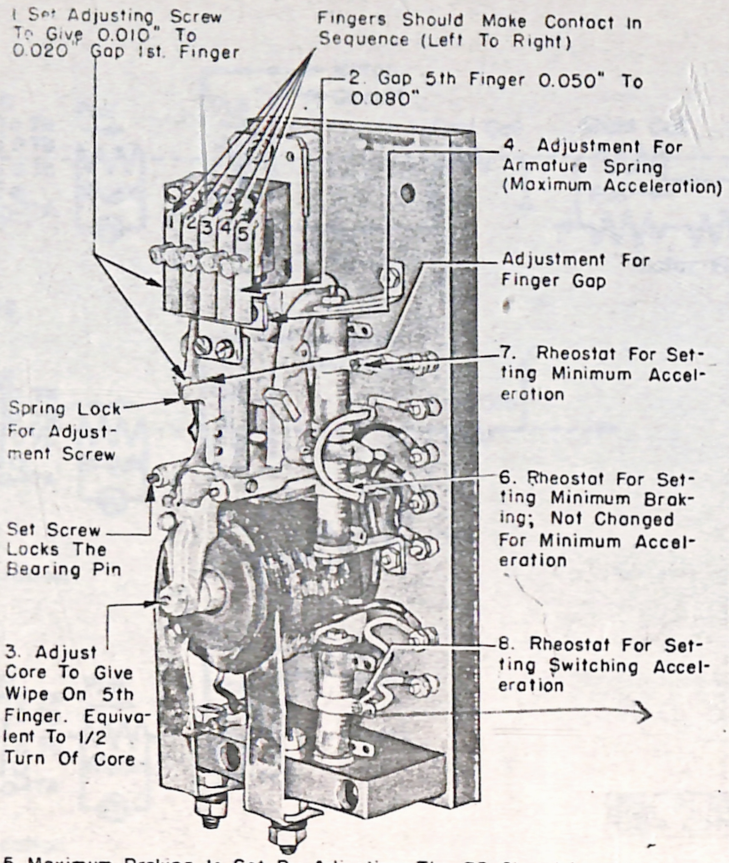
The use of ballast resistors in series with the ABR shunt coil causes the relay to have a current setting which rises slightly as braking current rises. This affects the relay to permit the braking current to rise rapidly at the beginning and slowly as the final current setting is being reached.

While the car is in motion, during accelerating, braking, or coasting, the ABR armature will be vibrating rapidly to run the pilot motor at a speed required to maintain the current at which the operator is requesting by the position of his operating pedals.

When the relay is operating to hold some current value, a state of approximate balance is obtained between the tension of the armature spring and the combined pull of the series, shunt, wiggle and rate coils.

By connecting the wiggle coil across the pilot motor armature, both "wiggle action" and "anticipation" are obtained. Wiggle action results from the fact that as the relay starts to pick up and close its contacts, closing of these contacts results in a reduction of voltage on the wiggle coil, tending to allow the armature to drop out. In opening of the relay contacts, a similar opposing action takes place. The result of this wiggle action is a vibrating of the relay armature producing an average motor voltage to give the motor speed required to hold the current the car operator is requesting.

ELECTRIC RUNNING SHEDS
BRANCH, HAVANA ST.




5. Maximum Braking Is Set By Adjusting The 35 Ohm Adustable Resistor On The 17FR13HI Panel Mounted On The Motor Controller.

Note: Make Settings In Numbered Sequence

PLATE A-125176A

Set correct car pedal travel - approximately 1/16-inch clearance measured at controller stops in maximum positions.

B. Make mechanical adjustments as per photograph references 1, 2, 3.

C. Make rate adjustments as per photograph references 4, 5, 6, 7, 8.

D. Make all adjustments in order given on photograph.

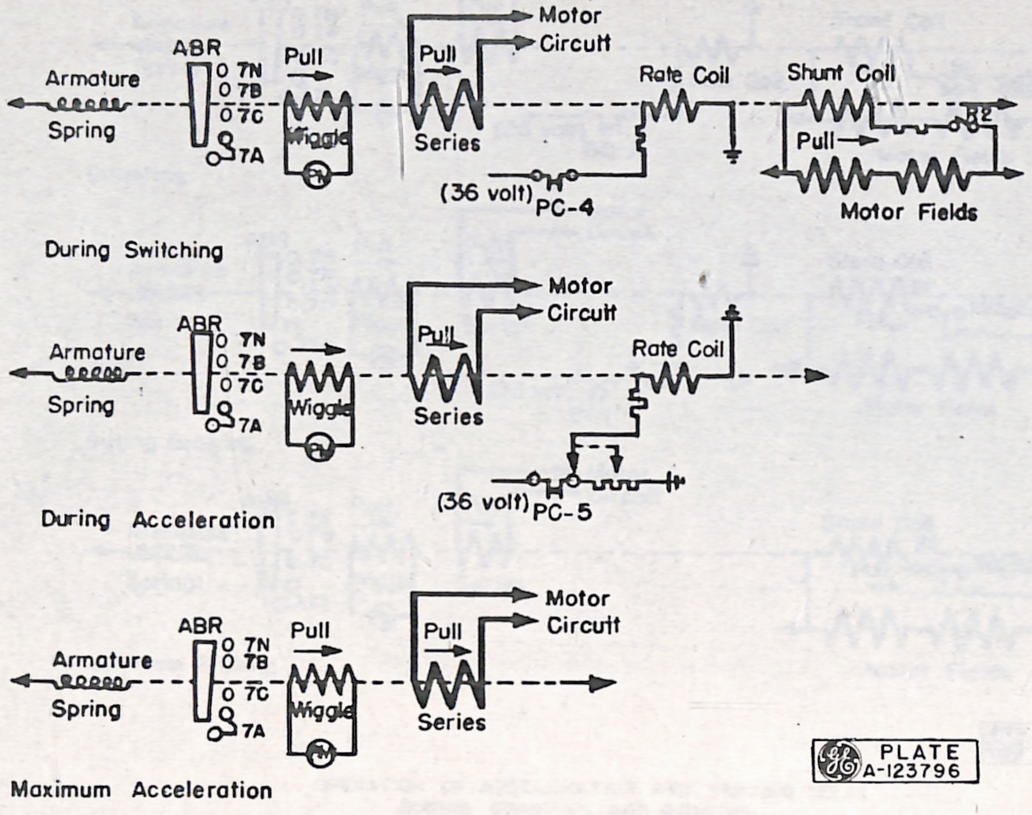
| | BRAKE FULL ON | POWER FULL ON | MINIMUM POWER | COAST | MIN. ACCEL. |
|---|---|---|---|---|---|
| (a) FOR 4 3/4 MI/HR/SEC ACCELERATION AND 4 MI/HR/SEC BRAKING | | | | | |
| Spring Tension | | | | | |
| Shunt Coil D.O. Amps | | | | | |
| Single Motor Amps | 180 | 250 | 112 | 25 | 120 |
| (b) FOR 4 1/2 MI/HR/SEC ACCELERATION AND 3 1/2 MI/HR/SEC BRAKING | | | | | |
| Spring Tension | | | | | |
| Shunt Coil D.O. Amps | | | | | |
| Single Motor Amps | 160 | 234 | 112 | 20 | 120 |

*Set minimum acceleration accurately with ammeter during test run. Rate varies slightly with voltage conditions.

All values given above are approximate due to many factors affecting rates. Values are for 38,000 pound car with 25-inch wheel diameter. For worn wheels (23-inch diameter average) reduce maximum values 5 per cent for same rates.

Spring tension or shunt coil drop-out amperes may be used to make preliminary rate adjustments. Values to be determined by actual test.

Adjustments for Type 17LC29C Braking and Accelerating Relay




OPERATION OF ACCELERATING AND BRAKING RELAY
DURING ACCELERATION

Anticipation results from the fact that the pilot motor is running at high speed in order to quickly obtain the current the operator requests. This causes a higher than normal wiggle-coil voltage. An example of this is when the operator rapidly calls for maximum rate. This extra voltage causes the ABR armature to pick up and start regulating before the final current value is reached, resulting in a smooth, but quick build-up. The extra voltage due to high speed, disappears when the final regulating point is reached.

Note that the pull of the armature spring tends to open up the relay contacts to allow PM to run, whereas the pull of the wiggle, shunt, series and rate coils tends to close these same contacts and stop the pilot motor.

Two contacts (7A) are used in parallel in last two points to allow long periods between contact replacements and to eliminate any possibility of dirt particles lodging momentarily on last contact and allowing pilot motor to creep when it should stop.

It is very important that the ABR be adjusted so that accelerating current rates are not below those specified:

Switching - 112 amps (single motor current)
Minimum accelerating - 120 amps

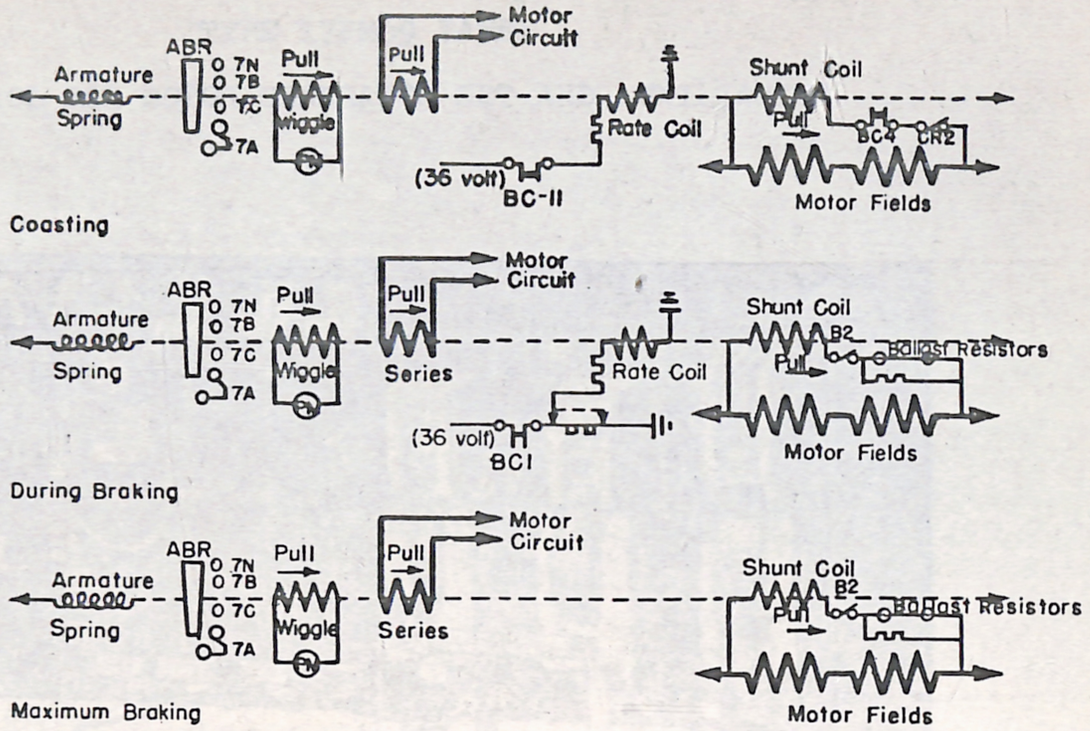



PLATE A-123797

OPERATION OF ACCELERATION AND BRAKING RELAY DURING COASTING AND BRAKING

If settings are not high enough, the ABR will not allow the pilot motor to cut out accelerating resistance until the car has begun moving. Under this condition, if coasting or braking is called for, plugging will result.

## 3. INSPECTION AND DATA

See INSPECTION SECTION and Inspection in CONTROL SECTION.

## 4. ADJUSTMENTS

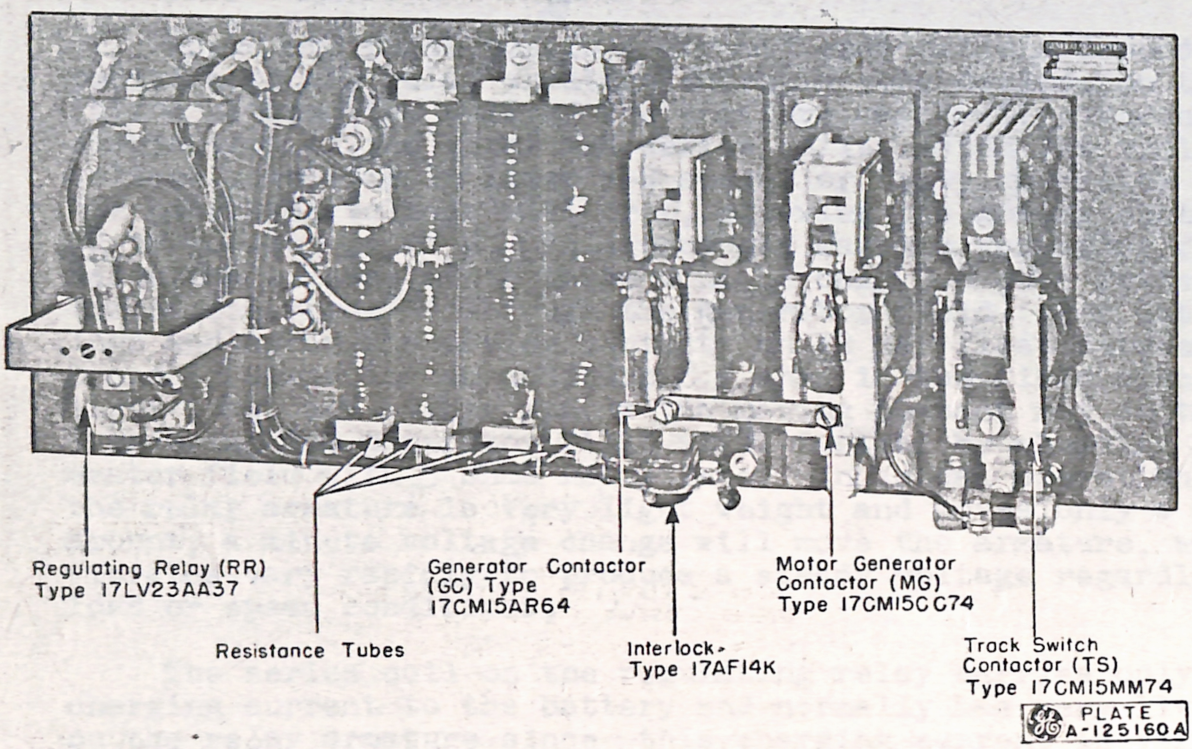
Adjustment for maximum braking is obtained through setting the 35-ohm adjustable resistor located on the 17KM12 motor controller panel (17FR13H1).

The maximum acceleration rate is set by adjusting the armature spring shown on Plate A-125176A.

For all other rate adjustments refer to Plate A-125176A.

# TYPE 17FM69 PANEL

## CONTROL FOR MOTOR-GENERATOR SET AND AUXILIARIES




### 1. DESCRIPTION

The apparatus required for regulating the generator voltage and current and for auxiliaries are mounted on the 17FM69 panel. This includes regulating relay, and contactors for the generator, motor-generator set, and track switch circuits.

## TYPE 17LV23 REGULATING RELAY

### 1. DESCRIPTION

The regulating relay consists of a frame mounting a shunt coil and series coil wound on the same spool, and an armature carrying a movable contact which operates between two fixed contacts. The contacts are connected to resistor tubes and arranged to vary the current flowing in the generator shunt field to maintain constant voltage.

## 2. OPERATION

The series coil is connected in the battery circuit so that it carries the charging current to the battery from the generator. The shunt coil is connected in series with a 20-ohm control resistor directly across the generator terminals and so varies in strength as generator voltage.

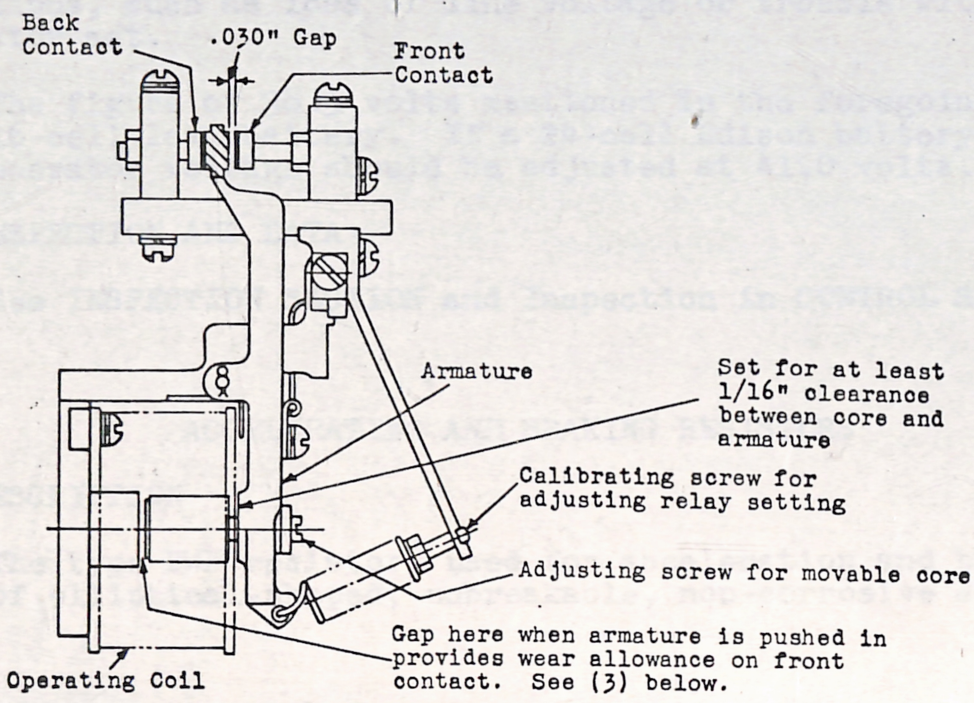
There are three possible circuit combinations depending on the position of the relay armature which in turn depends on the relation between the pull of the armature calibrating spring and the combination of the shunt and series coils. With low trolley voltage resulting in lower M-G speed, or heavy generator load, the generated voltage will drop, allowing the moving contact on RR to contact point 2. This produces maximum generator field to raise the voltage since there will be only 5.8 ohms resistance in the circuit from GA through the generator field. For intermediate load and speed the moving contacts on RR may float between points 2 and 3, inserting an addition 8.6 ohms in the field circuit. For light loads and higher speeds the moving contact may contact point 3 reducing the generator field still further by shunting the generator field with 5 ohms resistance. In actual operation, since the relay armature is very light weight and moves only a small amount, a minute voltage change will move the armature, so it vibrates vary rapidly to produce a steady voltage regardless of load or speed conditions.

The series coil on the regulating relay carries only the charging current to the battery and normally has very little effect on the relay armature since this charging current is very small with a fully charged battery. If, however, the battery becomes discharged, the charging current would try to go very high since the shunt coil on the relay tries to hold full voltage. To protect the battery and generator from damage, the charging current through the series coil produces a pull which limits the charging current by reducing the generator voltage in the same manner as an increase in voltage previously described.

## 3. ADJUSTMENTS

Ordinarily all necessary adjustments can be made on the regulating relay by changing the tension of the calibrating spring. Increase spring tension to raise setting. The relay should be set to hold 35.5 volts if the equipment is cold, and 36.5 volts if the equipment has been running long enough to heat up to normal operating temperature.

If any parts of the regulating relay are disassembled, or replaced, or if any new resistor tubes are installed, the contact adjustment should be checked as indicated on drawing and setting of relay rechecked.




Contact Adjustment - 17LV23 Relay

1. Set movable core so there is at least 1/16" clearance between core and armature. This adjustment required so overhanging edge of armature will not strike flange on operating coil.

2. With stationary contacts free, push armature in until core bottoms and hold there while screwing up front contact until it touches movable contact.

3. Screw front contact one more turn toward center to provide about .030" wear allowance before core can bottom.

4. Screw out back contact until there is no gap between front and back contacts, then back off one turn and lock. This will provide total gap of .030 between front and back contacts.

Voltage Adjustment

Set voltage by calibrating screw. If regulated voltage differs more than ½ volt between front and back contacts, change core position slightly to correct.

PLATE A-118581

General Notes

The battery floats on the motor-generator set, the latter supplying all load requirements. The battery is considered more or less as a standby and supplies low-voltage power under emergency conditions, such as loss of line voltage or trouble with the motor-generator set.

The figure of 36.5 volts mentioned in the foregoing applies to a 16-cell lead battery. If a 24-cell Edison battery is used, the generator voltage should be adjusted at 41.0 volts.

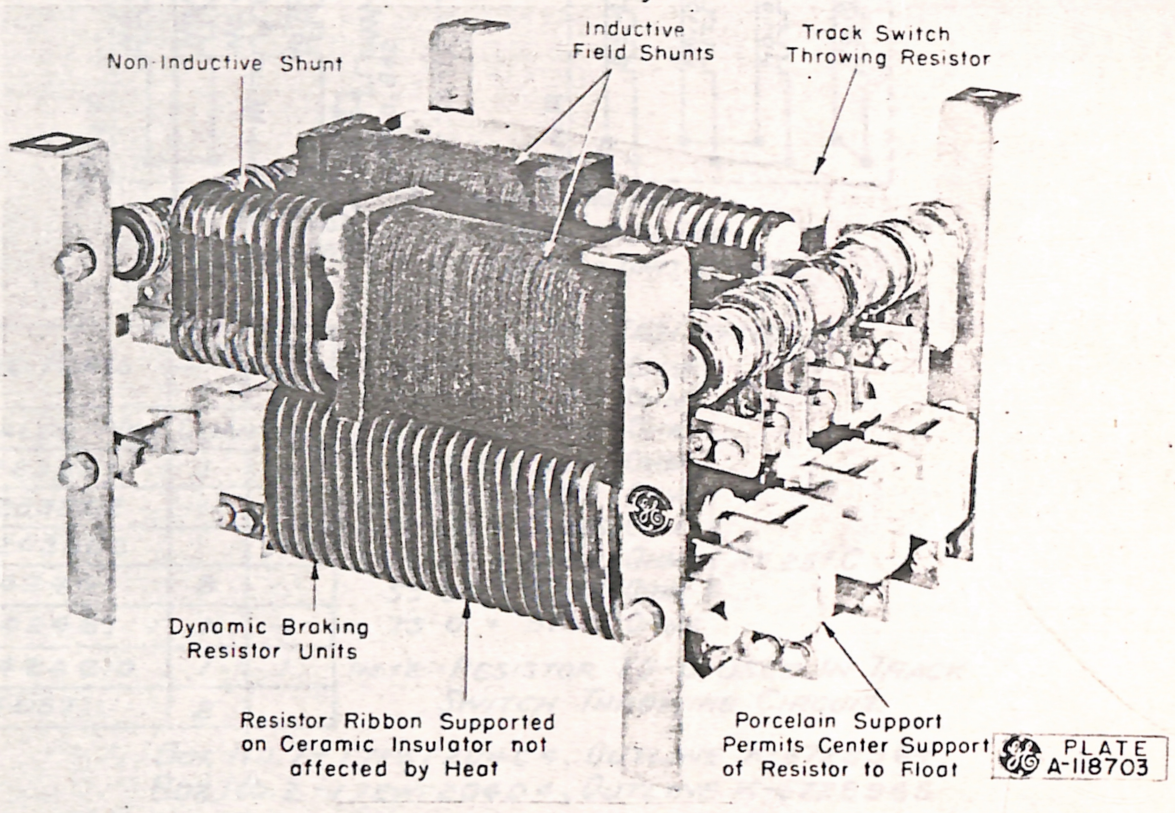
4. INSPECTION AND DATA

See INSPECTION SECTION and Inspection in CONTROL SECTION.

## ACCELERATING AND BRAKING RESISTORS

1. DESCRIPTION

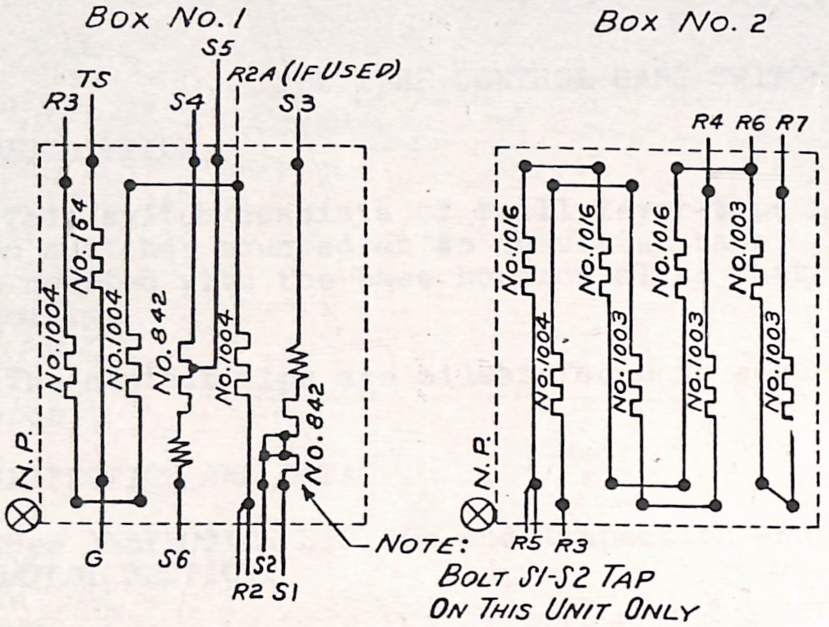
The type EWF resistors used for acceleration and braking are made of elliptical-shaped, unbreakable, non-corrosive alloy ribbon




Type 17EWF20C4 Resistor.

units, edgewise wound on heat-resisting insulation, supported by reinforced punched steel bars. These steel bars are so supported that they can expand and contract as the units heat and cool, thus preventing any tendency to buckle. Terminals are specially designed to hold the cable firmly and are bolted to a rigid copper plate by two 5/16-inch bolts.

In addition to the resistors required for motoring and braking circuits, there are also included two units incorporating the inductive and noninductive shunts for field shunting and one unit for the track-switch throwing circuit.




| MISC. PARTS | BOX NO. | |
|---|---|---|
| | 1 | 2 |
| CATALOG NO. | QUANTITY | |
| 6742038G1 | 1 | 2 |
| 6742038G2 | 1 | 3 |
| 6742038G3 | | 1 |
| 21D424G1 | 8 | |
| 21D424G7 | 1 | 4 |
| 21D424G10 | 1 | 1 |
| 6714057 | 2 | |

APPROXIMATE RESISTANCE

R2-R3 = 1.107 OHMS
R3-R4 = .979 OHM
R5-R6 = .474 OHM
R6-R7 = .610 OHM
S1-S3 = 0.201 OHM
S2-S3 = 0.086 OHM
S4-S6 = 0.247 OHM } AT 25°C
S5-S6 = 0.086 OHM
TS-G = 8.00 OHMS

NOTE:-RESISTOR TS-G USED IN TRACK SWITCH THROWING CIRCUIT.

BOX NO. 1 - 17EWF204C4, OUTLINE K-6728964
BOX NO. 2 - 17EWF204D4, OUTLINE K-6728965

Resistor Connection Diagram from K-6728842

2. INSTALLATION

Resistors are designed for mounting in an enclosed compartment and cooled by forced ventilation. The heat dissipated is used to warm the interior of the car in winter and discharged to atmosphere in summer. Suitable baffles should be installed, where necessary, to control the flow of air and provide equalized cooling. Resistor frames should be insulated from the car body by mounting on porcelain insulators furnished for this purpose. Fire-resisting insulating barriers must be installed above any resistors where the car floor is subject to heat from the resistors.

3. INSPECTION AND DATA

See INSPECTION SECTION and Inspection in CONTROL SECTION.

## TYPE 17HP CONTROL GANG SWITCH

1. DESCRIPTION

This switch consists of small lever-type toggle or spring-return switches mounted on an insulated base. This is arranged to be mounted with the base horizontal so that levers operate vertically.

The contact tips are silver faced to assure low-contact resistance.

2. INSPECTION AND DATA

See INSPECTION SECTION and Inspection and General Maintenance in CONTROL SECTION.

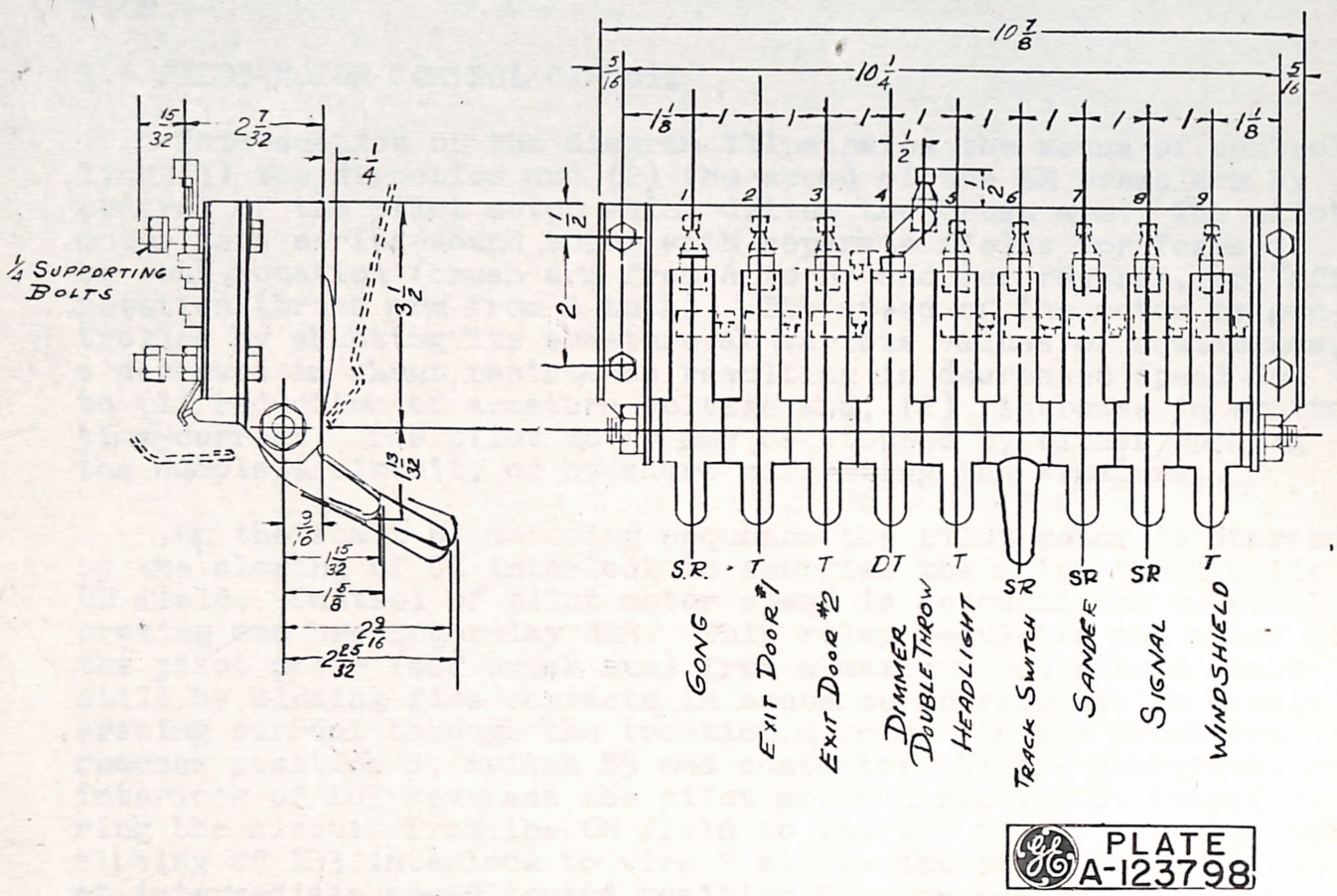



PLATE A-123798

"OUTLINE OF 17HPIIJI GANG SWITCH"
(FROM DRAWING L-8831663)

## ANALYSIS OF CONTROL CIRCUITS

An explanation and analysis is given of the circuits and functioning of Floating Control as used on the PCC-type car arranged for extended dynamic braking, track and friction brake. Refer to the main connections diagram and to the simplified connection diagram showing complete main control circuits.

The main motor circuits are explained in the OPERATION SECTION.

### 1. PILOT-MOTOR CONTROL CIRCUIT

This section of the diagram illustrates the means of controlling (1) the direction and (2) the speed of the KM brush arm by control of the pilot motor which drives the brush arm. The pilot motor is a series-wound motor with separate fields for forward, or "on" rotation (brush arm from A to B) and for reverse, or "off" rotation (brush arm from B to A). The speed of the motor is controlled by shunting its armature at various values of resistance, a decrease in shunt resistance resulting in decreased speed due to (1) reduction of armature voltage and, (2) increase in excitation current. The pilot motor may be stopped by either opening the complete circuit, or by short circuiting the armature.

At the start of motoring sequence the pilot motor is started by the closing of C1 interlock to energize the motor through its ON field. Control of pilot motor speed is accomplished by accelerating and braking relay ABR. This relay regulates the speed of the pilot motor (and brush arm) from a maximum value to a standstill by closing five contacts in sequence in response to accelerating current through the traction motors. As the brush arm reaches position B, switch B3 and contactor LB3 are energized. An interlock of LB3 reverses the pilot motor direction by transferring the circuit from the ON field to the OFF field. At this point closing of LB3 interlock to wire 7 allows the pilot motor to run at intermediate speed toward position A under control of the accelerating and braking relay. At position A, the pilot motor is de-energized by the opening contact of KM9.

In the coasting and braking sequence the pilot motor is started by the closing of B1 interlock which energizes the pilot motor through its ON field. Switch B3 drops out when the KM brush arm reaches position B and the B3 interlock reverses the pilot motor and brush arm motion. Again returning to position A, the pilot motor is de-energized by opening of contact KM9. During the whole coasting and braking sequence, speed of the pilot motor is controlled by operation of relay ABR in response to braking current through the traction motors. However, when the brush arm is within 34 commutator bars of the A position and is traveling from B to A, the top speed of the pilot motor is reduced by paralleling resistance with the motor armature through interlocks of B3, B1 and KM. This feature eliminates overshooting of

dynamic braking at low car speeds. The brush arm is also slowed down to intermediate speed by the closing of interlock on the motor cut-out switch (if used) and also through the back-up controller (if used) through its No. 3 finger.

Refer to 17LC29 relay for the control circuit for the accelerating and braking relay.

2. BRAKING CONTACTORS CONTROL CIRCUIT

Since effective dynamic braking is the most important feature of modern high-speed cars, the braking-control circuit is designed to be as simple and trouble-free as possible.

B1 and B2 are energized at all times except when power is applied which opens LB1 and LB2 interlocks feeding the 4A circuit.

B3 closes at approximately half speed through LB2 interlocks and KM6 finger during acceleration cycle but has no effect on main power circuit.

Closing of B3 transfers B3 interlock from 7F to 8B circuit, keeping B3 coil energized through 8-ohm resistor and KM7 even though LB2 or KM6 may open.

Slowing down of car during braking or coasting will open KM7 finger to de-energize B3 at approximately half speed.

3. FIELD-SHUNTING CONTROL CIRCUIT

At the start of the acceleration sequence, field-shunting contactors FS1 and FS2 are energized to partially shunt the fields of both pairs of motors until PC6 opens past switch position. This provides another step in attaining accelerating rate in addition to sequential operation of cushioning contactors C1 and C2.

If a high rate of acceleration is called for, PC7 will be closed. The resulting acceleration sequence will be as follows:

1. FS1 and FS2 drop out as power is appled.

2. FS1 and FS2 pick up at B position after LB3 closes. KM brush arm moves from B position toward A position.

3. FS3 picks up at 95th bar from A position.

4. FS4 picks up at 69th bar from A position.

During coasting, FS1 will be energized at all times so that current circulating in the motors will produce only a negligible braking effort. This field shunting is removed when the brake pedal is depressed, opening BC10 and de-energizing FS1, allowing the motors to develop full braking torque.

If switching is called for PC7 will be open and PC6 closed with following sequence:

1. FS1, FS2 closed as power is applied in A position.

PC7 finger allows FS3 and FS4 to be closed or not closed depending on position of power pedal.

4. CUSHIONING CONTACTORS CONTROL CIRCUIT

Since both C1 and C2 act to short out sections of resistance in series with the propulsion motors, their operation in sequence acts to apply and remove power to the motors in small steps.

Cushioning contactor C1 is energized from 600-volt power whenever line breaker LB1 picks up (accelerating controller finger PC1 closes before LB1 is energized). It is active only during acceleration.

Cushioning contactor C2 is energized from control power when the accelerator pedal is depressed enough to close PC8 (assuming C1 is energized).

For sequential operation of C1 and C2 during power application and power release, refer to Control Sequence Chart.

C2 is ordinarily energized during the braking cycle through wire 3Q. However, at the beginning of the braking cycle, which may be at high car speed, C2 is not energized and the resistance which it controls is added to the braking resistance until KM8 finger closes. At lower speeds B3 interlock keeps C2 closed.

Since C1 is energized from propulsion power it will drop out any time power is lost and will carry C2 out with it. If power is then suddenly reapplied an unreasonable surge of current will not pass through the propulsion motors because of the resistance inserted by C1 and C2.

5. POWER CONTACTORS CONTROL CIRCUIT

All power contactors are energized by control power from wire 7P through BC10, during normal operation.

To obtain acceleration, the accelerator pedal is depressed, thus operating the accelerating controller. This closes contacts PC2 and PC3 in sequence.

As soon as PC3 closes, contactor LB2 picks up and automatically opens the braking contactors B1 and B2. When B1 opens, its interlock closes the circuit through the operating coil of LB1 since PC2 is already closed. LB1 closes applying power to the motors with all resistance in the circuit. Motoring contactor LB3 closes later in the accelerating sequence by the operation of

switch B3. The closing of line breaker LB1 closes contactor C1 since PC1 is closed. C1 interlock by-passes PC2 and LB1 interlock by-passes PC3.

If the accelerator pedal is released, nothing happens until C1 interlock opens. At this time LB1, (possibly LB3) are de-energized, LB1 interlock then de-energizes LB2.

The above sequence of power contactors is for switching position of the power pedal only. When high rate of acceleration is used, PC8 will be closed, picking up C2 contactor in sequence after C1. When power pedal is released, C2 drops out before C1.

If, for any reason, too much current is passing through the propulsion motors the overload relay OLR will operate to de-energize LB1. After it operates, the OLR holds itself in the trip position by means of the holding coil. To reset after an overload, the foot is removed from the accelerator and opening of PC2 de-energizes the OLR holding-coil circuit.

6. DRUM OR FRICTION-BRAKE CONTROL CIRCUIT

When control power is turned on, TDR is energized through B6. Time delay of approximately two seconds on TDR permits brake-reset contactor to pick up. Closing of BRC main contacts puts full control voltage on all four drum-brake operating coils and resets (releases) drum brakes. TDR then picks up and de-energizes BRC.

Brake-indicating lights are grounded through interlocks on the brake-operating mechanisms.

Brake operators are in series-parallel combination and in normal service are energized through BC5, BC6, and BC7 depending on amount of brake called for. Normal B+ feed for operators is through KM10 and C2 interlock. C2 interlock keeps brake from applying at high speed through KM10. Closing of KM10 at low speed completes current to apply brake.

LOR is a safety device applying brake only in case dynamic braking does not build up in the required time. Applying brake opens BC12, de-energizing shunt coil. If current fails to build up in series coil (dynamic-brake current) LOR drops out after time delay. Normally series current keeps LOR closed.

Holding coils of brake-operating mechanisms are in parallel, fed through foot interlock.

7. TRACK-BRAKE CONTROL CIRCUIT

This circuit is energized by B1 which is fed by the generator and in case that is not running, by the battery.

When the brake pedal is pushed beyond a mid position, No. 2 finger of the brake controller closes first and picks up track

brake contactor TA. TA picking up allows the track-brake coils to be energized through 1.66-ohms resistance. Further movement of the brake pedal closes No. 3 finger which picks up contactor TB, while TA is still picked up. With TA and TB both picked up, a smaller amount of resistance is in the track-brake coil circuit. Additional movement of the pedal opens No. 2 finger which drops out contactor TA. With TB closed and TA dropped out, the track brake coils are across the line with no external resistance in the circuit.

8. CONTROL POWER CIRCUIT

Closing of master switch connects control circuit to operating coil of MG contactor. Closing of MG applies 600 volts at motor of M-G set. As armature voltage across motor builds up, GC closes, connecting trickle charge and generator furnishes control power. Closing of GC shorts out starting resistor.

Regulating relay RR controls generator voltage by varying its field. Refer to description of 17LV23AA regulating relay for detailed explanation.

9. AUXILIARIES CONTROL CIRCUITS

The track switch contactor is energized by the spring-return switch in the gang switch group on the dash.

10. EMERGENCY CONTROL CIRCUIT

This circuit is energized by control power from wire B6 through the foot interlocks and conductor's switches. In normal operation (foot interlocks in normal position and conductor's switches closed) the emergency relay ER is picked up.

When the foot interlock is released or pushed full down or a conductor's switch is opened, the operating coil of the emergency relay is de-energized and one of its contacts opens circuit 7P, thus opening the power contactor control circuit and field shunting circuit. The opening of the power contactor control circuit closes LB1 and LB2 interlocks which feed the braking contactor control circuit. Closing B1 and B2 initiates dynamic braking. ER dropping out also applies track brakes, sounds emergency signal and sands rails. A foot interlock emergency also applies the drum brakes.

11. SUMMARY

The following general points are mentioned again in this summary as an aid to a better understanding of the operation of this equipment.

a. With the master controller in the "off" position, control circuits are set up for coasting connections.

b. The main circuit connections are the same for coasting and braking with the exception that the field-shunting contactor FS1 is closed during coasting.

c. To apply power to the motors, the BC brake controller must be in the "off" position and the PC controller depressed to a power position.

d. If both power and brake pedals are depressed together (accidentally or otherwise) braking will always follow. This is done as a matter of safety.

e. The purpose of the braking switch B3 is to make it possible to use the variable resistance of the KM controller over again, in this way providing more steps for braking.

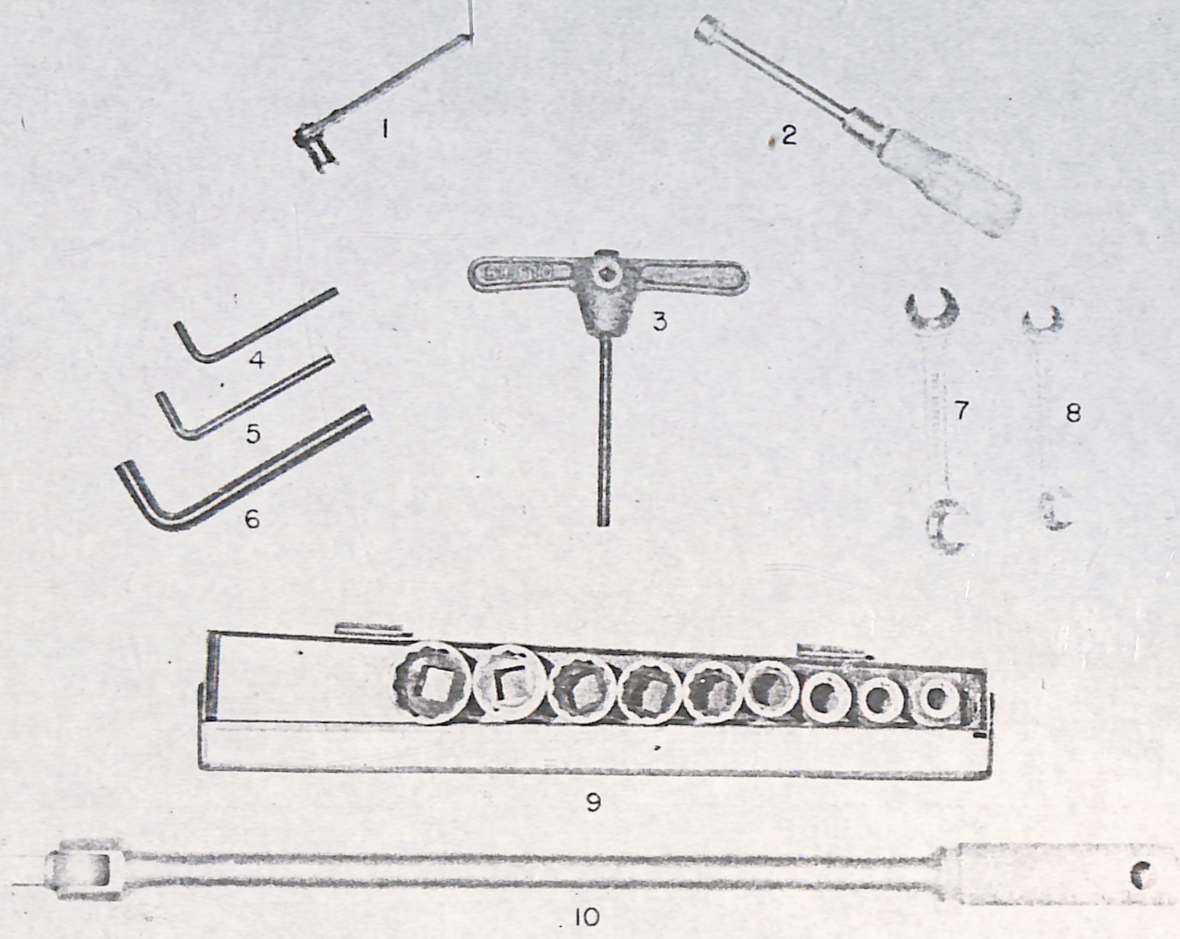
f. The same limit relay is used for accelerating and braking. During acceleration the series winding on the relay is used, during coasting and braking both series and shunt windings are used.

g. When changing from power to braking or vice versa it is not necessary for the brush arm to return to the "off" position. During the braking cycle, the brush arm always retraces the path it took for the previous motoring cycle, arriving back at the starting position when the car speed has been reduced to a few miles per hour.

h. The position of the LB3 contactor determines direction of brush arm movement during motoring. Likewise the position of the B3 switch determines direction of brush arm movement during coasting and braking.

## TOOLS

**The following tools are furnished for the disassembly and reassembly of control equipment.**




1 Offset, ratchet type, special screw driver, Cat. 8803494. Used on interlock guide post nuts.

2 Cat. 98X103 - 3/8-inch Stevens Spintite wrench No. 3412. Used on interlocks, control fingers, etc.

3 Cat. 89X419 Bristo Tee wrench for 5/16-inch cap screws. Used on contactor tips.

4 Cat. 98X100 Bristo wrench for No. 10 cap screws. Used on contactor tips.

5 Cat. 98X101 Bristo wrench for 1/4-inch cap screws. Used on contactor tips.

6 Cat. 286X25 Bristo wrench for 3/8-inch cap screws. Used on contactor tips.

7 Williams Superrench No. 1128 - 7/16-inch flat, open-end wrench. General use.

8 Williams Superrench No. 1124, 3/8-inch flat, open-end wrench. General use.

9 Cat. 278258 socket wrench set for general use.

10 Handle for Cat. 278258 socket wrench set.

PLATE A-118706