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METHODS OF REMOVING THE ARMATURE FROM BOX FRAME RAILWAY MOTORS

By J. L. BOOTH

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METHODS OF REMOVING THE ARMATURE FROM BOX FRAME RAILWAY MOTORS

By J. L. Booth

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The box type of frame for railway motors was originally developed in order to meet the demand for motors capable of giving the large outputs required for heavy service on interurban, elevated and subway lines. In addition to possessing many advantages from

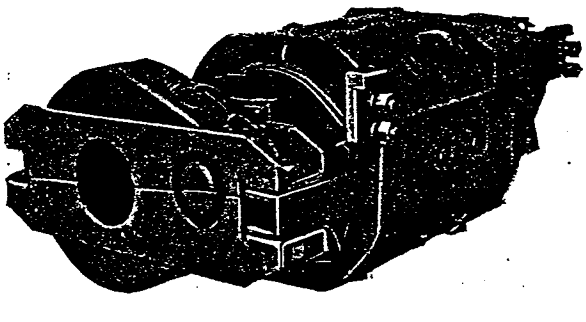


Fig. 1. Small Light-weight Motor with Box Frame for Small Wheel Cars

a mechanical point of view, it enables the designer to obtain a considerable increase in capacity for a given weight and space, when compared with the split frame. As the advantages of this type of frame became more widely known and recognized among operating engineers, the demand for box frames increased until at the present time they are being used for motors of all sizes from the largest to the smallest, and have almost entirely superseded the split frame. From 80 to 90 per cent of the railway motors now being made are of the box frame type, and many of the most recent designs of motors are being built with this type of frame only.

Advantages of the Box Frame

For a given space and weight, a larger output can be obtained than with a split frame, or for a given output the motor can be made both smaller and lighter. It also possesses greater structural strength and durability, and there is less chance of breakdowns due to the mechanical failure of parts of the machine, or the breakage of bolts. The lower half of malleable iron gear cases may be supported in a more substantial manner rendering them better able to withstand the severe stresses to which they are frequently subjected. The elimination of the joint in the frame, in addition to giving an unbroken magnetic circuit, prevents oil from working into the interior of the motor from the axle bearings, which is always liable to occur through the joint in a split frame.

From the absence of this joint, which is usually horizontal, a greater freedom of design is generally obtained for the armature, pole pieces, and coils, and for the same reason a better axle preparation and design of axle bearing housings is made possible.

With a ventilated motor, a greater space is available in the frame for the passage of the cooling air around the field coils. This allows unrestricted ventilation with a corresponding increase in the service capacity of the motor. Better protection is afforded to the field coil connections which, in the box frame motor, are all inside the frame. By removing the motor from the truck, repairs are effected, bearings seated and connections made under favorable conditions to insure good workmanship, while with the split

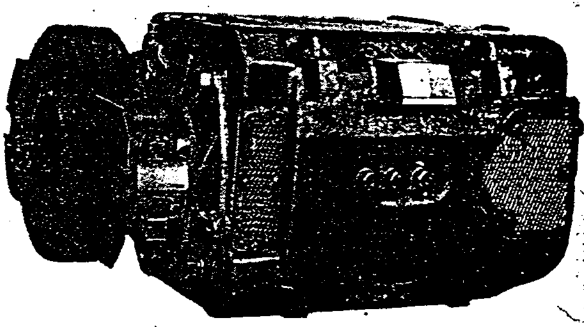


Fig. 2. 160-h.p. Motor with Box Type of Frame

frame the work is often done from the pit in a cramped position and under poor lighting and working conditions.

There are also a fewer number of parts which are liable to work on each other and which ultimately require liners to take up wear. This together with the increased reliability of the box frame motor gives a low maintenance cost.

A typical example of a small box frame motor is shown in Fig. 1. This motor has been especially developed for use with light cars having small wheel trucks. It is built in the box frame type only and although of 40 h.p. rating weighs only about 1500 lb. Even in this size of motor it is possible to provide openings, both on the top and suspension side of the motor, of sufficient size to permit the thorough inspection of the commutator and brush-holders.

A large motor is shown in Fig. 2. This motor which rates at 160 h.p. weighs complete with all parts, approximately, 5720 lb.

Methods of Removing Armatures

When the box frame was first advocated it was felt by some operating engineers that the necessity of dismounting the motor from the truck in order to remove the armature, for repairs, would take so much time and keep a car out of service so long that the cost of repairs would largely offset the advantages of the box frame. Experience, however, has shown this not to be so, and by the provision of various simple appliances to facilitate the removal of armatures, repairs to box frame motors are today being executed just as rapidly as with split frames. Indeed, in the opinion of some operating engineers of roads where both types are in operation, inspection and repairs can be effected in less time with the box frame, due to the superior working conditions which exist when the motor is off the truck. In many cases the time necessary to have an armature "on the floor" after the car has been run in has been cut down to something very small, and the systematic inspection of motors at regular intervals of time or of distance run is materially reducing the cost of maintenance and repairs. The removal of the box frame motor, however, without taking out the truck from under the car, presents no great difficulty and is recommended for the lighter type of car. The axle caps and bolts are first removed and the gear case taken down. The motor is then supported from the pit by a jack bearing against the center of the motor frame. The suspension bolts are next taken out (if of the bolted bar type) and the suspension bar unbolted from the truck. The motor may then be raised by the jack and moved away from the axle sufficiently far to allow the portion of the axle bearing housing that projects over the axle to clear it. The motor may then be lowered into the pit. If preferred, the axle may be used as a fulcrum and the motor swung down around the axle until the bearing housings are clear. In any case, the motors generally used on single-truck cars are small, and the weight to be handled is not great.

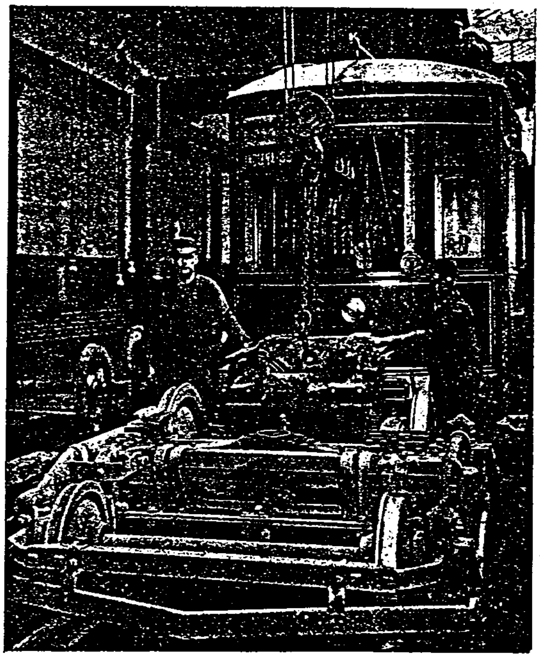


Fig. 3. Removing a 65-h.p. Box Frame Motor from the Truck. This operation takes fifteen minutes to perform

No elaborate equipment is required for removing a truck from a double-truck car. In most car barns, two pairs of chain blocks can be arranged to lift one end of the car while the truck is being removed, and it is not necessary to send the car to the main shops for the removal of an armature. Some examples are given here of the methods employed on various roads. Figs. 3, 4 and 5 show how motors are being handled on a large system in the middle west. The truck is run out from under the car, and the suspension bolts, gear case, axle caps and linings removed, the dust guard coming away with the axle caps.

The motor is then lifted out by means of the bails and an ordinary pair of chain slings (see Fig. 3). The four bolts securing the pinion end frame head are next removed and the head started by jack screws.

A lever, having a collar at one end which fits over and is clamped to the pinion, is used to support one end of the armature which is then pulled out sufficiently far to enable a wide lifting strap to be placed in position as shown in Fig. 4. The length of the bearing at the commutator end is sufficient to support that end of the armature until the lifting strap is in place.

By bearing down on the end of the lever, the weight of the armature can be balanced while being removed from the frame. Fig. 5 shows the armature clear of the frame, with the man's weight still on the lever, balancing the armature in the sling.

It will be noticed that the pinion has not been removed, and that it is only necessary to remove the four bolts in the pinion end armature head, also that in this method, which avoids turning the motor on end, it is not necessary to remove the oil from the oil boxes.

The time necessary to remove and replace an armature after the truck has been taken out from under the car body is as follows:

To perform the first operation, that is, the removal of the axle caps and suspension

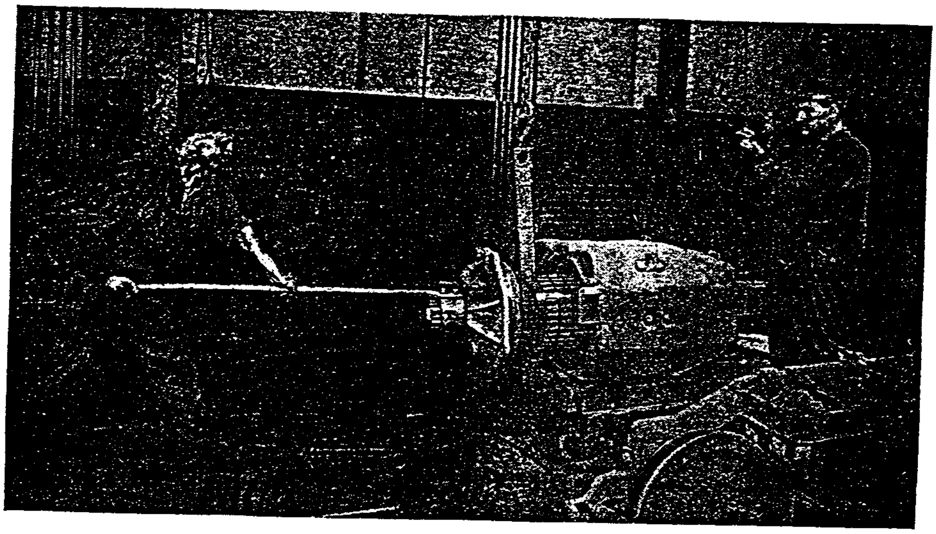


Fig. 4. Removing Armature from a 65-h.p. Box Frame Motor. Lifting strap in position. From the time the motor is off the truck until the armature is on the floor is twenty minutes

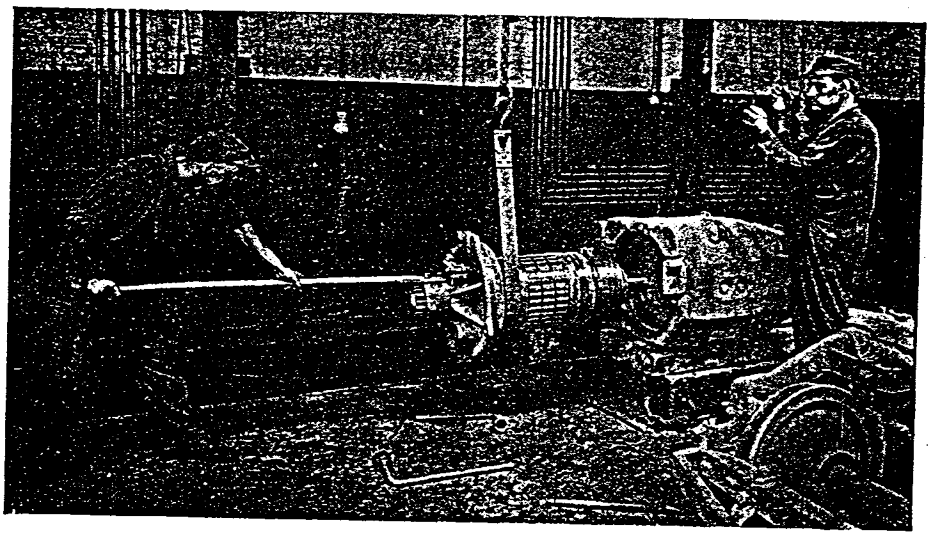


Fig. 5. Armature of a 65-h.p. Motor Removed. Man's weight on lever balances weight of armature. To replace armature and remount motor on truck takes twenty-five minutes

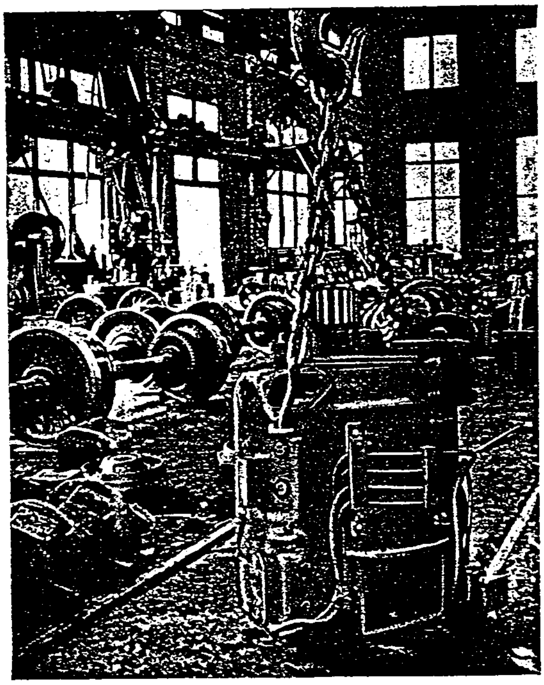


Fig. 6. A 140-h.p. Box Frame Motor Removed from Truck and Turned on End Preparatory to Lifting Out Armature

bolts and raising the motor frame from the truck, takes 15 minutes.

The second operation, covering the removal of frame head bolts, forcing off frame head,

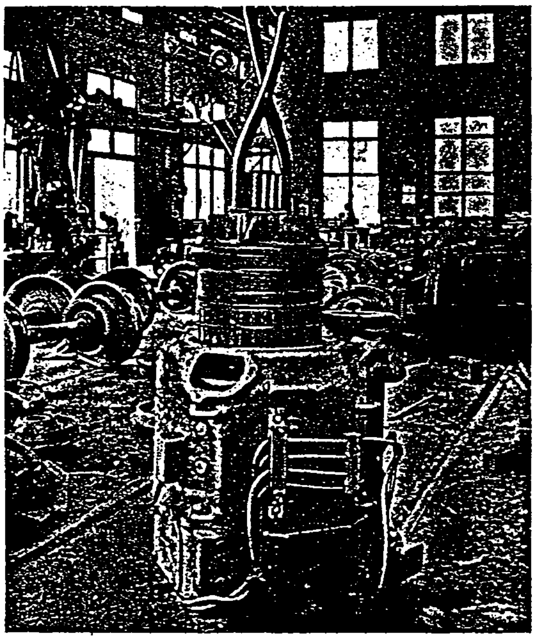


Fig. 7. Lifting out Armature of a 140-h.p. Box Frame Motor with Scissors-like Clamps which Fit Under Pinion

clamping lever to pinion, placing lifting strap in position, removing armature and layin it on floor, requires 20 minutes.

The third operation, picking up armature, replacing it in shell, bolting up frame head, lifting motor and placing it on truck ready for service, takes 25 minutes.

This makes a total time of one hour from the time the truck is taken from under the car until the motor is remounted and the truck ready to be replaced under the car body. This is, however, an average time and, under extraordinary circumstances, the work could and has been done in 45 minutes.

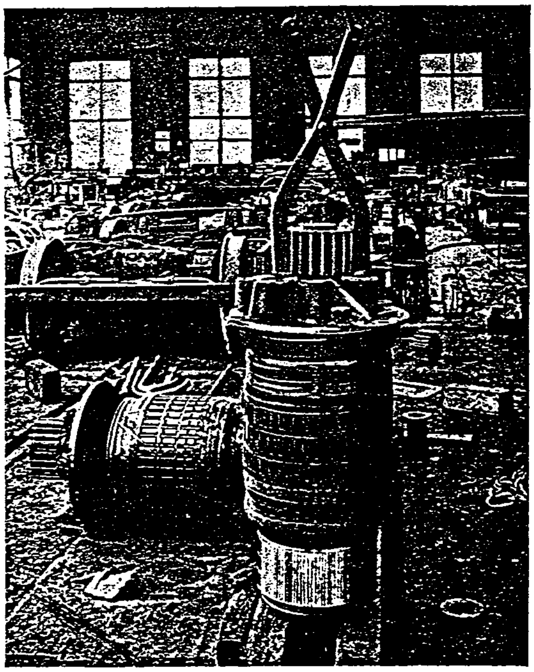


Fig. 8. The Clamps are Replaced by a Light Chain Before Laying the Armature Flat on the Ground

Handling a Large Motor

Photographs are reproduced in Figs. 6, 7 and 8 showing the method adopted by another road for removing the armatures from 140-h.p. motors weighing complete with all parts 4260 lb. In this case, the motor is turned on end, after having been removed from the truck by slings in the usual manner. To turn the motor on end, the air intake pipe is removed, and a sling with hooks is attached to one of the bails on the motor frame, and to an eyebolt screwed into one of the axle cap bolt holes. For removing the armature the chain slings for taking the motor out of the

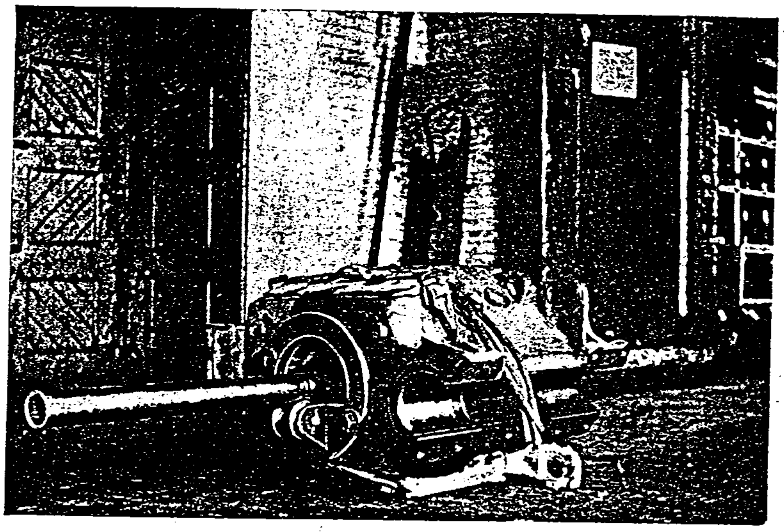


Fig. 9. Removing an Armature by Means of an Extension of the Armature Shaft Supported by a Roller in a Bracket Bolted to the Frame

truck, and for turning it on end, are replaced by scissors-like clamps which fit under the pinion teeth. The armature is then withdrawn, and stood vertically on blocks, while the clamps are replaced by a light chain before laying the armature flat on the ground.

A road operating a large number of 40-h.p. box frame motors is using an extension of the armature shaft to support one end while the latter is being dismounted. The pinion end frame head is removed, and the head at the commutator end replaced by a malleable iron bracket which fits the bore of the frame and is held in place by two tap bolts. This bracket carries a machined roller of such a diameter that the extension of the armature shaft, see Fig. 9, is kept in the center of the frame. This extension is a steel tube machined on the inside to just slip over the armature shaft. The shaft at the other end is supported by an oak pole 3 inches in diameter having a steel tube at one end of it that fits over the armature shaft. The armature is moved out horizontally and is supported at one end by the roller until it is clear of the frame.

Two somewhat similar methods are in use on another road for handling 70-h.p. motors. In one case the frame is stationary and the armature moved. An iron pipe having one end bushed with brass, to avoid injury to the armature shaft, is used to support one end of the shaft. The armature is lifted by slings and moved out of the frame horizontally by an overhead traveller, see Figs. 11 and 12. The illustrations show the pinion and pinion end frame head removed from the shaft, though this is not actually necessary for the removal of the armature.

Fig. 10. The Other End of Shaft Than That Shown in Fig. 9 Supported by an Oak Pole With a Steel Tube Fitting Over the Shaft

With the second method in use on this road, the armature is held stationary and the frame moved. Figs. 13 and 14 show this. The armature is supported by jacks, a bushed pipe being used at one end as before. The jacks can be readily adjusted to take the weight of the armature off the pole pieces, and the truck with the frame is moved along until the armature is clear.

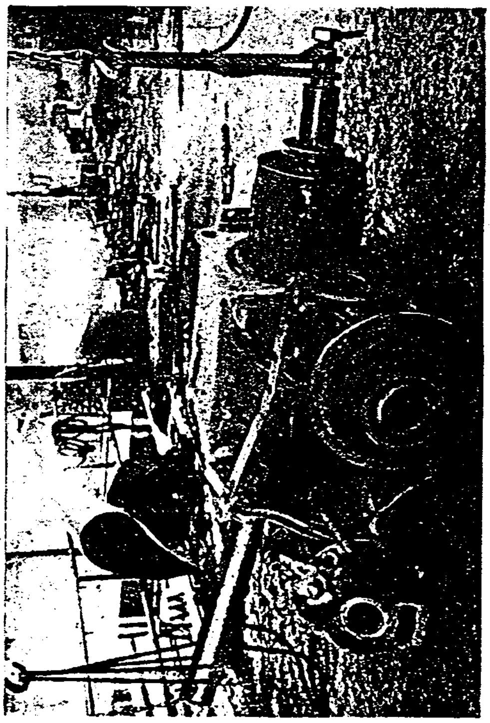


Fig. 11. An Armature Removed by Overhead Crane. Frame is stationary and armature is moved out horizontally

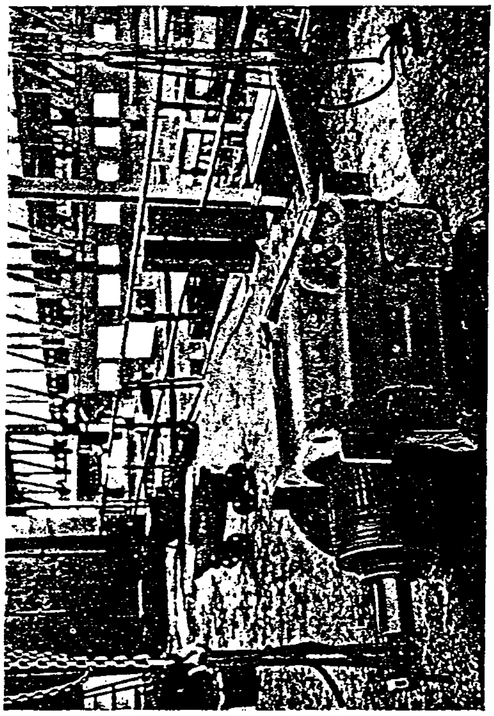


Fig. 12. One End of Armature Supported by a Tube Fitting Over the Armature Shaft

Fig. 13. The Armature is Held Stationary and Frame is Moved horizontally on a truck

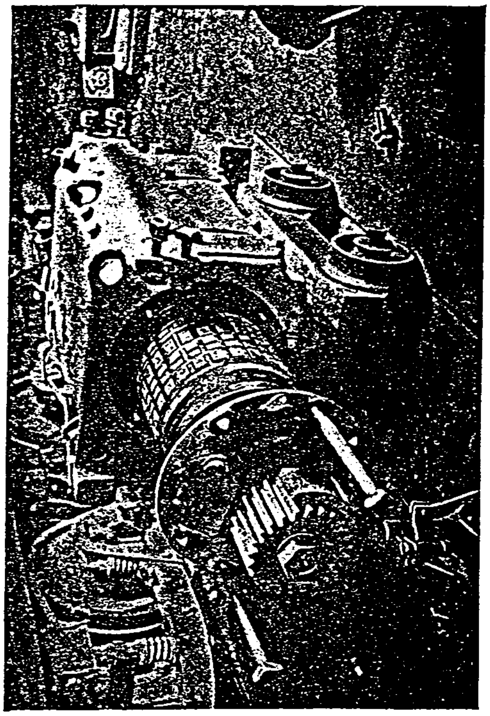
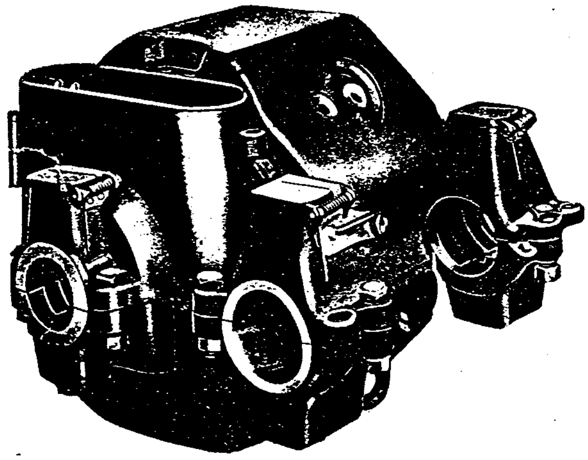


Fig. 14. The Armature is Supported by Jacks Which Can Be Readily Adjusted to Take the Weight of the Armature off the Pole Pieces

Instructions for Ordering

MAGNET FRAMES

For Railway and Mine Haulage Motors



Split Frame Showing What Will be Furnished on Orders, As Indicated in Item No. 1

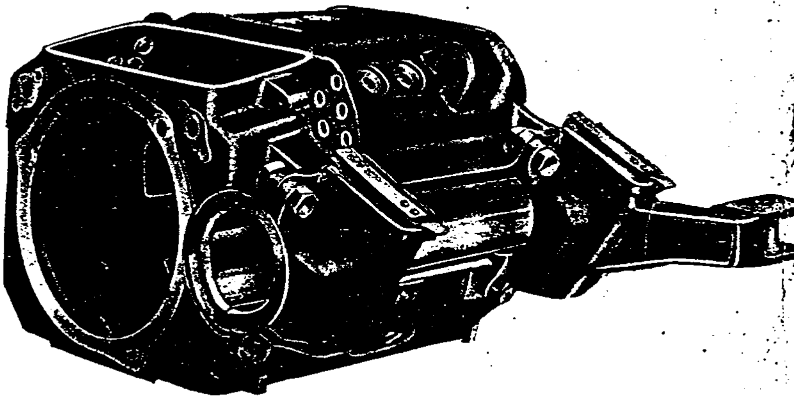
IN ordering magnet frames for railway or mine haulage motors much time will be saved by specifying the exact material required. Generally the bare magnet frame with bearing caps is wanted and orders are so interpreted unless other parts are specifically mentioned. Orders for complete magnet frames are sometimes misinterpreted since some customers expect a complete motor less the armature, while others would want certain other parts omitted. Field coils, brush-holders, frame covers, pole pieces and cables are not furnished unless specified.

To avoid delay in filling orders for magnet frames they should be made to read in some one of the forms listed below:

1. Magnet frame with cable bushings including all bearing caps equipped with covers. (Orders will be filled in this manner unless other parts are specified.)
2. Magnet frame with cable bushings including all bearing caps equipped with covers and frame heads equipped with covers.
3. Magnet frame with cable bushings including all bearing caps equipped with covers assembled with the following, or other, parts as may be specified on the order:
   a. Pole pieces with flanges and pads.
   b. Field coils (exciting and commutating).
   c. Brush-holder supports.
   d. Brush-holders.
   e. Brush-holder cables and field coil cables.
   f. Frame covers.
   g. Frame heads with covers but without bearing linings.

Bearing linings are not furnished unless specified.

The type, class and form of motor should be specified, for example GE-67A, and in the case of mine locomotive motors the serial number of the locomotive should also be given.



Box Frame Showing What Will be Furnished on Orders, As Indicated in Item No. 1

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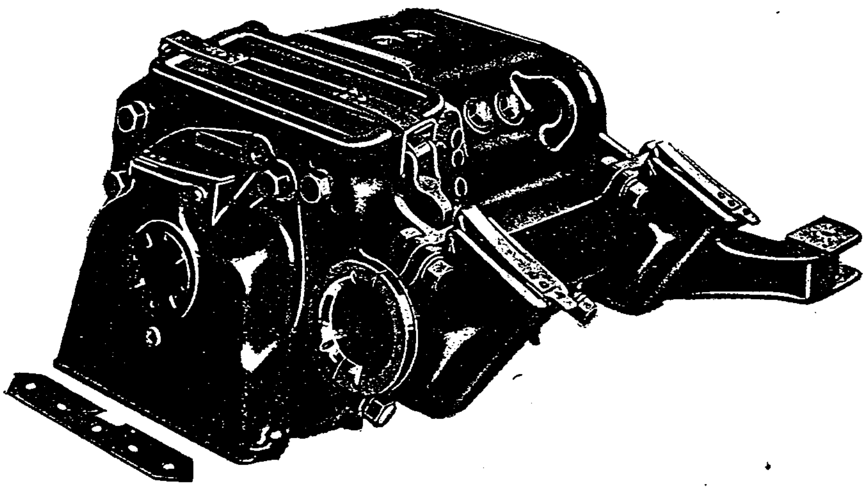
Winter Covers for Ventilated Railway Motors



TYPE GE-265 FORM A MOTOR SHOWING WINTER COVER

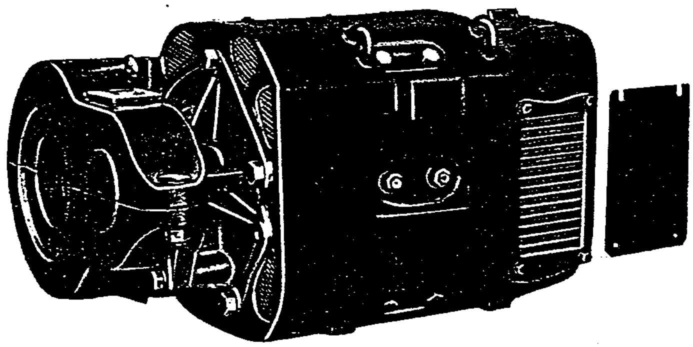
It has been found advisable in some instances to use covers over the intake openings of ventilated motors during severe winter weather to prevent the entrance of snow and water. The need of covers applies more to multiple ventilated motors although in a few cases it has been found desirable to use them with motors having series ventilation. When ordering covers for winter use, the serial numbers of the motors for which these covers are intended should always be specified.

Snow

Where trouble has been caused by the entrance of snow, it has usually been where severe storms of fine light drifting snow have been encountered. This kind of snow may be blown into the motors in sufficient quantities to cause damage. It is more liable to occur in interurban service and in open country than in the city service where snow is generally more tightly packed down. At higher speeds there is frequently a cloud of fine snow swept up and carried along by the car, which may be drawn into the motor. Under such conditions the use of winter covers may be found advisable.

General Electric Company, Schenectady, N. Y.
SALES OFFICES IN ALL LARGE CITIES

Winter Covers for Ventilated Railway Motors



TYPE GE-254 FORM A MOTOR SHOWING WINTER COVER

Water

During thaws, in cases where tracks are not well drained, some trouble has been experienced from water getting into the motors in sufficient quantities to cause burnouts, especially of the armature; or grounding of the brush-holders. This trouble is aggravated by salt which is often used by railroad companies to prevent switches from freezing.

Cold Motors

In cold weather, cars may be run into the barn with the interior of the motors at a temperature considerably below that of the barn, causing moisture to be deposited on the commutator and windings in an excessive amount. The service may be such that the motor is never heated sufficiently to dry out and a continued condensation of moisture eventually breaks down the insulation. Even without extreme cold, atmospheric conditions may be such that moisture may form in the motors and it is probable that the penetrating quality of moisture-laden air is more injurious to insulation than the occasional entrance of water from wheelwash.

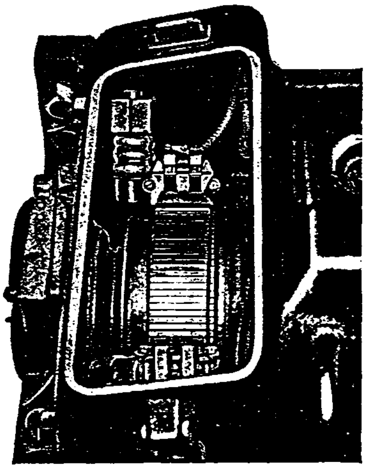
These conditions may be improved by closing the intakes, causing the motors to operate at higher temperature. Care must be taken, however, that this is not done when the service is such that the use of covers would cause overheating, although generally when motors come out of service with a temperature rise not sufficient to prevent condensation in the car barn, they will operate at a safe temperature with the covers on.

When covers are used, great care must be taken against overheating the motors by bucking snow drifts, also to remove the covers before the arrival of warm weather.

Better Commutation

for

Railway Motors



The commutation of railway motors can be improved by carrying out the following recommendations:

1. Keep commutator mica segments undercut or grooved; cutting depth about $\frac{3}{64}$ inch.

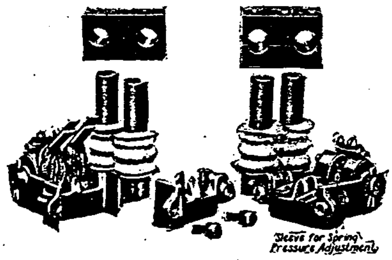
2. Keep commutator surface smooth.

3. Use best grade of brush made of highest quality materials. Selection of brush depends upon local conditions and design of motor involved. See descriptive sheet 64404.

4. Do not allow oil to come in contact with commutator mica or carbon brushes.

5. Keep bottom of carbon box between $\frac{1}{8}$ and $\frac{1}{4}$ inch away from commutator surface.

6. See that brush fits carbonway without excessive clearance, but is free to move in response to the brush pressure used. Maximum clearance between new brush and new carbonway is 0.008 inch. The clearance should not be allowed to exceed $\frac{1}{32}$ of an inch.



7. Replace worn carbonways promptly. Many motors are equipped with brush-holders having *renewable* carbonways.

8. Clean brush-holders and supports regularly. Moisture or dust on any part of brush-holder or support may cause failure.

9. Keep armature linings in good condition so that air gap will be maintained uniform. This will minimize the movement of the armature in going over rough track, which tends to cause flashover.

10. Maintain proper brush pressure. It is advisable to follow the brush manufacturer's recommendations on the pressure to use. The pressure depends on the type of brush as well as the local conditions of service. It is essential that the pressure be sufficient to keep the brush on the commutator at all times.

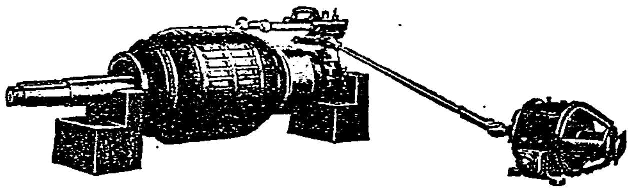
11. Keep track and road bed in good condition. Rough track is the cause of many commutation troubles.

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Commutator Grooving Machines

Portable and Stationary Types



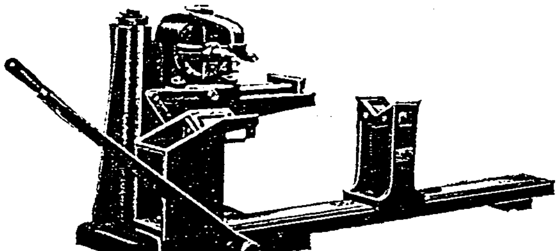
PORTABLE MACHINES—FORM 3

The Form 3 machine is a simple portable outfit which can readily be moved to any part of the shop, clamped to the armature and thus completely groove the commutator in a few minutes.

This machine has adjustable stops, which direct the travel of the saw to the brush surface of the commutator. It is equipped with a floating driving shaft which permits the grooving of a number of slots at one setting of the armature and an angular adjustment which can be used when the commutator bars are not exactly parallel to the shaft.

Loosening of the clamp bolts is unnecessary as a slight tap with the hand readily shifts the saw from slot to slot. The clamp is lined and will not mar the armature shaft.

The driving shaft is equipped with universal toggle joints and provision is made for either belt or motor drive.



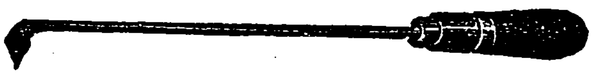
STATIONARY MACHINES—FORM 2

The Form 2 machine meets the need of large railways for a stationary shop tool.

The base is provided with adjustable pillow blocks having "V" shaped bearing surfaces with brass rollers.

The slide arm is designed for both vertical and angular adjustment, the latter adjustment to be used where the commutator bars are not exactly parallel to the shaft.

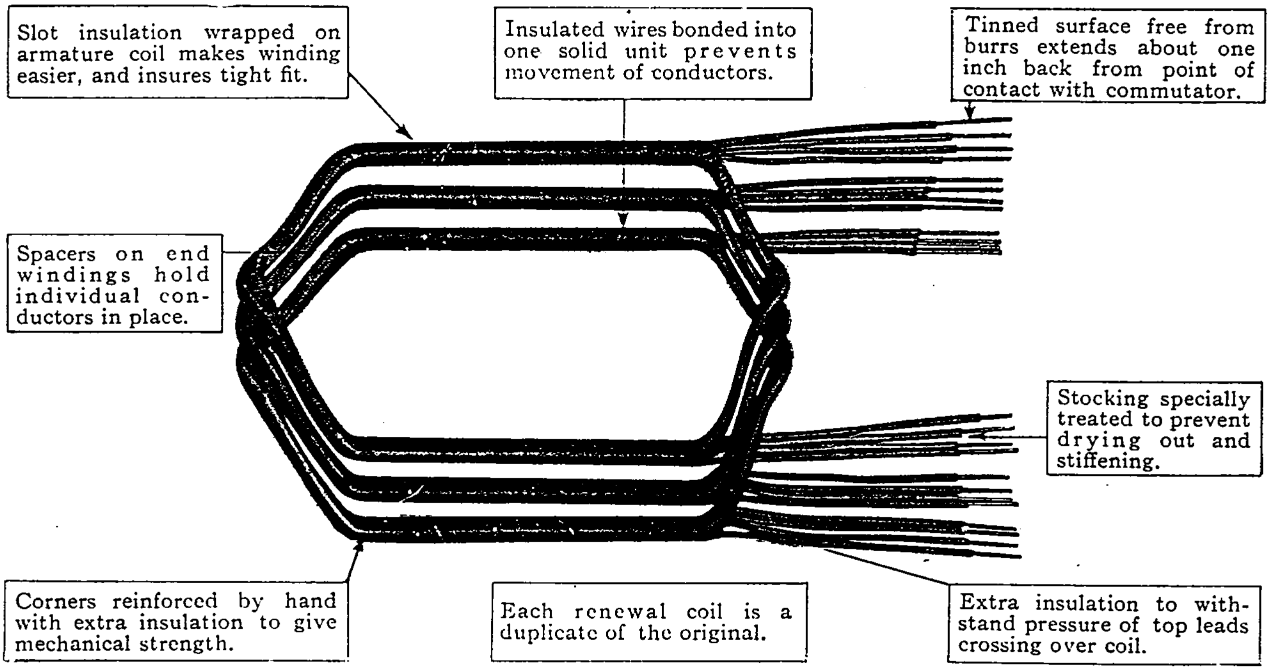
The rotating saw is mounted on the end of the motor shaft which is extended and supported by an offset bearing, which readily permits the grooving of commutators having ears. Owing to the small size of the motors used with these machines, no starting resistance is necessary.



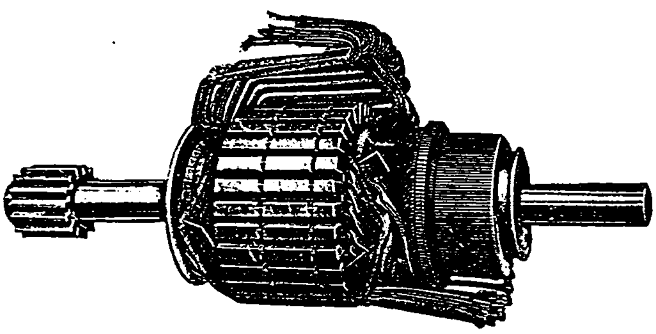
COMMUTATOR HAND SCRAPER

The hand scraper is for removing mica fins which are left in the slot by the grooving saw. A triangular curved file is sometimes used for removing the copper projections, but the removal of a very thin portion of the commutator surface by turning in a lathe using a special high-speed steel tool (trade name No. 3 Stellite), is recommended. The remaining copper burr left on the trailing edge of each commutator bar can be removed by the hand scraper above illustrated. A final polishing with sandpaper will make a smooth surface which is necessary for good commutation and long life of brush.

Railway Motor Armature Coils



Coils for railway motors are subjected to the most difficult service of any electrical equipment. This is due largely to the vibration and unfavorable conditions, such as exposure to dirt and moisture, under which these motors operate. Particular care must therefore be taken to prevent any possible movement of the coil in the core slots as such motion or vibration is sure to result sooner or later in a grounded or short circuited armature. The importance of a properly fitting coil cannot be too strongly emphasized, as the life of the coil depends to a very great extent on the prevention of abrasion in the slot and between individual turns. The coil must have a good tight fit, taking up all the available space in the slot and, at the same time, not so tight as to be damaged in assembling the coils on the armature. While an armature may be wound much more quickly if the coils slip into the slots easily, the saving in labor and ease in winding is offset by the much shorter life of such loose fitting coils.

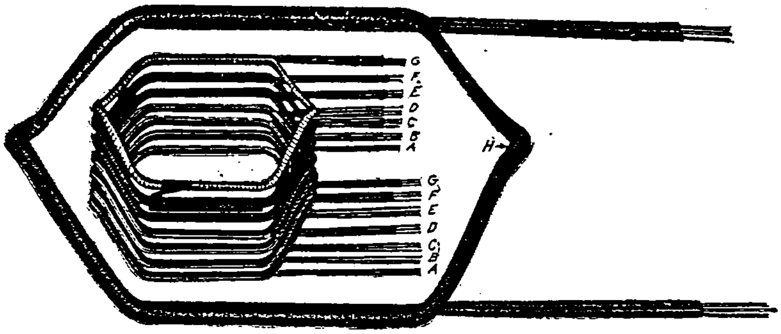


Railway Motor Armature, Partially Wound

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Railway Motor Armature Coils



The Evolution of an Armature Coil Showing Stages in Development

A—Armature Coil as wound on form.
B—Insulation coated with bonding material inserted.
C—Stocking slipped over leads.
D—Slot portion steam moulded.
E—Coil dipped in insulating compound.
F—Wrapping on slot insulation.
G—Taping, showing additional top spacer.
H—Completed coil.

Armature coils in original equipments are especially designed to meet the exacting service required of a particular motor. The conductors are of ample size properly insulated for maximum life. The slot portion of the coil is bonded into a solid unit by the use of heated moulds making assembly easier and greatly reducing liability of damage to the conductors. The leads are cleaned, tinned and carefully inspected to eliminate burrs. A stocking is slipped over each lead and securely fastened. This stocking is especially treated to prevent drying out and consequent stiffening and to prevent unravelling of the insulation on the conductors. The completed coil is dipped several times in varnish and thoroughly baked after each dipping.

Only by the use of coils made of the same materials and in exactly the same manner can the original quality of the equipment be maintained. Coils made in any other manner will not have the exact fit necessary for easy winding on the one hand or the tightness in the slots to withstand vibration on the other. If inferior materials are used the coils will deteriorate rapidly under severe service conditions. Coils designed simply to produce an interchangeable product at a lower price cannot do the work as well as the equipment manufacturer's high standard product.

G-E coils are made for G-E motors to perform a particular service under carefully analyzed conditions. The same care that is used in selecting original equipment should be exercised in the selection of repair parts for it.

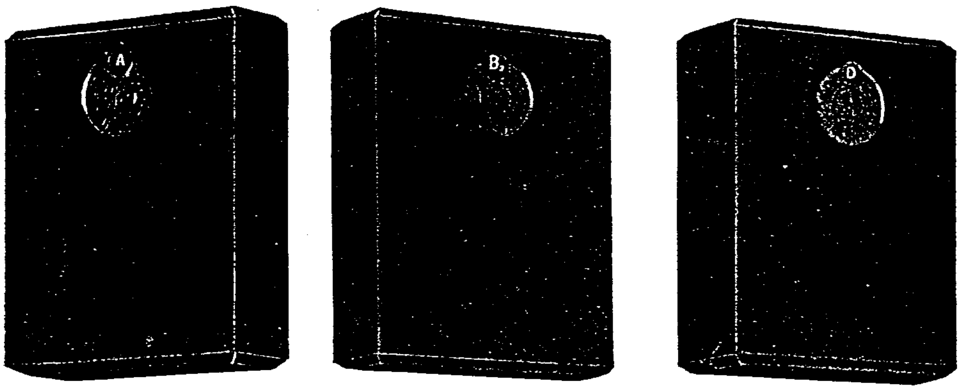
Each G-E coil is a duplicate of the original. The use of G-E replacement coils insures satisfactory operation of G-E motors and minimum maintenance expense.

General Electric Company

CARBON BRUSHES

for

Railway Motors



Brush Selection

The selection of the brush to use is governed by the type of motor and local service conditions. It is impossible to make a specific recommendation which will apply to every operating condition, but the following suggestions will be helpful in the majority of cases.

Abrasive, High Resistance Brush

For use on commutators not grooved

Motors having commutator side mica flush with the commutator surface require a brush with an abrasive content sufficient to cut the mica. Non-commutating pole motors generally require a comparatively high resistance brush to reduce the current in the coil short circuited by the brush. The brush must also have ample current carrying capacity.

The G-E Grade A brush meets these requirements.

Semi Self-Lubricating, High Resistance Brush

For use on grooved commutators

Motors subject at times to heavy overloads, which may cause burning or pitting of the commutator, generally require a semi self-lubricating brush containing just enough abrasive to keep the commutator smooth. Where commutation is affected by excessive vibration and possible flashing, a medium abrasive brush is also required. Such a brush usually has sufficient resistance to properly commutate the current in non-commutating pole motors.

The G-E Grade B-2 brush meets these requirements.

Ask our nearest office for complete information

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Carbon Brushes for Railway Motors

Self-Lubricating, Low Resistance Brush

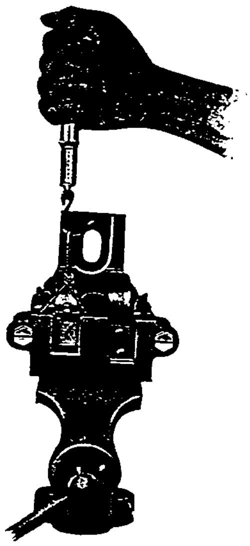
For use on grooved commutators

Under favorable conditions, such as absence of excess overloads, destructive vibration, and flashing, the use of a non-abrasive, low resistance brush is recommended for commutating pole motors. A brush of this character causes minimum brush friction and minimum wear on the commutator.

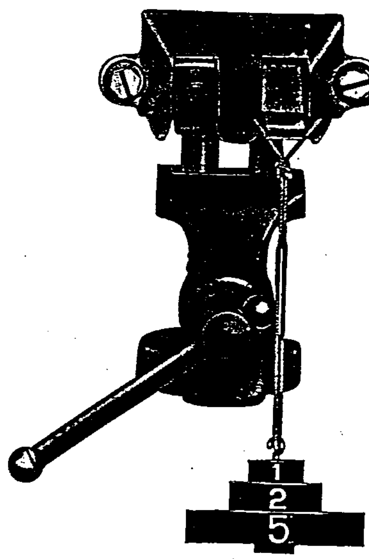
The G-E Grade D brush meets these requirements.

Brush Pressure Adjustment

Brush troubles are frequently caused by using pressures entirely unsuited to the brush. Too little pressure allows the brush to jump, often causing a flashover. It is necessary to use a high brush pressure on lines having rough tracks. The pressure should be sufficient to keep the brush on the commutator at all times.



Spring Balance Method



Weight Method

Methods of Measuring Brush Pressure

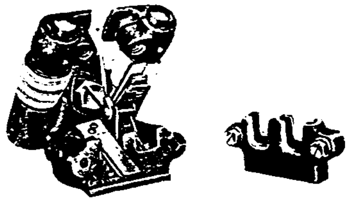
When measuring brush pressure by either of the methods illustrated above, it is recommended that a wooden block of the same size as the brush be used. This should be grooved lengthwise to hold the cord. If the wooden block is omitted, care must be taken to place the cord around the finger at the center of the carbonway, otherwise an incorrect reading will be taken.

There are few motors which allow sufficient space within the motor to measure pressure on both brush-holders with the spring balance. However, it is always desirable and generally necessary to remove the brush-holder from the motor in taking measurements of brush pressure.

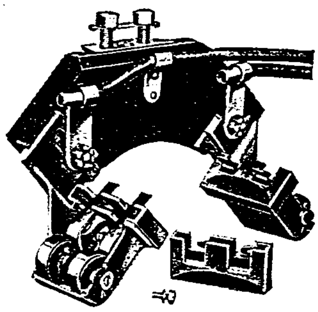
In the weight method, a weight equal to the proper pressure is applied as shown in the above illustration. If the weight does not just balance the pressure of the finger, the ratchet adjustment on the brush-holder should be changed. This operation should be repeated until proper adjustment is made.

Renewable Carbon-Way Brush-Holders
for
Railway Motors

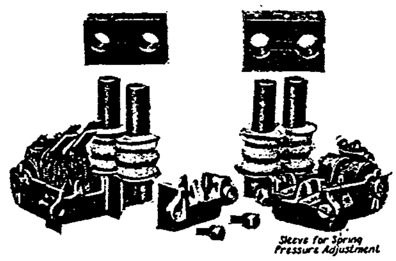
Many modern railway motors are equipped with brush-holders having renewable carbon-ways. These brush-holders are also available for older type motors.



Side Supported Bracket Type



Yoke Type



End Supported Cleat Type

Good operation requires the prompt replacement of worn carbon-ways. With the non-renewable type of brush-holder it is necessary to scrap the complete holder when the carbon-way becomes worn out. There is a tendency to continue operation with the worn part rather than make replacement. This usually results in a higher maintenance cost than if the complete brush-holder were thrown away.

Many motors now in service have worn holders that should be replaced. It is strongly recommended that these be replaced by the RENEWABLE CARBON-WAY type. By such substitution the future replacement of a carbon-way can be made quickly and at minimum expense, since the cost of the RENEWABLE CARBON-WAY is but a fraction of the cost of the complete holder.

Brush-holders of this type are available as listed below.

MOTOR		Type of Support	CAT. NO. BRUSH-HOLDER COMPLETE		Cat. No. Renewable Carbon-Way Only
Type	Volts		Axle Side	Suspension Side	
GE 57	500	Yoke	2625846G2	2625846G1	2194893P3
GE 67	500	Yoke	245395	245396	1979246P3
GE 70	500	Yoke	222233	222234	222236
GE 73	500	Bracket	2162453G1	2162453G2	2136950P2
GE 80	500	Yoke	222233	222234	222236
GE 88	500	Bracket	222167	222167	222169
GE201	600	Bracket	2625839G1	2625839G1	2194890P2
*GE203	600	Bracket	1934980G2	1934980G2	234026
†GE210	600	Yoke	247294	247295	2136942P3
GE240	600	Cleat	222170	222172	222175
GE247	600	Cleat	222177	222178	222179
GE258	600	Cleat	1889929G4	1889929G3	222182
GE260	600	....	260169	260169	2194891P2
GE263	600	Bracket	2625839G1	2625839G1	2194890P2
GE264	600	Cleat	1889929G4	1889929G3	222182
GE265	600	Cleat	1979202G4	1979202G3	1889903P11
GE275	600	Cleat	2136953G2	2136953G2	2162452P2

*For Forms E, G, H, I, L, M, N and O only.
†For Form A only.

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General Electric Company, Schenectady, N. Y.

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Springfield, Mass....................387 Main Street
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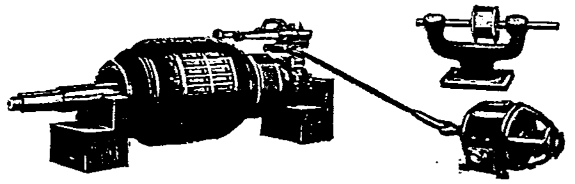
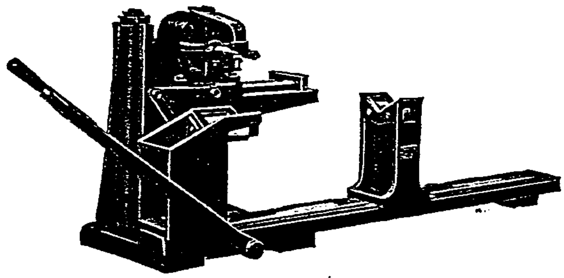
COMMUTATOR GROOVING MACHINES



Portable Machine—Form 3



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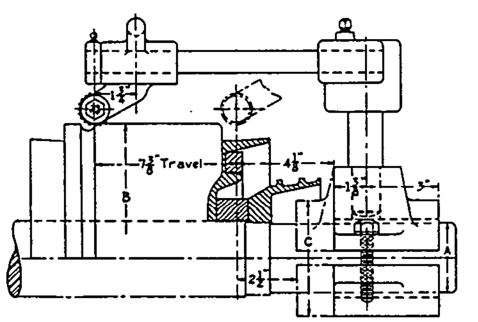
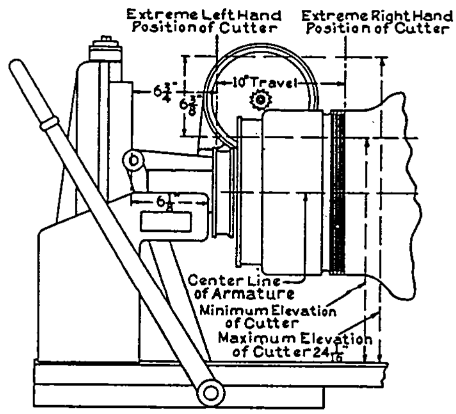


Form 3 Portable Commutator Grooving Machine



Form 2 Stationary Commutator Grooving Machine

PORTABLE TYPE

DIAMETERS	DIMENSIONS IN INCHES (Based on a Cutter Diameter of 1⅜ In.)						
Shaft diameter (A)......	2¼	2½	2¾	3	3¼	3½	3¾
Max. comm. dia. (B).....	11	11¼	11½	11¾	12	12¼	12½
Diam. at C.............	4⅞	4 25/32	5⅛	5 15/32	5 13/16	6 5/32	6½

STATIONARY TYPE

DIAMETERS	DIMENSIONS IN INCHES (Based on a Cutter Diameter of 1⅜ In.)						
Shaft diameter..........	2¼	2½	2¾	3	3¼	3½	3¾
Max. possible comm. dia..	20 9/16	20 3/16	19¾	19 9/16	19⅛	18¾	18⅜
Max. possible arm. dia....	20	20	20	20	20	20	20

General Electric Company, Schenectady, N. Y.

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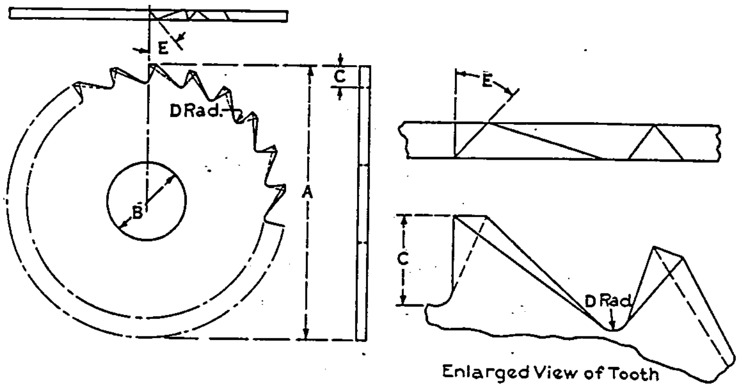
COMMUTATOR GROOVING MACHINES



High Speed Steel 22-Tooth Grooving Saw

A = 1 3/8 In. B = 3/8 In. C = 3/32 In. D = 1/64 In. E = 40 Deg.

Catalog No.	Thickness in Inches
2672300P1	0.020
2672300P2	0.025
2672300P3	0.030
2672300P4	0.035
2672300P5	0.040

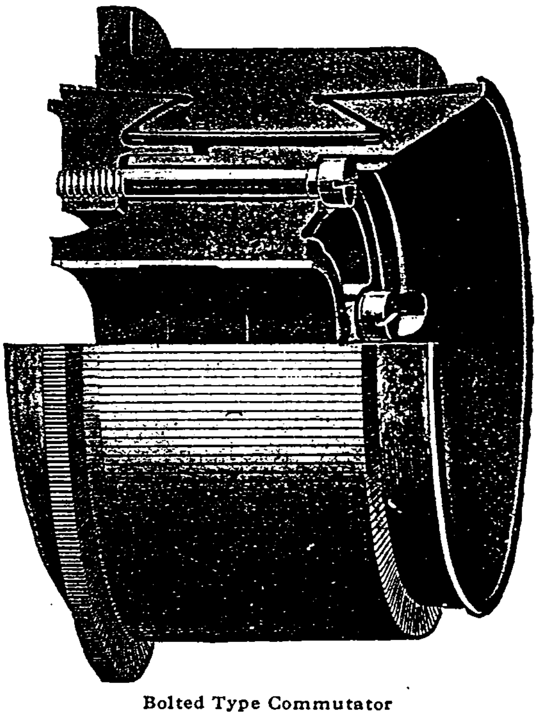
These saws are *cut* from a solid bar of metal, and are hardened, ground, and sharpened. This method produces an absolutely true tool of uniform thickness. A saw will usually groove several commutators with one sharpening and can be resharpened many times, making it far more efficient than an ordinary punched saw which cannot be resharpened. The teeth should be resharpened with angles approximately as shown in the above sketch.

Commutator Hand Scraper

The hand scraper is for removing mica fins which are left in the slot by the grooving saw. A triangular curved file is sometimes used for removing the copper projections, but the removal of a very thin portion of the commutator surface by turning in a lathe, using a special high-speed steel tool (trade name No. 3 Stellite), is recommended. The remaining copper burr left on the trailing edge of each commutator bar can be removed by the hand scraper above illustrated. A final polishing with sandpaper will make a smooth surface which is necessary for good commutation and long life of brush.

THE REPAIR OF RAILWAY MOTOR COMMUTATORS

G-E railway motor commutators are of either the *bolted* or *ring nut* construction. The bolted type usually has the cap at the back and the shell which presses on the shaft or spider in the front, the two members being held together by bolts. The ring nut type of commutator has the cap in front and the shell in back, the two members being held together by a ring nut threading on the shell which extends through to the front end of the commutator. The commutator ring nut is locked in place by a set screw. When it is necessary to repair either type, the process is very similar after the shell or cap, as the case may be, is removed.



Bolted Type Commutator

Replacement of Segments

Bolted Type Commutator

When replacing the copper segments in bolted type commutators, operations should proceed as follows: Remove thrust collar from shaft and draw a few turns of wire tightly around the commutator to prevent segments from separating during the removal of the shell which frequently entails more or less pounding and jarring. Remove the leads directly connected to the segments to be replaced; remove all of the bolts and pull out the shell; next remove the mica cone; then take off the wire band, drive forward and take out *one* of the segments to be replaced. A new segment should be made using the old one as a template. This should be cut from solid copper since commutator segments are not interchangeable and must be of the same bar gauge or taper as the old segment. Place the two segments together with the bottom edges or thin side even, then lay out and form the new segment from the old one, taking care that the 30 degree and 3 degree angles are exact. Insert new side mica and place the new segment in the commutator. If necessary to replace several segments, proceed, *one segment at a time,* as described above. The mica cone, if not damaged while being removed, should be put back. If it is damaged, insert a new cone. Then press the shell back on the shaft until it is approximately one inch from its original position. Insert the bolts and take them up all around a little at a time to insure that the cap at the back of the commutator is drawn up evenly as the shell is being pressed home. The commutator should next be heated with a gas ring to approximately 115 degrees centigrade and the bolts tightened while it is still hot. It is highly important that the segments be clamped as tightly as possible so they will not loosen in service —test for this by tapping them with a light hammer. After cooling, turn the face of the commutator and regroove if necessary.

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General Electric Company, Schenectady, N. Y.

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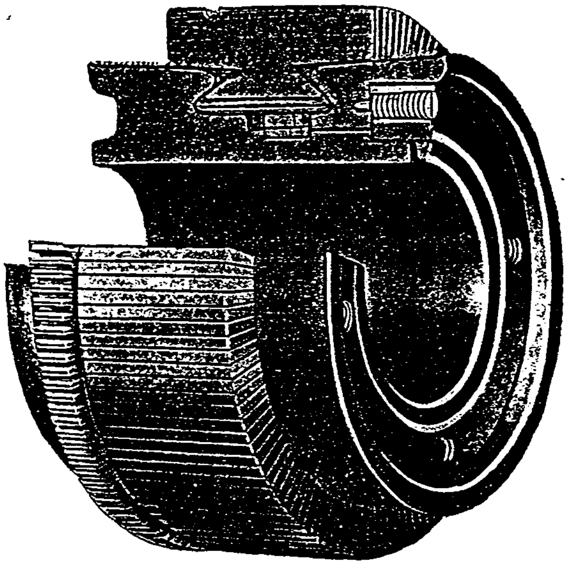
Replacement of Segments

Ring Nut Type Commutator

In order to replace the segments on a commutator of the ring nut type, remove the thrust collar, band some wire around the segments, and disconnect the coil leads from the segments to be replaced. Take out the set screw and unscrew the commutator nut. Remove the cap and mica cone. Next replace the copper segments as described in the preceding paragraph; reassemble the mica cone and cap; and thread in the nut as far as possible while the commutator is cold. Heat the commutator as described above and tighten the ring nut. Turn the face and regroove if necessary.

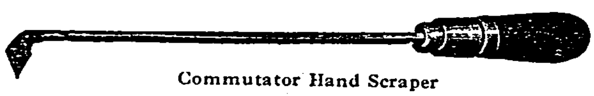


Ring Nut Type Commutator

Turning the Commutator

Before turning a commutator, a suitable head covering should be made to prevent chips or dust from working into the armature. This is best accomplished as follows: Take a strip of cotton several inches wider than the length of the end connections and long enough to encircle the commutator; wrap it around the commutator, binding the inside edge with cord as closely to the end connections as possible; then turn the cloth up over the latter and bind with cord to the outside of the armature. Make sure that the turning post is so set that the ways are absolutely parallel to the commutator and are securely fastened and braced. Use a side-cutting tool with point ground to about a $\frac{1}{16}$-in. radius. The cutting side and point should be given considerably more rake than is customary for working iron or steel. The tool must be sharp enough to make a clean, smooth cut without dragging copper over the mica.

While turning, the commutator surface should be run at a speed of approximately 300 feet per minute. This is about as fast as a tool will cut without burning. It is important to round off the ends of the copper segments to at least a $\frac{1}{16}$-in. radius with a file while the commutator is in the lathe. If this is not done and sharp corners are left at the ends of the copper segments, the mica is easily broken out and a short circuit may be established by oil and dust at these points.



Commutator Hand Scraper

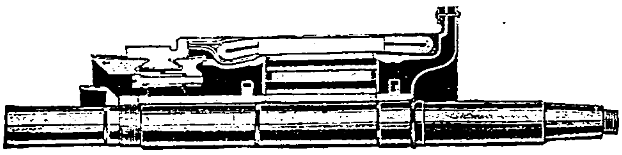
Grooving the Commutator

After turning the commutator, the side mica should be grooved to a depth of approximately $\frac{3}{64}$ of an inch. Refer to G-E Railway Supplies Catalog No. 6002, pages 303 and 304, for commutator grooving machines, to Descriptive Sheet No. 64407.

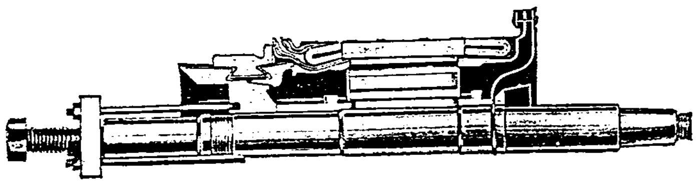
The finishing of the slots left by the grooving saw is an important operation because good commutation and brush wear depend very much upon the condition in which the commutator goes into service. The hand scraper, Cat. No. 775854G1, illustrated above is used for removing mica fins which are left in the slot by the grooving saw. The grooving saw is usually 0.005 of an inch less in thickness than the mica between the commutator segments. The grooving saw generally cuts into the copper and leaves projections which must be removed. A curved triangular file is sometimes used for removing these copper projections, but the removal of a very thin portion of the commutator surface by turning in a lathe is recommended. For this final turning, a special high speed steel tool (trade name No. 3 Stellite) will give good results. The remaining copper burr which projects into the slot on the trailing edge of each commutator segment can be removed by the hand scraper above illustrated. Final polishing with sandpaper will make the smooth surface necessary for good commutation and long brush life.

In making repairs to the commutator, especial care should be taken to keep all parts clean and free from dust and foreign material. Careful work is essential for the best results.

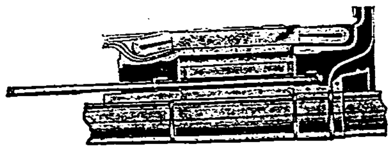
Views of Armature with Bolted Type Commutator



Normal Operating Condition

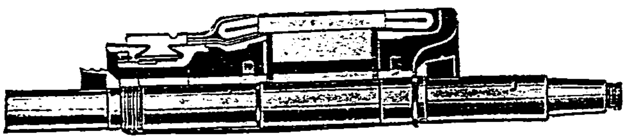


Showing Bolts for Removing Commutator

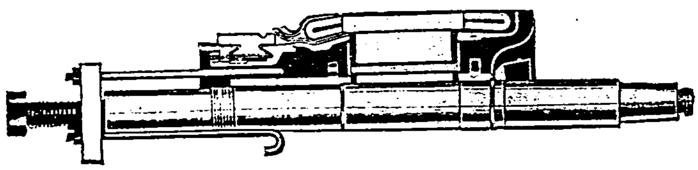


Shaft and Commutator Removed

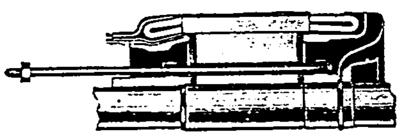
Views of Armature with Ring Nut Type Commutator



Normal Operating Condition



Showing Hook Bolts for Removing Commutator



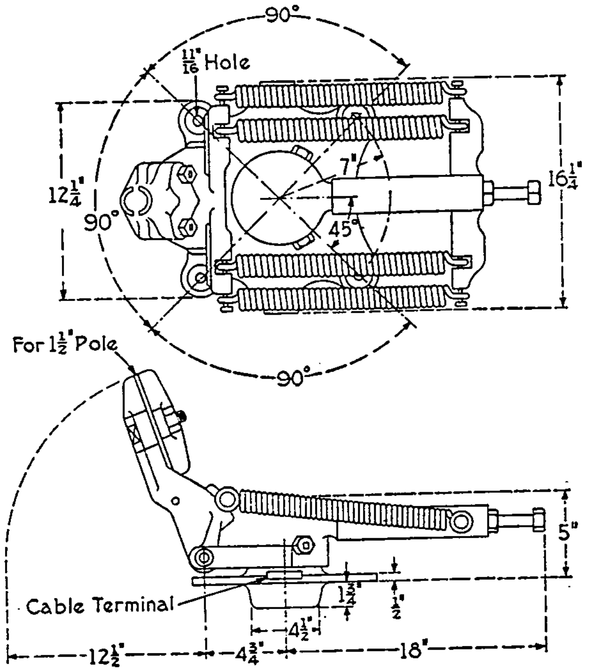
Shaft and Commutator Removed

Removal and Replacement of Complete Commutators

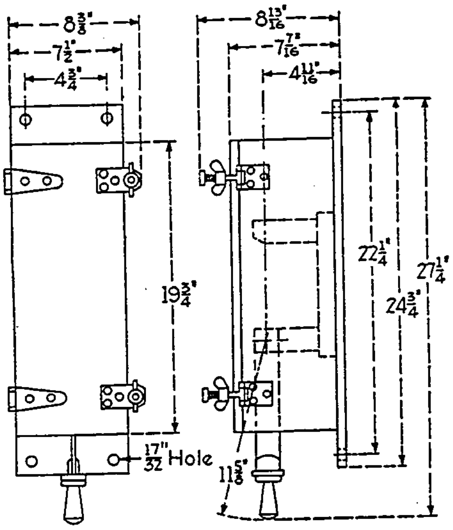
In case the commutator as a whole must be replaced, the above illustrations show methods of removing it from the shaft for both the bolted and the ring nut types of commutators. Note the bolts used for clamping the core laminations together while the armature nut is removed.

The Initials of a Friend

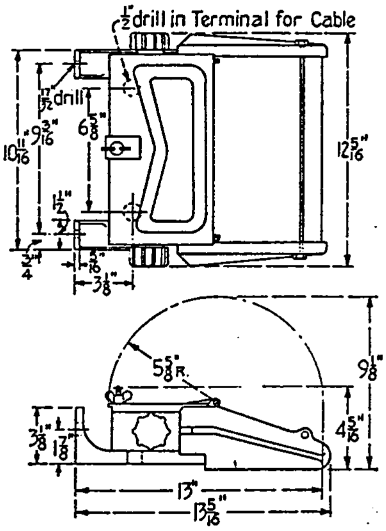
DIMENSIONS OF ELECTRICAL APPARATUS USED WITH 600-VOLT, TYPE PC RAILWAY CONTROL EQUIPMENT



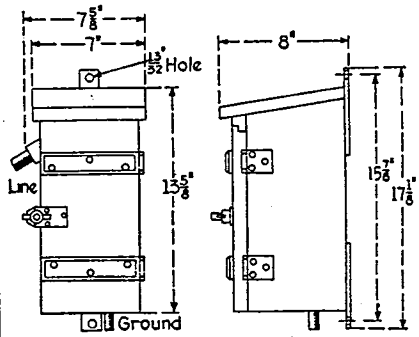
US-13-E Trolley Base
Approx. Weight 115 lb.



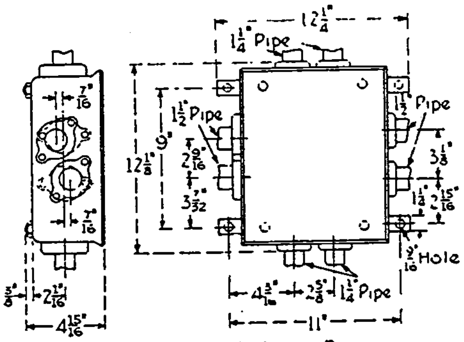
MS-118-A Main Switch
Approx Weight 24 lb.



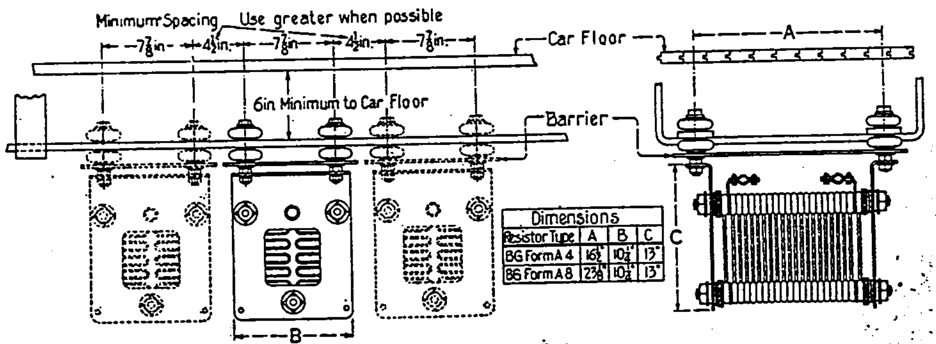
MA-13-F Fuse Box
Approx. Weight 17 lb.



MD-3 Lightning Arrester
Approx. Weight 15 lb.



BJ-386-B Distributing Box
Approx Weight 18 lb



Dimensions			
Resistor Type	A	B	C
BG Form A 4	16"	10 1/4"	13"
BG Form A 8	23 3/8"	10 1/4"	13"

Dimensions of Type BG Railway Resistors

Form	Approx. Weight
A-4	80 lb.
A-8	110 lb

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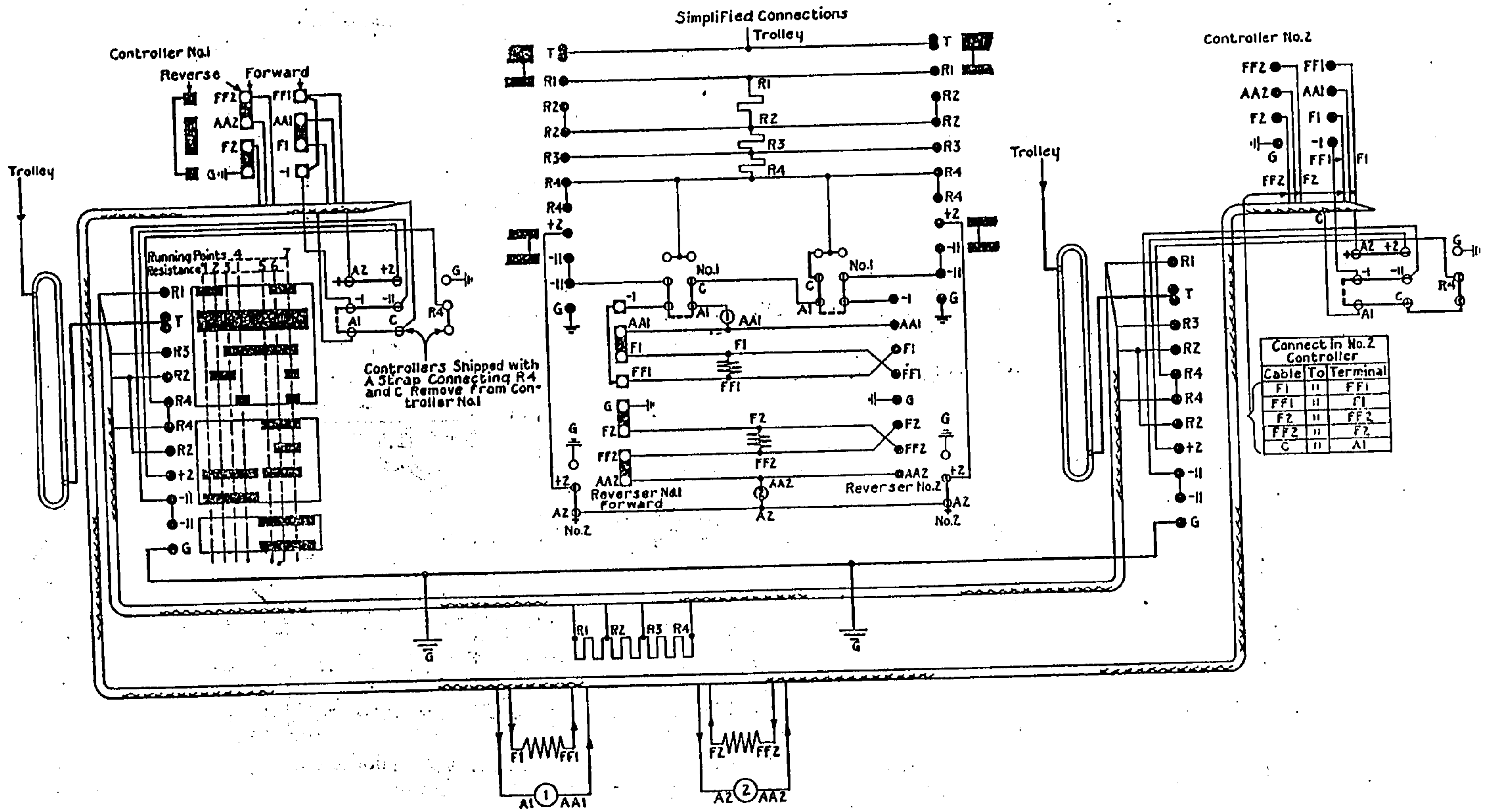
2 JAN., 1924

No. 15380

2m 1-14-24

ENGINEERING DEPT.
GENERAL ELECTRIC COMPANY, U.S.A.

CONNECTIONS OF TYPE K-63-BR RAILWAY CONTROLLERS (AND EQUIPMENT)



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1 MAR., 1921

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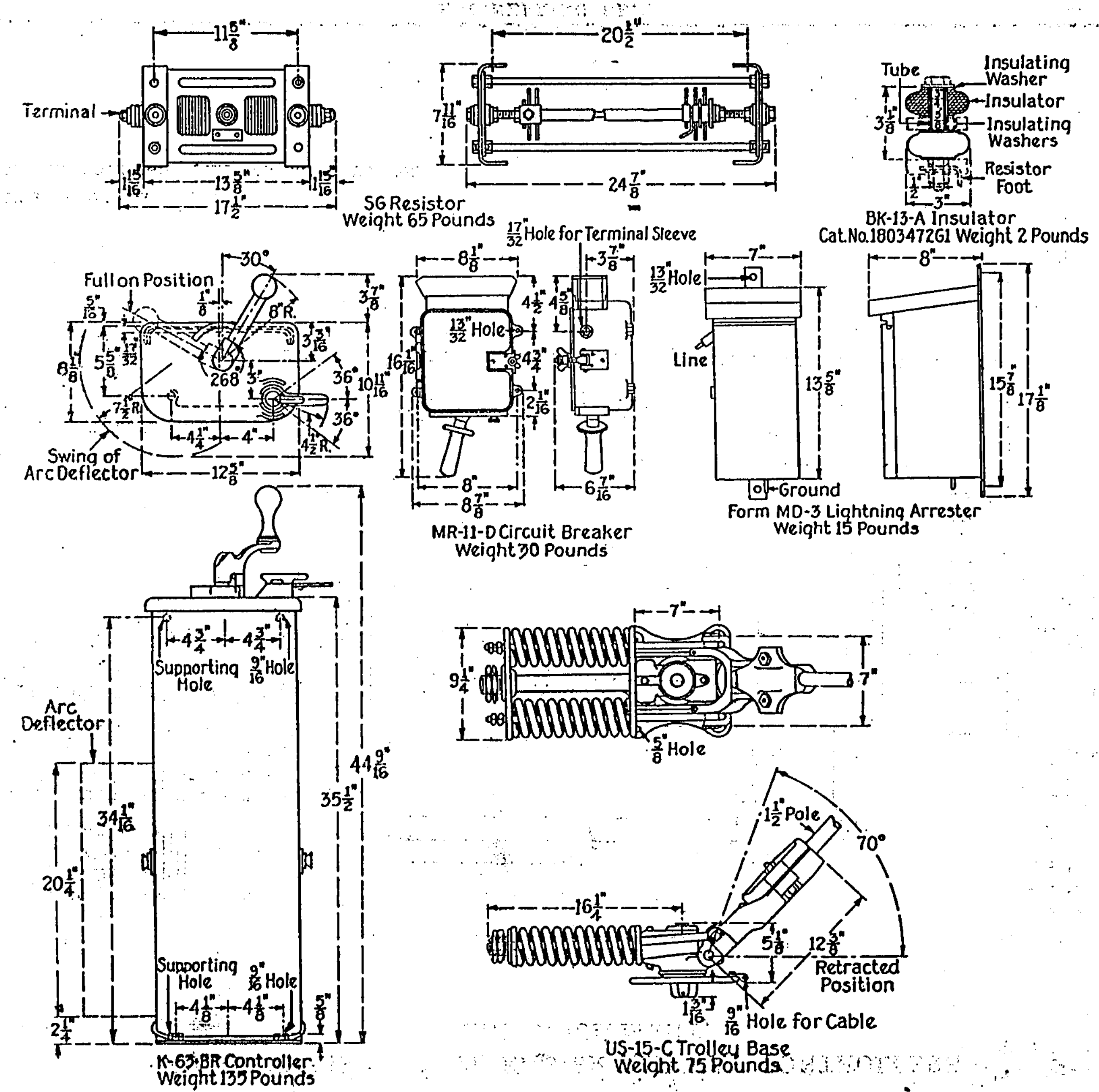
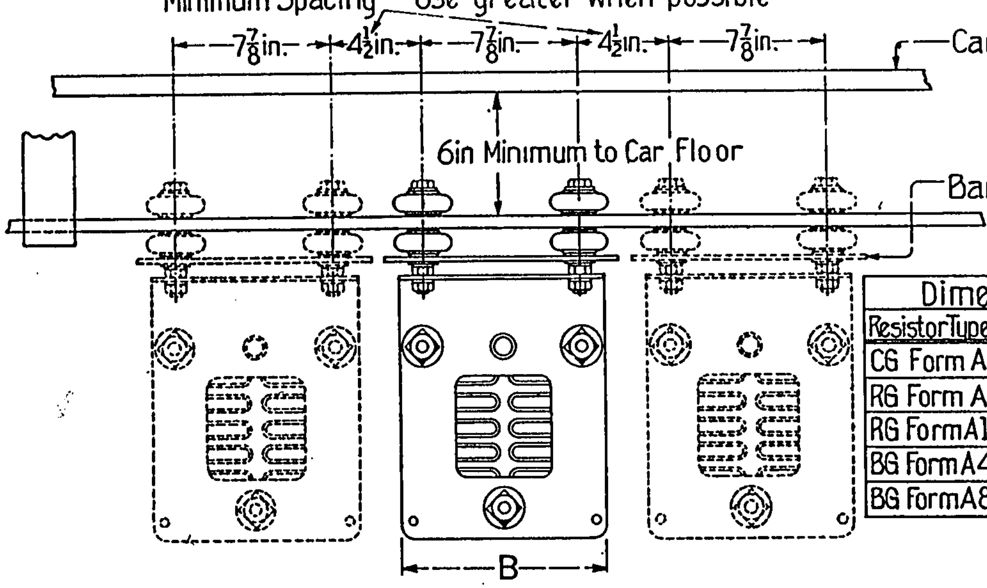
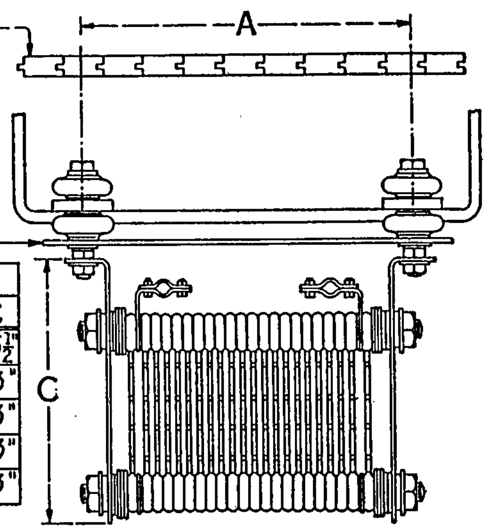
DIMENSIONS OF TYPE K-63-BR RAILWAY CONTROLLER EQUIPMENT



*METHOD OF SUPPORTING RAILWAY RESISTORS USING PORCELAIN BOLT INSULATORS FOR 600- AND [redacted]-VOLT WORK

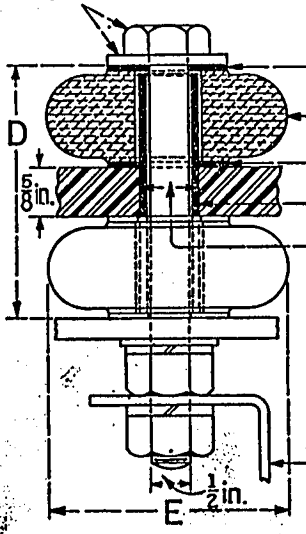
1500





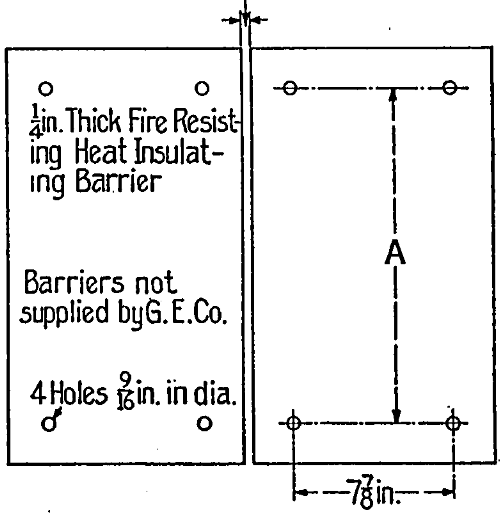
Dimensions			
Resistor Type	A	B	C
CG Form A	$16\frac{1}{2}$"	$10\frac{3}{4}$"	$13\frac{1}{2}$"
RG Form A	$16\frac{1}{2}$"	$10\frac{3}{4}$"	13"
RG Form A1	$23\frac{3}{8}$"	$10\frac{3}{4}$"	13"
BG Form A4	$16\frac{1}{2}$"	$10\frac{1}{4}$"	13"
BG Form A8	$23\frac{3}{8}$"	$10\frac{1}{4}$"	13"

Bolt and Metal Washer not supplied by G.E.Co.



	600 Volts	1500 Volts
Packing Washer	Cat.No.1435581	Cat.No.1435581
Porcelain Insulator	Cat.No. 450869	Cat.No. 450880
Packing Washer	Cat.No.1435582	Cat.No.1435796
Insulating Tube	Cat.No.1803472P4	Cat.No.1436075
Hole in Support	$\frac{13}{16}$ in.	$\frac{15}{16}$ in.
Complete Insulator	Cat.No.1803472G1	Cat.No.1949194G2
Weight	1 lb.	2 lb.
Dimension D	$3\frac{1}{8}$ in.	$4\frac{1}{8}$ in.
Dimension E	3in.	$3\frac{1}{2}$ in.

$\frac{1}{2}$in. Space between Barriers



Drilling for Barriers

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Changed 1 NOV., 1923 Destroy all copies of previous issue.

3m 11-23-23

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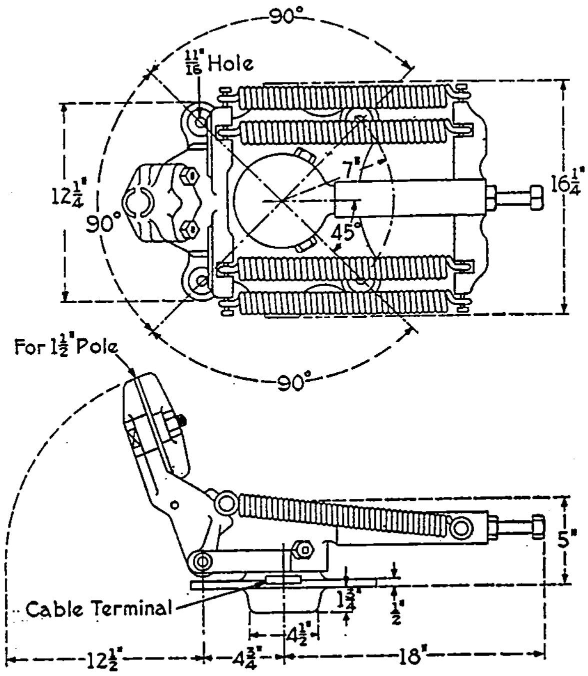
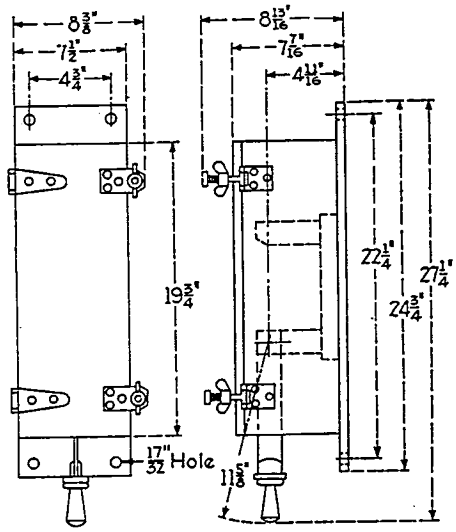
GENERAL ELECTRIC COMPANY, U.S.A.

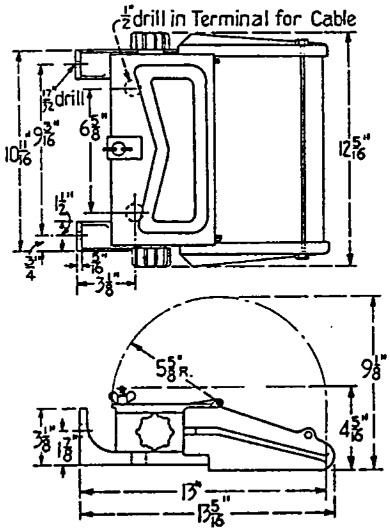
DIMENSIONS OF ELECTRICAL APPARATUS USED WITH TYPE M RAILWAY CONTROL EQUIPMENT



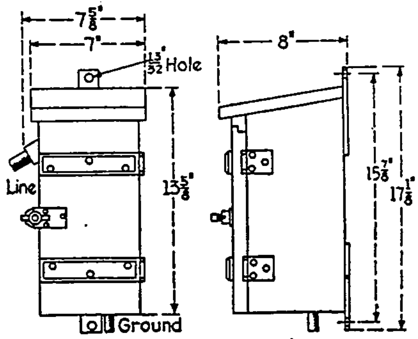
US-13-E Trolley Base
Approx. Weight 115 lb.



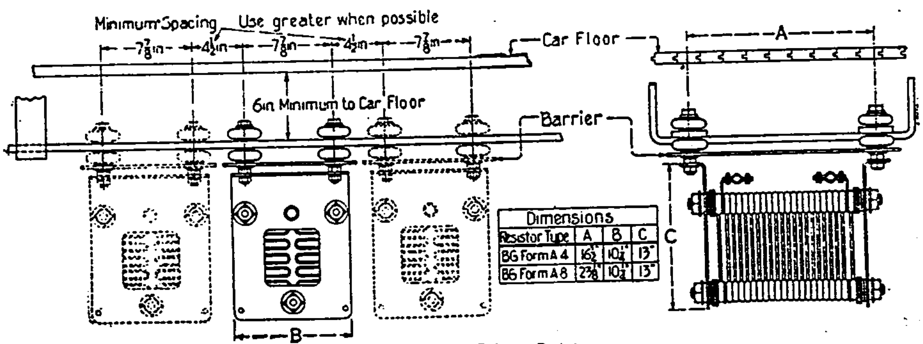
MS-118-A Main Switch
Approx Weight 24 lb.



MA-13-F Fuse Box
Approx. Weight 17 lb.



MD-3 Lightning Arrester
Approx. Weight 15 lb.



Dimensions			
Resistor Type	A	B	C
BG Form A 4	16½"	10¼"	13"
BG Form A 8	2⅞"	10½"	13"

Dimensions of Type BG Railway Resistors

Form	Approx Weight
A-4	80 lb.
A-8	110 lb.

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2 JAN., 1924

No. 15381

2m 1-14-24

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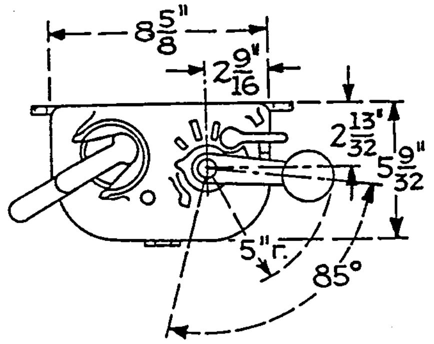
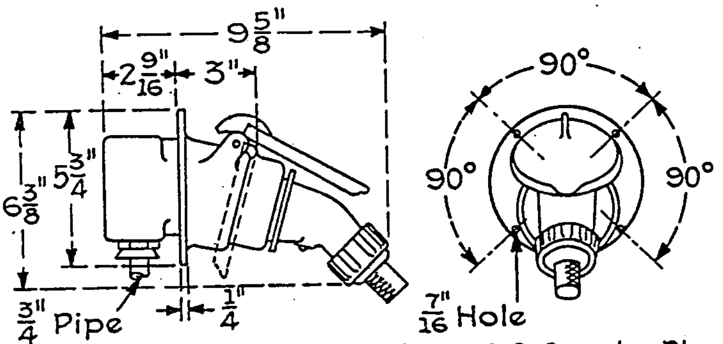
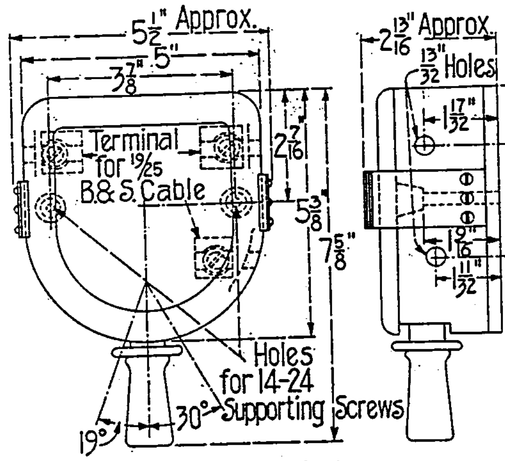
DIMENSIONS OF ELECTRICAL APPARATUS USED WITH 600-VOLT, TYPE PC RAILWAY CONTROL EQUIPMENT

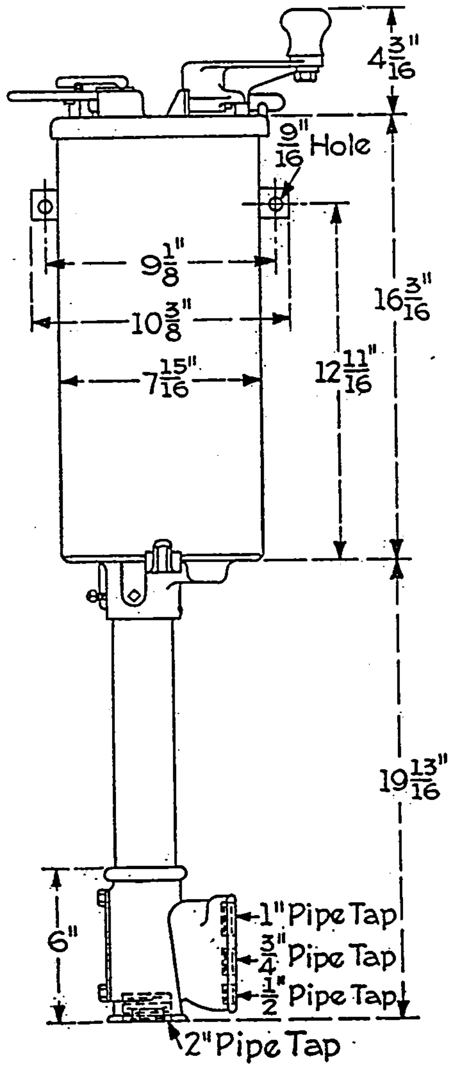


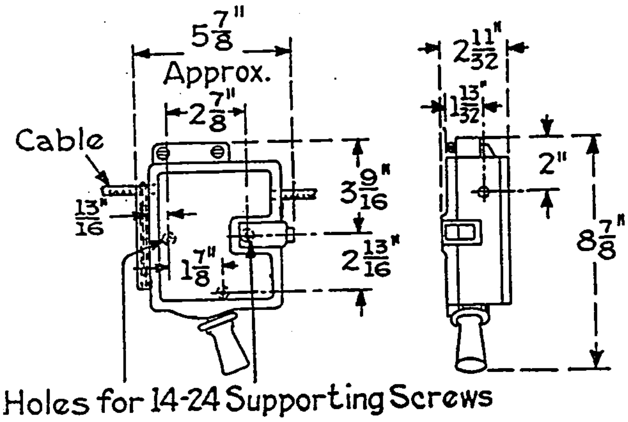


DA-82-C Coupler Socket and DC-54-C Coupler Plug
Approx. Weight 12 1/2 lb.



MS-14-G Switch
Approx. Weight 4 lb.





C-129-A Master Controller
Approx. Weight 45 lb.

MS-46-H Switch
Approx. Weight 4 1/2 lb.

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No. 15382

2m 1-14-24

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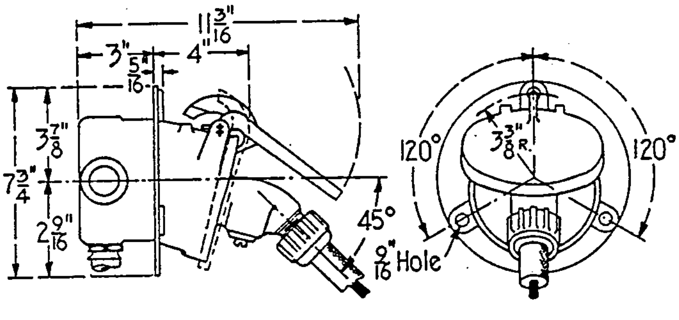
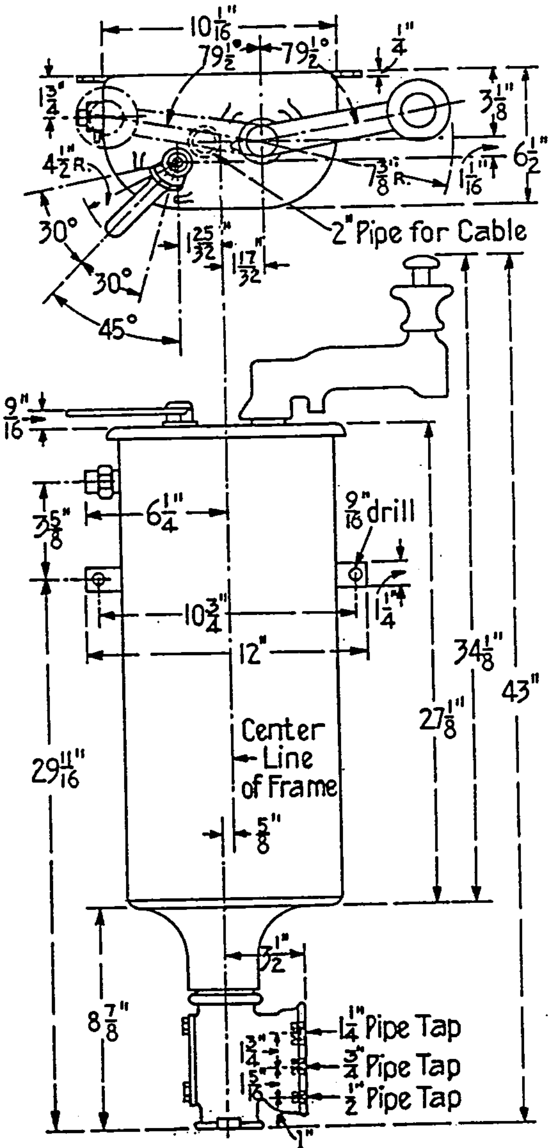
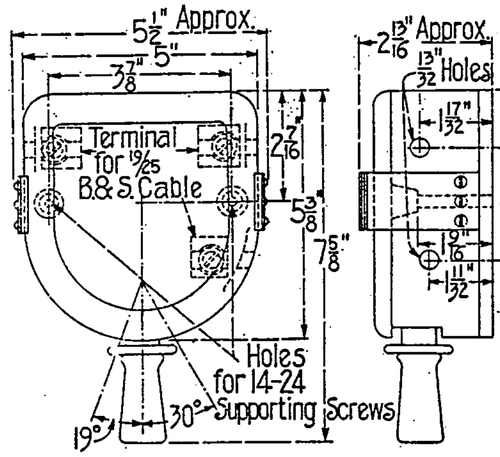
DIMENSIONS OF ELECTRICAL APPARATUS USED WITH TYPE M RAILWAY EQUIPMENT



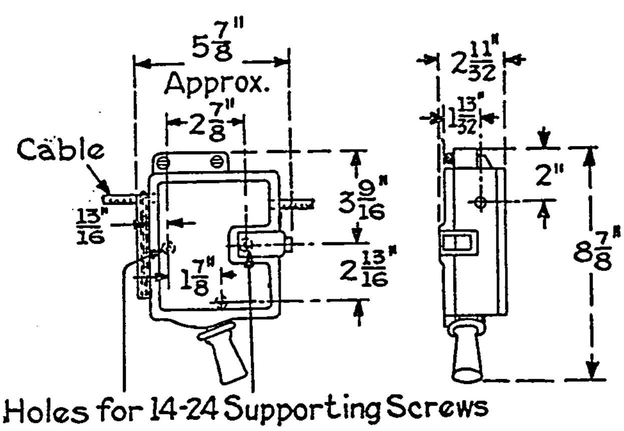
DA-69-B Coupler Socket
DC-66-C Coupler Plug
Approximate Weight 18.5 lb.



C-169-A Controller
Approx. Weight 85 lb.



MS-14-G Switch
Approx. Weight 4 lb.



MS-46-H Switch
Approx. Weight 4 1/2 lb.

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2m 1-14-24

ENGINEERING DEPT.
GENERAL ELECTRIC COMPANY, U.S.A.

METHOD OF MAKING TAP CONNECTIONS FOR CAR CABLES

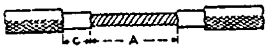

Fig.1
Main Cable Insulation Removed

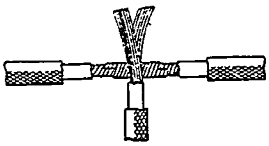

Fig.4
19 Strand Cable with Inside Strands Wound Tight

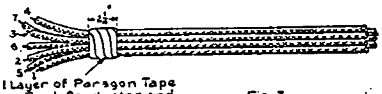

Fig.7

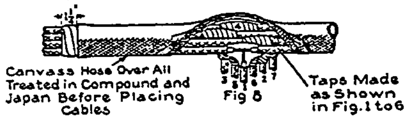

Fig 8

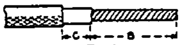

Fig.2
Tap Cable Insulation Removed

Fig.5
Wound Tight
Ready to be Soldered

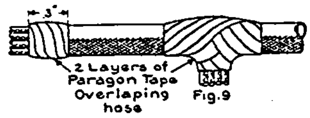

Fig.9

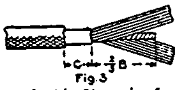

Fig.3
Inside Strands of 19 Strand Cable cut Shorter

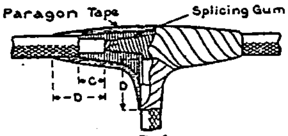

Fig.6
Completed Joint to be thoroughly Covered with Insulating Paint

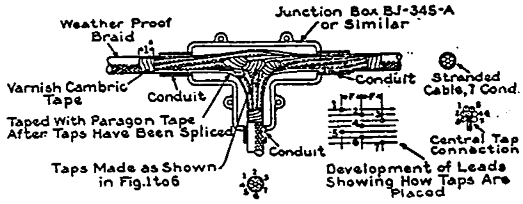

Fig. 10

Size of Tap Cable (Circular Mils)	SIZE OF MAIN CABLE																							
	B.&S. 4/0		B.&S. 3/0		B.&S. 2/0		B.&S. 1/0		B.&S. 1		B.&S. 2		B.&S. 4		B.&S. 6		B.&S. 8		B.&S. 10		B.&S. 12		B.&S. 14	
	Circular Mils																							
	212,000		168,000		133,000		106,000		83,500		66,600		41,600		26,200		16,600		10,400		6,560		4,100	
	Dimensions in Inches																							
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
212000	4	5	3¾	4½	3¼	4	3½	3¾	3	3½	3	3¼	3	2¾	3	2½								
168000	3½	4¾	3¼	4½	3¼	4	3¼	3¾	3	3½	3	3¼	3	2¾	3	2½								
133000	3	4½	3	4½	3	4	3	3¾	2¾	3½	2¾	3	2¾	2½	2¾	2								
106000	2¾	4½	2¾	4½	2¾	4	2¾	3¾	2¾	3½	2¾	3	2¾	2½	2¾	2								
83500	2½	4¼	2½	4½	2½	4	2½	3¾	2½	3½	2½	3	2½	2½	2¼	2								
66000	2¼	5	2¼	4½	2¼	3¾	2¼	3½	2¼	3¼	2¼	2¾	2¼	2¼	2¼	1¾	2¼	1½	2¼	1¼	2¼	1	2¼	¾
41600	2	5	2	4½	2	3¾	2	3½	2	3¼	2	2¾	2	2¼	2	1¾	2	1½	2	1¼	2	1	2	¾
26200	1½	5	1½	4½	1½	3¾	1½	3½	1½	3¼	1½	2¾	1½	2¼	1½	1¾	1½	1½	1½	1¼	1½	1	1½	¾
16600	1¼	5	1¼	4½	1¼	3¾	1¼	3½	1¼	3¼	1¼	2¾	1¼	2¼	1¼	1¾	1¼	1½	1¼	1¼	1¼	1	1¼	¾
10400	1	5	1	4½	1	3¾	1	3½	1	3¼	1	2¾	1	2¼	1	1¾	1	1½	1	1¼	1	1	1	¾
6560	1	5	1	4½	1	3¾	1	3½	1	3¼	1	2¾	1	2¼	1	1¾	1	1½	1	1¼	¾	1	¾	¾
4100	¾	5	¾	4½	¾	3¾	¾	3½	¾	3¼	¾	2¾	¾	2¼	¾	1¾	¾	1½	¾	1¼	⅝	1	⅝	¾

212,000 C.M. to 83,000 C.M. inclusive, C = 1 in., D = 1¾ in. Use three wraps each of splicing gum and paragon tape.
80,000 C.M. to 26,000 C.M. inclusive, C = ¾ in., D = 1¼ in. Use three wraps of splicing gum and two wraps of paragon tape.
25,000 C.M. to 10,400 C.M. inclusive, C = ½ in., D = 1 in. Use two wraps each of splicing gum and paragon tape.
9,000 C.M. and smaller, C = ⅜ in., D = ¾ in. Use two wraps each of splicing gum and paragon tape.

For extra flexible taps make B ¾ of length called for on list.

Figs. 7, 8 and 9 show different stages of making up cables with canvas hose overall. Conductors are pulled through the hose straight and taps are applied after slit is made in the hose.

Fig. 10 shows a cable the conductors of which have been stranded together and finished overall with varnished cambric and weatherproofed cotton braid. It also shows how cable may be installed in iron pipe conduit with a junction box where taps come out.

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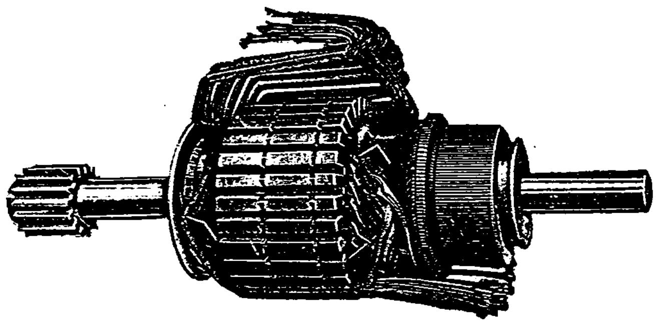
NOV. 1, 1924

ENGINEERING DEPT.
GENERAL ELECTRIC COMPANY, U.S.A.

The Repair of 600-Volt Railway Motor Armatures



G-E Railway Motor Armature, Partially Wound

Railway motor armatures are subject to duty of the most severe character, and with the best of care will ultimately fail in service. The purpose of this publication is to outline the correct methods of repairing armatures, insulated with varnished cambric and cotton tape, in such a way that satisfactory results will be assured.

Inspection

First, inspect the armature to determine the cause of failure so as to avoid a repetition of the trouble. The next steps are to determine the extent of the damage and how the repairs are to be made. If there is no external indication of failure, an insulation test of 1000 volts, alternating current, should be made between conductors and core. If this test shows that a ground exists, disconnect the commutator, if not, apply a bar to bar test of 125 volts, direct current, with a 125-volt lamp in series, to ascertain if there are any short circuits. If there is a short circuit but no ground, only part of the following operations will be necessary, depending upon the nature of the difficulty. The directions given in the following paragraphs cover the complete rewinding and reinsulating of an armature.

Disconnecting the Commutator

Remove the binding bands over the conductors at the commutator end and take off the outside head insulation over the coils. Then disconnect the coil leads from the commutator (this may be done by the "cold method" using a wedge shaped drift to force the leads out of the cups; or by the "hot method" using a soldering copper). If the "cold method" is used, the drift should be slightly narrower than the slot in the commutator bar so that the copper will not be damaged. After all of the leads have been disconnected from the commutator, the ground may be located. Each coil and each commutator segment can be tested for insulation from ground.

Repair of the Commutator

If the trouble is found in the commutator, clean the exposed surfaces thoroughly and examine for defective bars. Repairs may then be made in accordance with the specific instructions given on Descriptive Sheet 64405. Apply a bar to bar test of 125 volts, direct current, with a lamp in the circuit, after making repairs to the commutator.

Stripping the Armature

If the trouble is found in the coils, strip them from the core, proceeding as follows:

Raise all the top members of the coil out of the slots first, and then pull them back one at a time, thereby removing the bottom members in succession around the core.

General Electric Company, Schenectady, N. Y.

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The Repair of 600-Volt Railway Motor Armatures

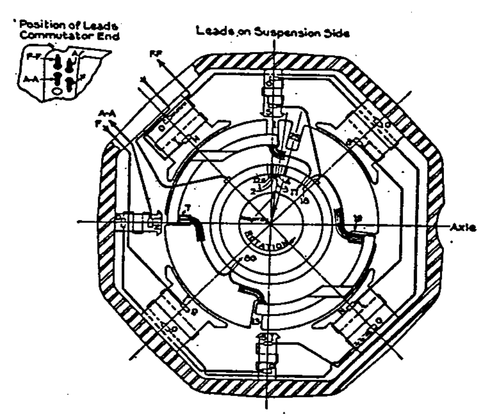
Insulating the Core

The core head insulation need not be removed if found in good condition, but should be given a few coats of G-E No. 458 air drying black insulating varnish. If the insulation is damaged or badly charred, remove it and replace with new core insulation. This core insulation may be obtained ready-cut to shape and in the exact quantity of pieces necessary for reinsulating the armature core of any G-E railway motor. Use G-E No. 462 black insulating varnish when cementing to the core the pieces of cut insulation and the layers of binding tape used in building up the space in forming the coil seat. Finish the surface with at least two applications of G-E No. 458 varnish as directed above. Thoroughly inspect the laminations which constitute the core proper, and repair any uneven or damaged portions so that the slots are perfectly smooth. Any projections of metal into the slots may injure the insulation of the coils when they are assembled on the core.

Rewinding the Armature

Before starting to assemble the coils on the core, locate a commutator bar, the center of which lines up with the center of a slot: call these "bar No. 1" and "slot No. 1" respectively. If, however, the center line of the slot falls on a mica segment, call the bar to the right (facing the commutator) "bar No. 1." Counting to the right from bar No. 1, make the lead connection for the bottom coil in slot No. 1, as shown in the connection diagram furnished for all G-E railway motors. *Be sure to mark this bar,* since the lead of the coil to be placed in slot No. 1 must be connected to it. If the number of conductors per coil is odd, middle lead should be called lead No. 1. In the case of an even number of conductors per coil, the right hand middle lead (facing commutator) will be lead No. 1.

When assembling the coils on the core, place the bottom side of the first coil in slot No. 1 and the top side of the same coil in its respective slot to the left. Then place lead No. 1 in the commutator bar marked as described in the preceding paragraph. Next assemble the coils in succession around the coil, setting the bottom sides of the coils down into the bottoms of the slots and pulling the top sides of the coils back into their proper slots but not setting them all the way down. After about 40 per cent of the coils have been assembled, all of them may be set into the slots as far as they will go.



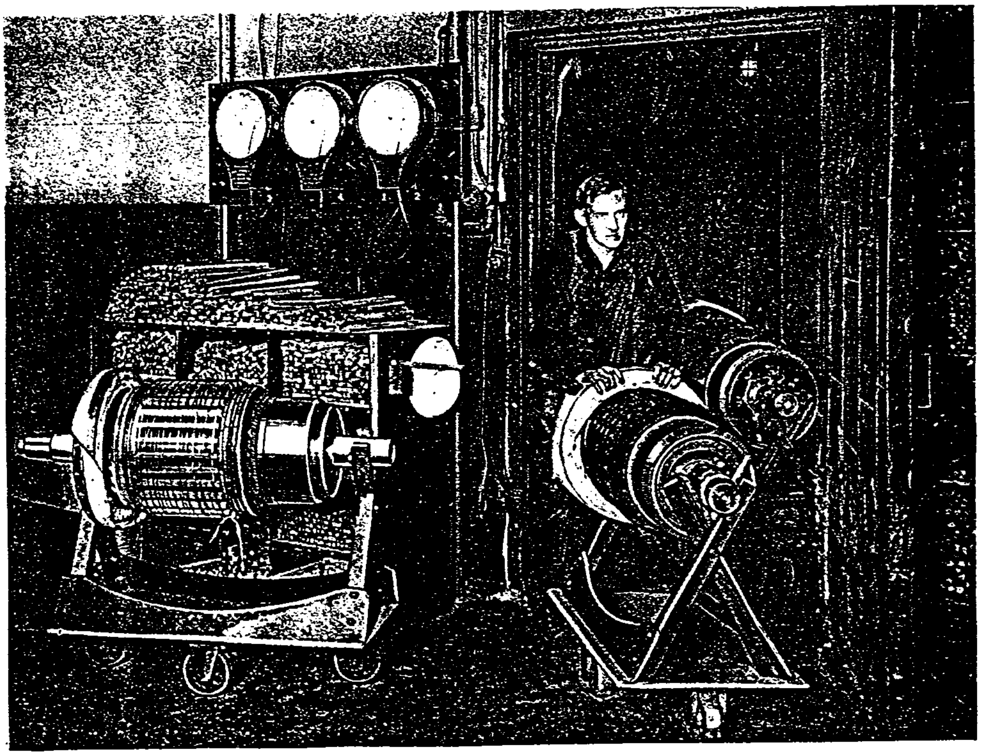
Typical Connection Diagram for G-E Railway Motor Armature

While assembling the coils on the core, place pieces of G-E standard cut insulation between the end windings at both the commutator and pinion ends of the coils. Place other pieces of cut insulation provided for the purpose between the bottom leads and end windings. If necessary, place strips of insulation between the coils in the slots as they are assembled on the core to bring them up slightly higher than the tops of the slots. This is desirable in order that the binding operations as described in the subsequent paragraphs may be readily performed.

Test after Rewinding

After all the coils have been assembled on the core with the bottom leads connected to the commutator, apply a high potential test to ground of approximately 2200 volts, alternating current, for a period of one minute, to the top leads and the commutator. Apply a second bar to bar test of 125 volts, direct current, with a lamp in the circuit, for a period of five seconds and a lead to lead test between the top leads to ascertain that both the windings and the commutator are free from short circuits before proceeding to connect the top leads to the commutator. After making this test, insert the correct pieces of insulation between the top leads and the end windings. Then connect the top leads to the commutator. Follow this operation by soldering all bottom and top lead connections.

The Repair of 600-Volt Railway Motor Armatures



G-E Railway Motor Armature Ready for Temporary Banding

Temporary Binding

In order to insure a tight final binding, it is first essential that a temporary binding be placed on the armature, proceeding as follows:

Place the armature in an oven and heat it to a temperature of approximately 110 degrees Centigrade (230 degrees Fahrenheit). Provide a suitable number of wooden sticks, cut approximately square the width of the coils and as long as the slot portion of the coils. While the armature is hot, wind a temporary band of steel wire over the sticks on the slot portion of the coils at a tension of about 200 pounds, depending upon the diameter of the armature. This operation is clearly shown in the illustration on the following page. Wind another spiral band at a tension of 150 pounds over temporary pieces of pressed board .060 of an inch thick placed over the end windings. The tension should be sufficient to draw the coils down flush with the bottoms of the bar recesses. After the armature has cooled to room temperature, subject it to a high potential test between windings and core of 2000 volts, alternating current, for a period of five seconds.

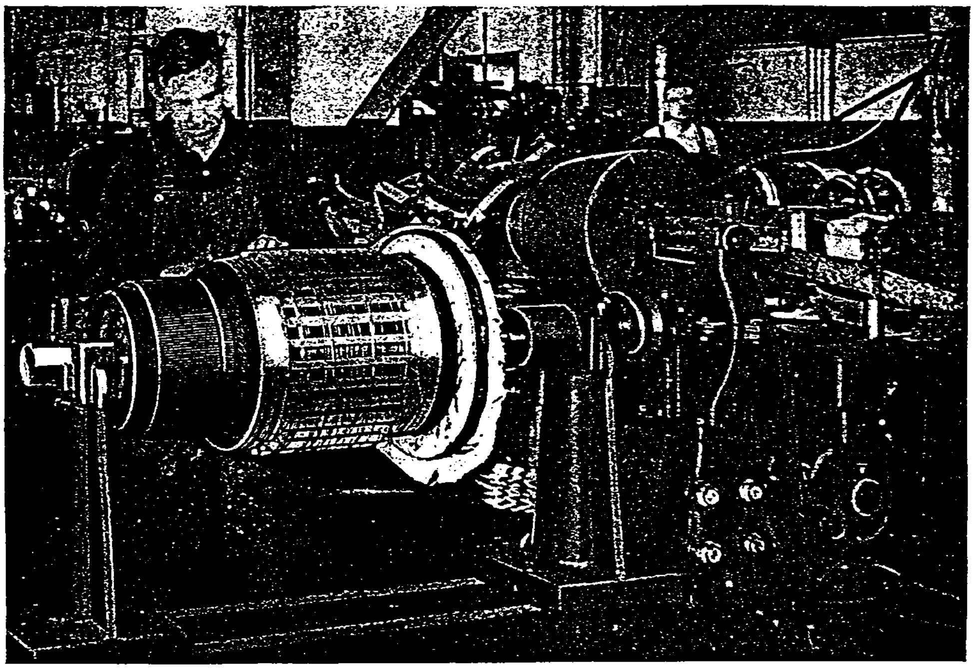
Dipping the Armature

To obtain the best results it is recommended that when rewinding railway motor armatures two dippings of G-E No. 458 black insulating varnish be given before the final binding is applied, unless the armature is to be bound open over the end windings, i.e., the canvas head dressing left off so that the ends of the coils are exposed, except for the insulation directly under the end bands. In this case the armature may be completely bound before dipping. If the armature is not to be bound open, remove the temporary binding before dipping so that the varnish may thoroughly penetrate the end windings and the solvent evaporated when the armature is baked.

Providing the dipping process described in the preceding paragraph is used, operations should proceed as follows:

Heat the armature in an oven to a temperature of approximately 110 degrees Centigrade and while hot dip it in the varnish either in a vertical position with the commutator end up, or

The Repair of 600-Volt Railway Motor Armatures



G-E Railway Motor Armature Showing Temporary Banding

revolve it in a pan of varnish in a horizontal position. After dipping, return the armature to the oven and bake it for a sufficient length of time to thoroughly dry out the varnish. An insulation resistance of at least one-half megohm should be obtained before removing the armature from the oven. After baking, allow the armature to cool to room temperature, then turn and groove the commutator as described in detail on Descriptive Sheet No. 64405. The armature is now ready for the permanent dressing and binding.

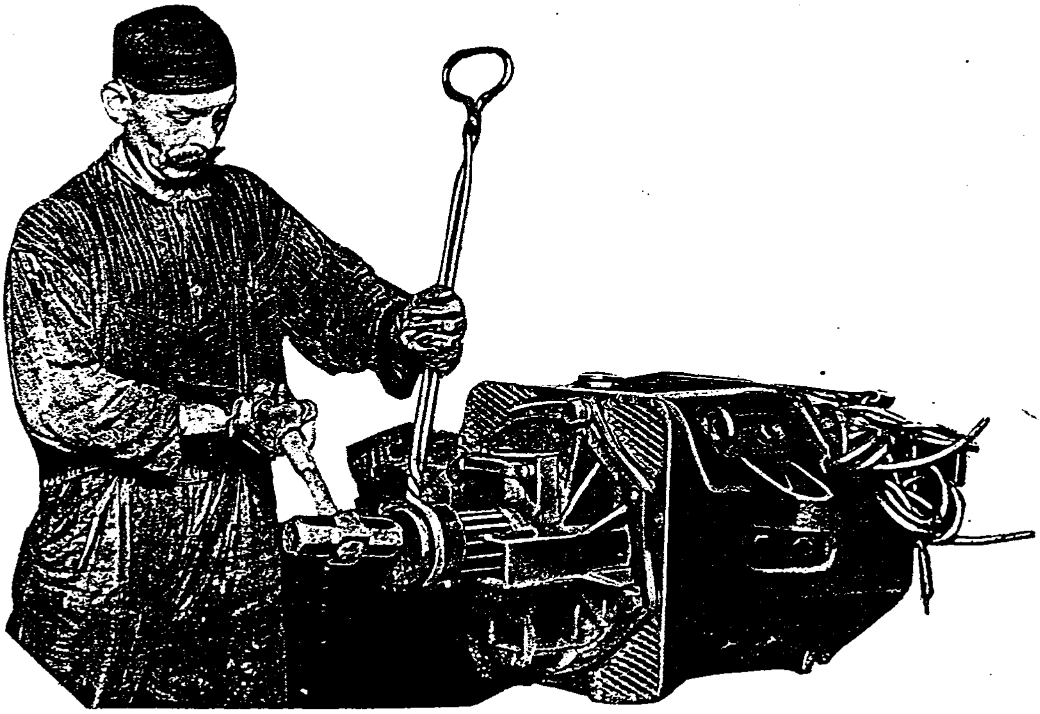
Permanent Binding

Wind strips of duck over both ends of the armature coils. This insulation should extend from the ends of the slot portion of the coils well down to the ends of the coils and be held in place by several turns of tape. Wind one band of varnished cambric tape, one-half lapped, over the end windings. This cambric tape should extend from the straight portion of the coils over the entire end windings, and be held in place by a few turns of Acme tape. Next, place the cloth head dressing over the end windings, pull it tight and hold it in place with binding cord. Wind bands of tinned steel wire over both the head dressing and also over horn fiber strips placed in the band recesses of the core. Apply a tension of about 200 pounds depending upon the diameter of the armature. Fold two clips over each band to hold the wire secure, and solder all bands with pure tin solder. The size of the wire, the number of turns of wire per band, and the number of bands used should be the same as on the original armature.

Finishing

If the front cone of the commutator has been disturbed while making repairs, give its extended surface a brushing of shellac and one wrapping of cotton webbing. Brush this webbing with shellac and iron out dry. Wind the webbing with a treated cord band and brush the whole with G-E No. 462 black insulating varnish, ironing dry with a hot iron. Apply two or three coats of G-E No. 458 air drying varnish and allow to dry. After all winding and binding operations, give the entire armature two or three final coats of G-E No. 458 varnish and allow it to dry thoroughly before assembling in the motor.

Proper Method of Mounting and Dismounting Railway Motor Pinions



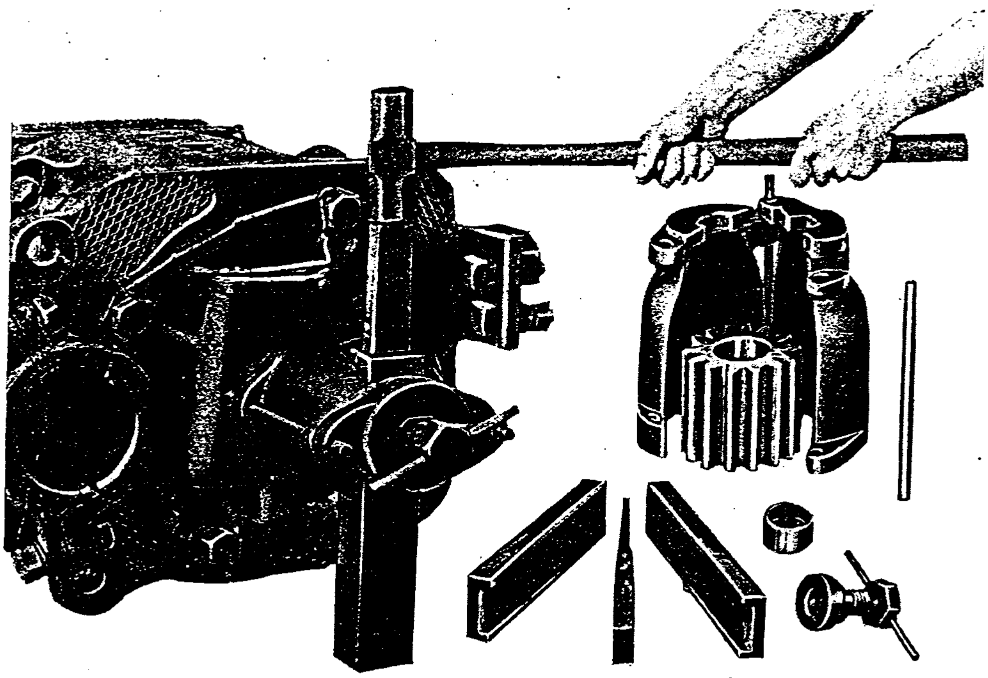
Seating a Small Pinion with a Four-pound Hammer and Metal Shield

Mounting

All grades of pinions, when being mounted, should first be tried on the shaft by hand. The pinion should bear evenly all around the shaft and care should be taken to see that the shaft is not swelled at the sides of the key, which is liable to happen if a too tightly fitting key is driven down on the seat. It is important to have clearance between the top of the key and the pinion, because if the pinion rides on the key, mounting stresses are apt to be localized in the body of the pinion and lead to ultimate fracture. This clearance should not be less than $\frac{1}{64}$ in.

After being tried by hand, and wiped clean, the pinion should be placed in boiling water until heated through. This will take from three-quarters of an hour to an hour depending on the size of the pinion. When hot, the pinion should be immediately placed on the shaft, and firmly seated by striking one blow with a four-pound short-handle sledge. The blow should not be delivered directly on the pinion but on a piece of metal which is held firmly against it. The end of the metal piece should be cupped to clear the threaded end of the armature shaft.

The nut should be tightened up while the pinion is still hot, care being taken to see that the lock washer is properly seated to hold the nut. The pinion should then be hit a second time, one blow, and the nut again tightened, with a wrench not over 3 ft. long. The whole operation should be performed as quickly as possible, before the pinion has had time to heat up the shaft.



Pinion Puller Assembled and Mounted (Left) and Disassembled

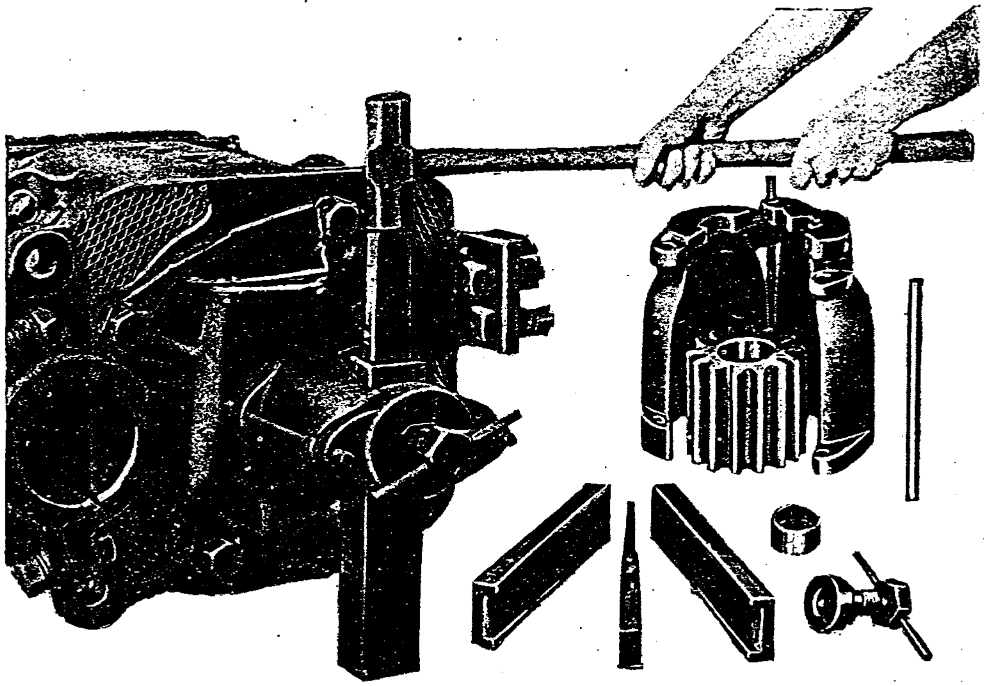
ismounting

When removing the pinion from the shaft, a pinion puller similar to the type shown bove should be used. In applying the puller to a pinion, open it by removing one hinge in using the other as a hinge. Place the pressure cap over the threaded end of the shaft. 'his cap is used on the smaller motors to prevent possible damage to the threads on the haft, and on the larger motors using pinions with deep counterbore, to prevent the vedge box from touching the wheel side of the pinion.

The two halves of the puller ring should then be closed around the pinion. At the ame time, the square sided bushing containing the jack screw should be inserted at mall end of the puller ring. When inserting the bushing, this flanged end should be laced inside the puller ring. The free hinge pin should now be inserted.

Turn the puller ring until its cored openings are in a vertical position and insert the vedge box (with small opening down) through them to the floor. Tighten up the jack crew until the wedge box is held firmly between it and the end of the shaft or pressure ap. Drop the wedge in the tapered opening of the wedge box and strike it a few orceful blows with a sledge having a handle 3 or 4 ft. long. This should be sufficient orce to remove any pinion that has been properly mounted. A pinion which clings very ightly on the shaft may require a few additional blows with the sledge.

Pinion Pullers for Railway Motors

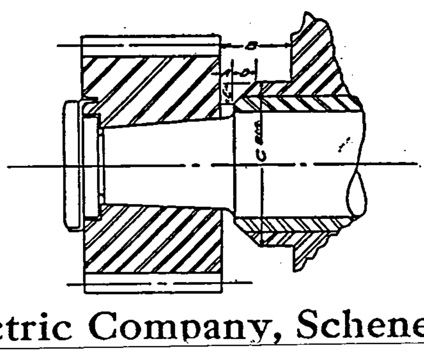


Railway Motor Pinion Puller Assembled (left) and Disassembled

The G-E Pinion Puller illustrated above consists of two half rings, each half being provided with lugs through which hinge pins are placed to hold the halves firmly together. The principle involved in this pinion puller is the old time wedging idea; but in this case the wedge, instead of being used where it can damage bearings and housings, is applied at a place where it can do no damage. The puller ring grips all the teeth of the pinion equally, thereby eliminating the possibility of localizing the removing stresses on a small number of teeth.

The component parts of the pinion puller are the puller ring, the pressure cap, the jack screw, the wedge box, the wedge, and the hinge pins. The wedges, jack screw, etc., are the same for all pullers; the puller rings and pressure caps vary with the diameter of the pinion for which the puller is required. A common ring may be used in some cases for pinions varying only slightly in diameter.

In ordering pinion pullers for G-E railway motors, be sure to specify the type and form of each motor, and the outside diameter of the pinions involved. For other motors, the dimensions indicated in the cut below by the letters, A, B, C, etc., should be given in addition to the outside diameter and face of the pinion.



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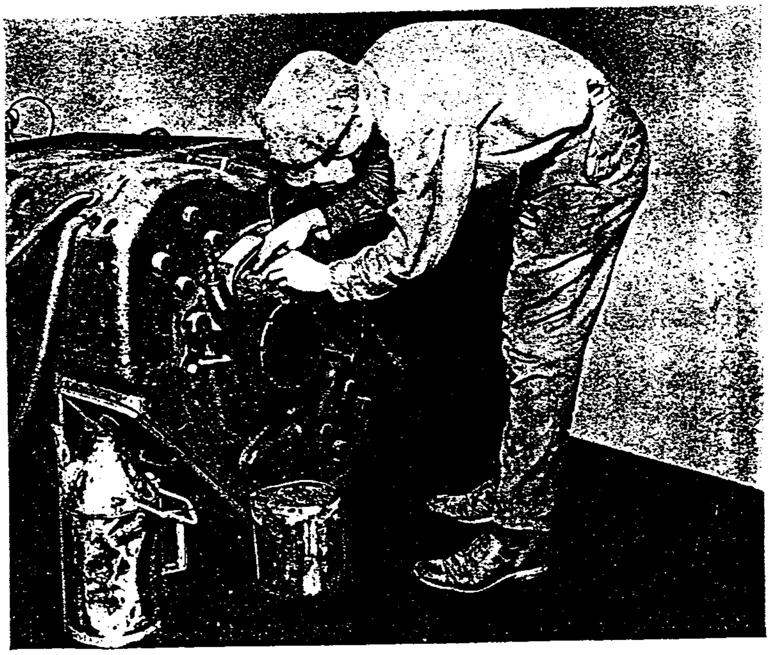
The Care of

RAILWAY MOTOR BEARINGS



Packing a Railway Motor Bearing

Railway motor bearings are all of the sleeve type with the exception of a few small motors which have armature bearings of the ball or roller type. Lubrication is provided by means of waste and oil; *proper lubrication and care of bearings is something which cannot be over emphasized.* In addition to serving their usual function, axle bearings must also support a considerable part of the weight of the motor.

ARMATURE LININGS

The armature linings are carried in motor frameheads which have waste pockets and drain pockets. The standard armature lining consists of a bronze shell lined with babbitt and keyed in the framehead. The babbitt is of such thickness that should the metal melt and run, due to accidental overheating, the armature is prevented from striking the pole pieces by the bronze shell and the armature shaft bearing surfaces are protected from injury. The linings are provided with an opening on one side to allow the oily waste in the pockets to come in contact with the bearing surface of the shaft.

AXLE LININGS

The axle linings of a railway motor are generally of bronze for maximum axle sizes, but malleable iron lined with babbitt is sometimes used for smaller diameters of axle. The two halves are prevented from turning by a clamp fit and are either keyed or doweled. An opening provided in the lining on the low pressure side allows the oily waste in the bearing pockets to come in contact with the axle.

The edges of the openings in the linings are chamfered to assist oil in entering the bearing, and grooves are provided to insure the passage of oil from the bearing surface to the flange which must take the thrust. Every precaution is taken to exclude d[illegible] from the bearings. The bearings are of ample size and with proper care and lubrication should gi[illegible]ng life.

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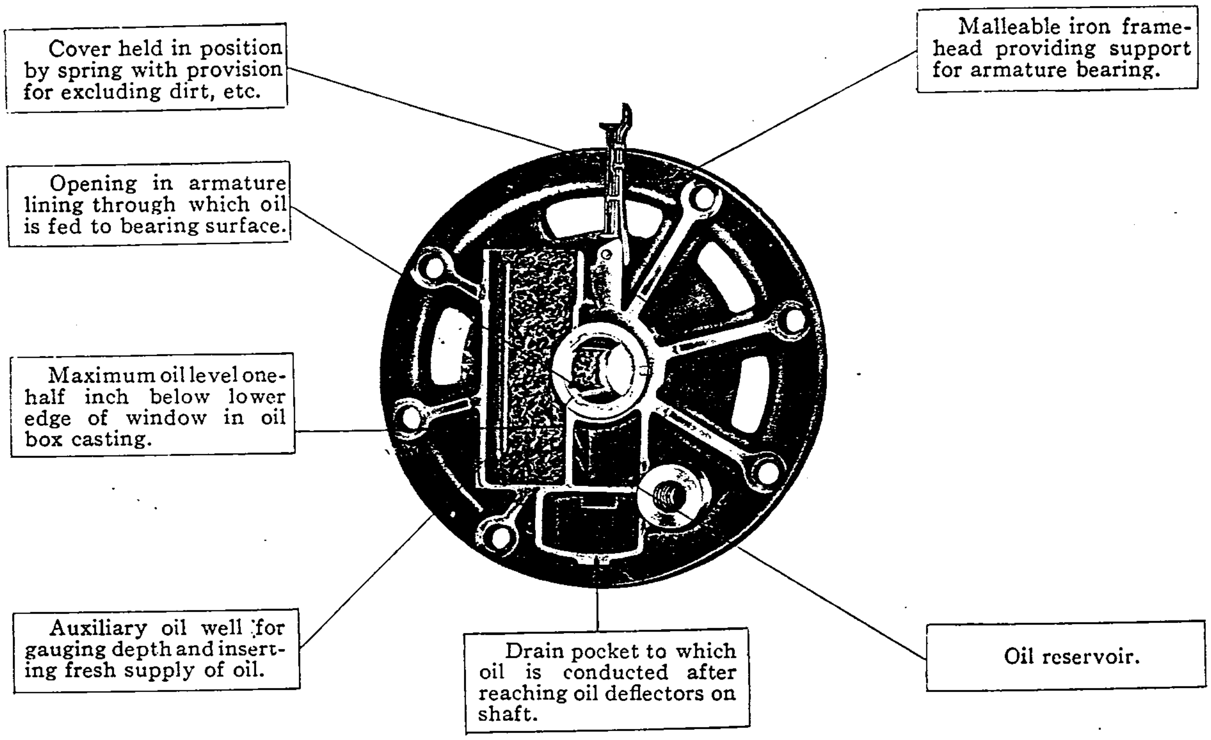


Section Through Oil Box Showing Method of Lubrication

BRASS AND BABBITT LININGS

The material used for lining shells must offer the best bearing surface with the least amount of friction and have sufficient strength and ductility to withstand the severe operating conditions of railway service. The alloy used for brass or bronze shells is composed of copper, tin, zinc, and lead, the proportions of which have been determined after many years of exacting and exhaustive tests.

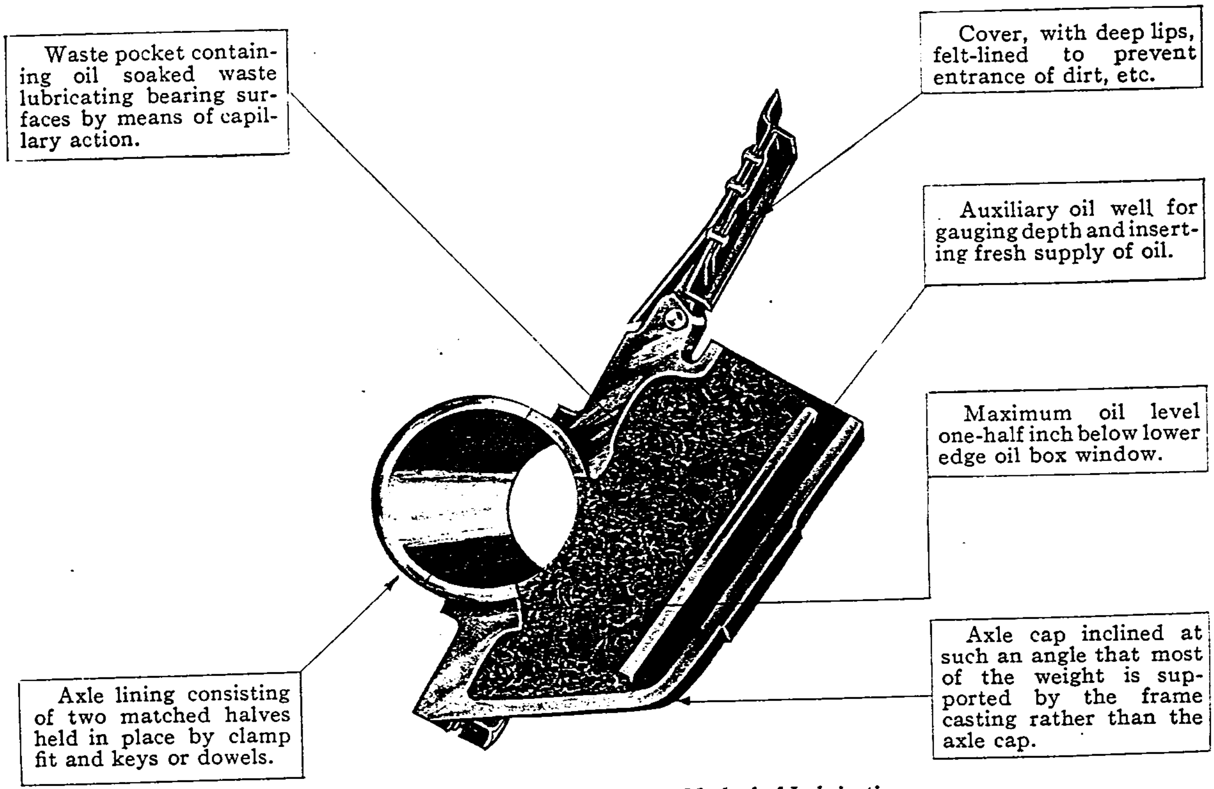
Alloy No. 4 is the equipment standard preferred by many railways for replacements on account of its general recognition as the highest grade bearing alloy obtainable. Alloy No. 80 has been standardized for replacements by many large operating companies and gives nearly as good service as Alloy No. 4 at a considerable reduction in cost.

The composition of these alloys is as follows:

MATERIAL	ALLOY NO. 4	ALLOY NO. 80
Copper	84.0%	78.0%
Lead	0.5	16.0
Tin	12.0	4.0
Zinc	3.5	2.0

Brass and babbitt linings are now almost universally used for armature bearings. This type is preferred to the straight bronze type for the following reasons:

1. A rough or uneven surface due to imperfect machining which might be barely detected will quickly wear out of the babbitt presenting a perfectly smooth bearing surface.
2. When grit or any cutting substance becomes lodged between the shaft and bearings, it imbeds in the babbitt without injury to the shaft, whereas in the bronze bearing, the grit powders and acts as an abrasive lap on both shaft and bearing.
3. All types of linings will run hot on either armature shaft or axle if not properly lubricated. When this trouble develops, the shaft is seldom damaged by the babbitt bearing. In fact, many cases have been noted where the babbitt after running hot and melting or becoming scored on the bearing surface took on a smooth glazed surface by the application of sufficient lubricant without causing the least damage to the shaft. Under similar conditions, the bronze unlined bearings were ruined and invariably damaged the bearing surface of the armature shaft.
4. The babbitt can be held more securely in the brass shell, for it can be sweated in the brass in addition to being anchored by the usual dovetailed grooves. This permits the use of a very thin liner of babbitt or a thickness slightly less than the air gap between the armature and pole pieces. Therefore, in case the lining runs hot and the babbitt melts, the armature cannot rub on the pole pieces without first wearing into the brass shell.



Section Through Axle Cap Showing Method of Lubrication

IRON AND BABBITT LININGS

Cast or malleable iron shells lined with babbitt have been used quite extensively in old type motors. Where provision is made in a bearing for various sizes of shafts, it is customary to use bronze linings either babbitt lined or merely tinned for maximum shaft sizes. For the smaller shaft sizes where more bearing metal is required, malleable iron shells with a thick layer of babbitt cost much less than a straight bronze shell. It is standard practice to use bronze linings for axle bearings except where the thickness of the shell would exceed ⅝ of an inch, in which case malleable iron and babbitt are used.

REBABBITTING BEARINGS

The bearing shells are first rough bored in the dovetailed anchored grooves, slotted through the body and turned in each end. First, clean the bearing lining thoroughly, removing all of the old babbitt and any foreign matter in order to obtain a clean bright surface to which the babbitt will adhere. After cleaning, brass linings should be tinned in a bath of half and half solder (melting point 178 deg. Centigrade) and pour the babbitt while still hot from the tin bath. The best results are obtained by preheating the shell and jig to a high temperature nearly equal to that of the babbitt. The latter will then flow freely into anchored grooves and adhere firmly to the tin surface. Then bore and ream the babbitt shell to size and finish the outside.

Heat the babbitt to a temperature of 500 to 550 deg. Centigrade (but not more than 550 deg. or decomposition of the alloy will take place). The dross which rises to the top of the metal should be cleaned off with a ladle before dipping the babbitt from the kettle. Be sure none of this dross is allowed to get into the bearing.

When pouring armature linings, use nothing but new metal. Under no circumstances mix babbitt from old linings in the pot with the new metal. Babbitt melted from old linings may be used for journal or axle bearings.

A rough estimate of the temperature of the babbitt may be made by dipping a pine stick in the pot. If the metal is hot enough to be poured, it will quickly set the stick on fire. However, the most reliable method is to determine the temperature with a thermometer or with a pyrometer. When babbitting iron shells, it is essential that all of the inner surfaces to which the babbitt must adhere are thoroughly clean. Dovetails are provided in the flange as well as in the body of the shell to anchor the babbitt. Heat the shells to the temperature of the babbitt, place them in jigs and pour the babbitt. Then bore the lining ream to size and finish the outside and ends.

BABBITT

The babbitt used in General Electric railway motor bearings has a tin base composition, the proportions being 83⅓ per cent tin, 8⅓ per cent copper and 8⅓ per cent antimony. This is known as Alloy No. 17 and, not only in regard to the proportions of the ingredients, but also in regard to methods of mixing, handling and the temperature employed, is the result of exhaustive tests over a period of many years.

PROPER OIL LEVELS

The maximum oil level in the bearing pocket should not be above a point one-half inch below the lower edge of the opening in the oil box casting. The minimum depth of oil should not be less than one inch depending somewhat on the shape and size of the waste pocket. The accompanying table indicates the maximum and minimum depths of oil to be carried in armature and axle bearings of some modern G-E railway motors. The bearings should not be filled above the maximum depth or the bearings may be flooded and the oil wasted. The depths indicated are as measured in the auxiliary oil wells. In most cases axle caps are inclined at an angle of about 60–70 deg. with the horizontal, consequently the oil thus measured would not be a true depth. The depths as listed below are as they would appear on a measuring stick placed in the well.

PROPER DEPTHS OF OIL IN INCHES—G-E STANDARD RAILWAY MOTORS

Motor	Axle Bearings Axle Caps		Armature Bearings Pinion End		Armature Bearings Commutator End	
	Min.	Max.	Min.	Max.	Min.	Max.
GE-201-G	1½	3	2	3¾	1	2½
GE-203-P	1	2½	2	3½	1	2½
GE-240-A	1½	3½	2	3¾	1	2¾
GE-247-A-D	1	2¼	1½	2½	1	2½
GE-254-A	1	2¾	1½	3	1	2½
GE-258-C	1	2¼				
GE-263-A	1	2¼	1½	3½	1	2¾
GE-264-A-B	1	2¼	1½	2¾	1	2¼
GE-265-A-C	1	2¼	1½	2½	1	2¼
GE-275-A-D	1½	3	1½	2½	1	2½

METHOD OF PACKING BEARINGS

Successful operation of a bearing and the long life of a lining depend on the maintenance of the film of oil between the two metallic surfaces. As long as the film is unbroken, friction is minimized and heating is avoided. The oil is fed continually to the active surfaces through the waste packing by capillary action. Use live and elastic waste with long threads. Before packing the waste in the bearing, soak it in the suitable grade of oil for at least twenty-four hours. To obtain the best results, the waste should be placed in the pocket, as follows:

String the waste out vertically and pack it lightly but securely in position against the shaft using small quantities and taking care that there are no lumps which will cause vacant spaces; if the oil is to feed correctly, there should be no breaks in the string of waste between the oil supply and the point of contact, for gaps tend to destroy the capillary action.

Auxiliary oil wells are provided in most modern railway motors for replenishing the supply of oil and gauging its depth. Use these wells when renewing the oil supply since they conduct the oil to the bottom from whence it is fed up through the waste, thus avoiding the introduction of dirt to the bearing surface. If no oil wells are provided, press the waste toward the opening in the lining and pour the oil down the outside wall of the pocket. Pouring oil on top of the waste will only crush it down and pack it in too solidly.

INSPECTION

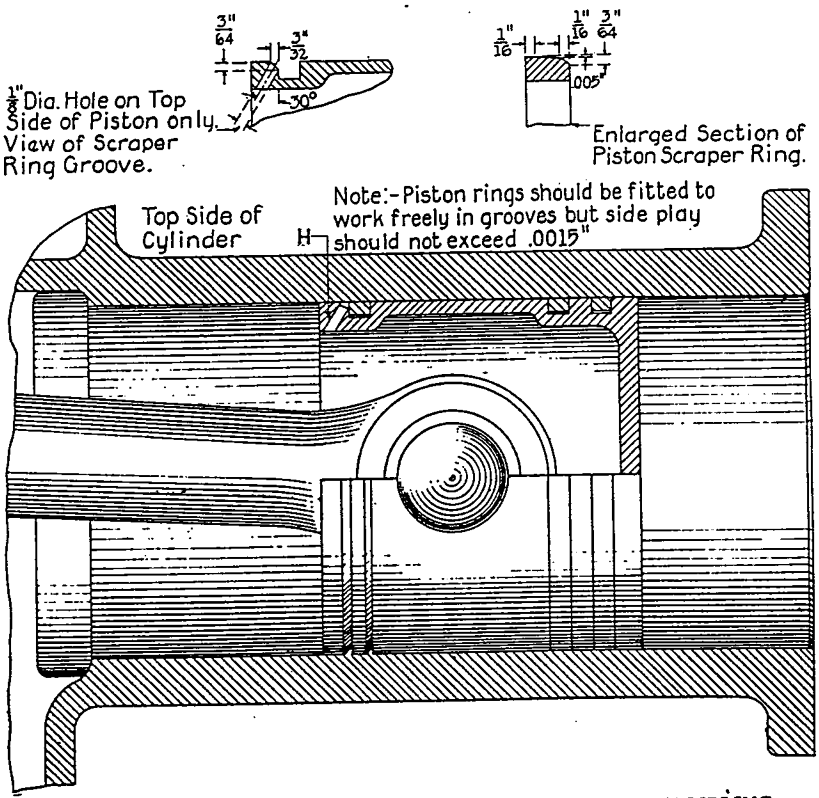
The consumption of oil depends on the mileage made, the condition of the bearings and the severity of the service. The frequency of inspection can best be determined by experience on a particular line, keeping in mind that new equipment should always have careful attention. It has been found to be necessary at intervals of from ten days to three weeks. A few drops of oil may save ten times their cost in babbitt at a critical time. The packing should be turned over occasionally and particular care taken to see that the lining flanges are being properly lubricated.

OIL SCRAPER RINGS
for
AIR COMPRESSORS

DESCRIPTION

The effect of oil in the air lines of electric cars and locomotives on the operation and life of the devices on the lines is such as to make its total exclusion highly desirable.

To insure oil exclusion, G-E air compressor pistons are equipped with a special ring, known as the oil scraper ring, that fits into the groove nearest the crank chamber. The ring is ground with a slight bevel, and has one edge chamfered. Thus it presents a sharp scraping edge to oil on the crank chamber side, and a wiping edge on the other side, effectively preventing the passage of oil.



SECTION THROUGH CYLINDER SHOWING METHOD OF ASSEMBLING OIL SCRAPER PISTON RING ON AIR COMPRESSOR PISTON

INSTALLATION

When assembling the piston with the oil scraper ring in the cylinder, care should be taken to make sure that the small hole (H), at the edge of the ring groove near the open end of the piston is on top in the cylinder. The purpose of this hole is to permit the oil collected in the groove by the ring to drain back into the crank chamber. The scraper ring should be assembled in the groove with the beveled side toward the wrist pin hole, i.e. away from the crank chamber. Mechanical peening on the inside surface of the ring insures a snug and even fit.

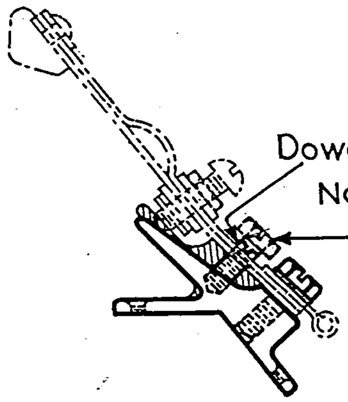
General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Finger Bases For Type K-63 Controller

Cat. No. 1469042, Narrow—For One Finger

Cat. No. 1469043, Wide—For Two Fingers



The Design of These Finger Bases Has Been Changed as Shown By The Above Cross Section. This Improved Base Embodies The Following Features.

1-It allows for a greater and more varied adjustment.

2-It increases the flexilibity of the spring, by substituting a threaded steel dowel, in place of, the cap screw formally used.

3-It facilitates assembly

4-It insures positive contact of the finger, with maximum finger life.

5-It prolongs the life of both spring and finger.

IMPORTANT NOTE:

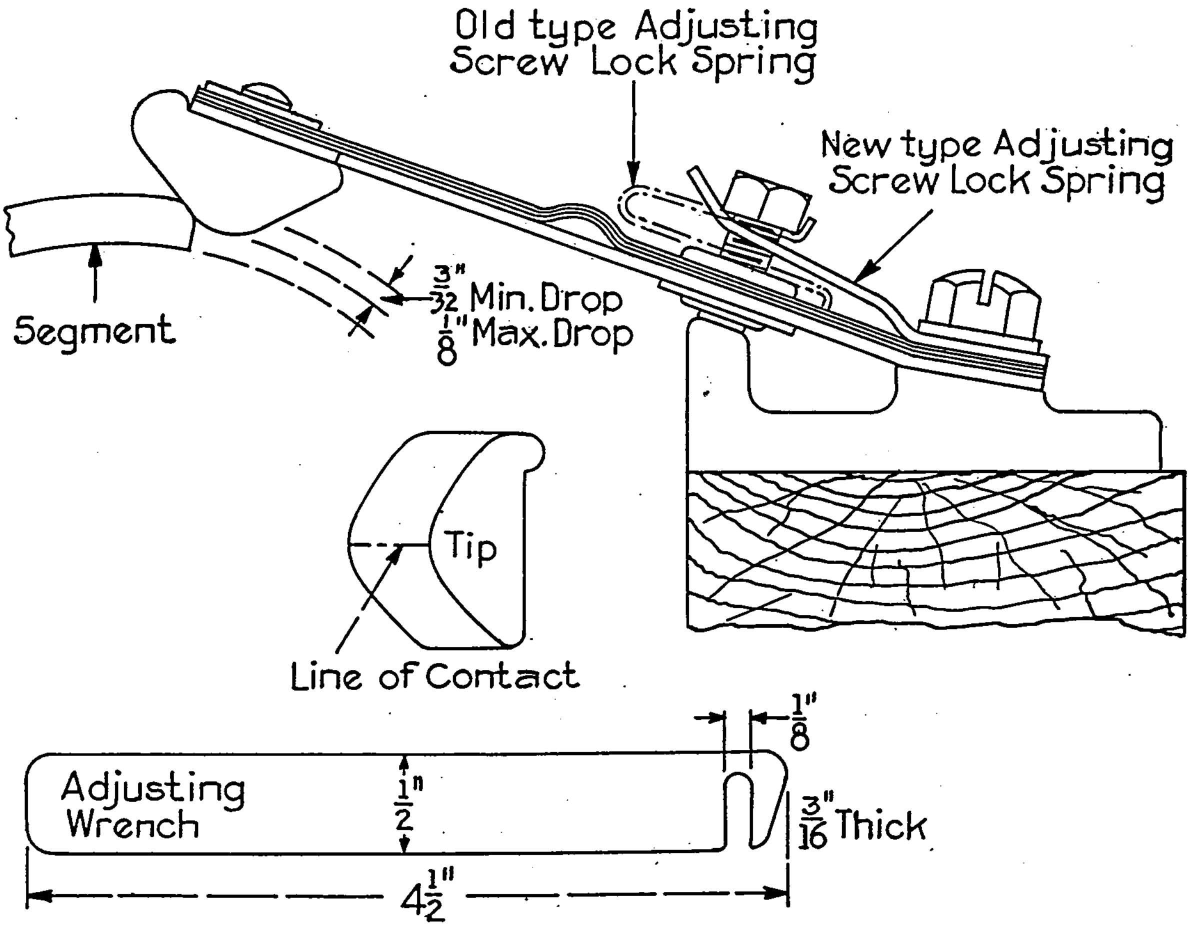
Threaded Steel Dowel Cat. No. 2405283 Must Be Used When Replacing The Old Style Finger Bases.

The Operation of Type K-63 Controllers Now In Service Will be Greatly Improved by Installing These Improved Finger Bases.

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Adjustment
of
Drum Controller Fingers



Each finger of a drum controller is provided with an adjusting screw for limiting the movement of the finger as the tip breaks contact with the segment. This movement should not exceed 1/8 in. at the tip for easy operation of the controller and reasonable wear of fingers and segments, but must be at least 3/32 in. for proper contact. The 3/32-in. movement should be carefully checked in adjusting new fingers to operate on worn segments. If proper adjustments cannot be made, the segments are probably worn out and should be replaced.

The contact line of the finger tip should touch the segment at all points. If contact is not made all along this line, the finger should be twisted until such contact is made. If this is not done, both the finger and segment will overheat, causing the finger spring to soften and lose its tension. An adjusting wrench similar to the one illustrated above is useful in twisting the finger, so that the tip will make proper contact with the segment. This wrench will fit over the finger spring and shunt just back of the finger tip.

The tip should bear on the segment with a 6-pound pressure, measured at the line of contact.

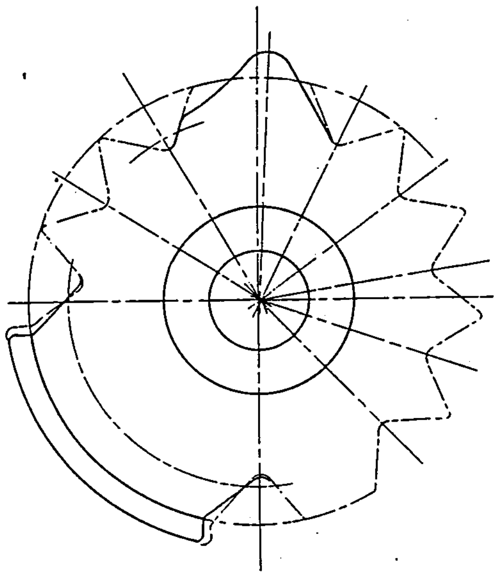
Ask our nearest office for complete information

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Star Wheels for Type K Controllers

Cat. No. 112059 Cat. No. 206286
Cat. No. 206303 Cat. No. 224190
Cat. No. 821020P7



Full Lines Show Changes Made

The design of these star wheels has been changed as shown by the illustration. The catalogue numbers, however, remain the same. The following features are embodied in this improved starwheel:

1. It insures a definite position for main cylinder in OFF and FULL ON positions, independent of stop on cap plate and emergency stops in controller. In each of these positions the stop on handle should just make contact with the stop on cap plate.

2. It provides an emergency stop in OFF and FULL ON positions independent of stops on cap plate.

3. It prolongs the life of the main star wheel, pawl, and hinge pin, by preventing roller from coming in contact with the emergency stop during normal operation.

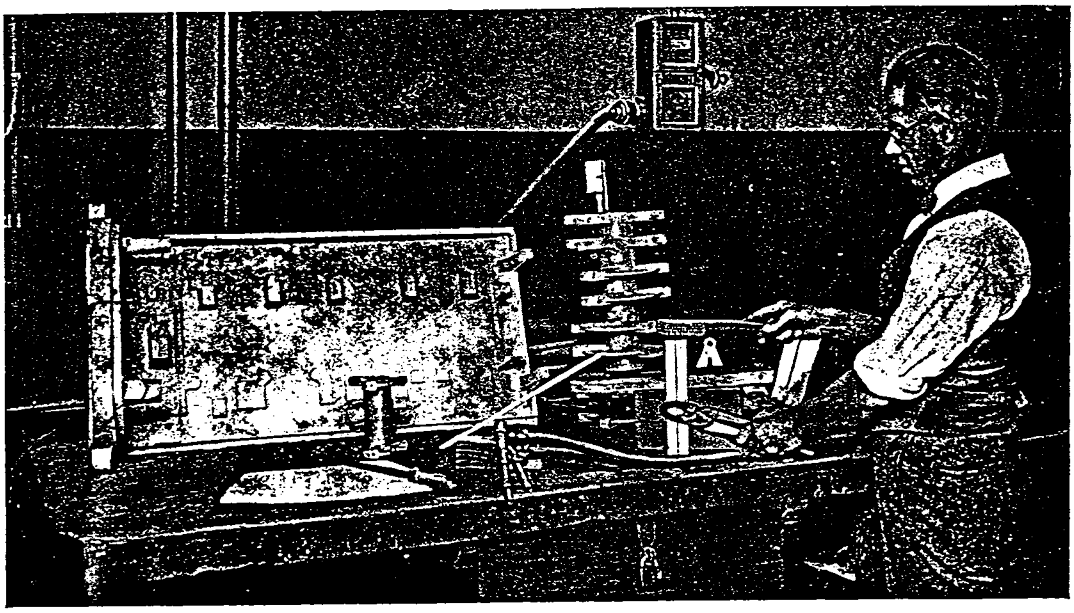
The operation of controllers now in service, using the old design star wheels, will be improved by installing star wheels of the new design. All future replacement orders will be filled with this improved star wheel.

General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

Soldering Aluminum Controller Cylinder Castings

The lugs on aluminum controller cylinder castings sometimes burn off or become broken, and it is often desirable to repair them by building up certain portions rather than making a replacement. These and similar castings are sometimes salvaged by means of welding. Procedure, in this case, is as follows: Fire clay is placed around the part and the lug is built up with $\frac{3}{16}$ in. diameter aluminum rods. This is usually done without removing the section. If necessary, the section may be removed to avoid burning the shaft insulation.



Rubbing in Aluminum Solder with a Wire Brush

Soldering is generally a more satisfactory and economical method of repairing such castings, except in certain cases where salt spray or excessive humidity render the climate particularly severe.

A joint, carefully made by the soldering method, will stand up quite well even under adverse climate conditions. Soldered joints will have a longer life if coated with paint or other protective substance which will exclude air and moisture.

In soldering aluminum the following *general* rules should be observed:

1. The parts to be soldered should be preheated above the melting point of the solder. Aluminum conducts heat readily and if not preheated, chills the solder.
2. Aluminum oxidizes easily at soldering temperatures, forming a thin film of mineral character. This film is not easily fluxed, once it forms, but should be removed mechanically under the first layer of solder. The first "tinning" layer of solder, rubbed into the surface after the oxide has been scraped off, keeps the oxidizing atmosphere away from the aluminum and prevents further oxidation. The subsequent layers of solder serve as a binder between the tinned surfaces.
3. Oxidized solder should be removed from the joint. A dirty joint is always weak.
4. The melting point of aluminum or, to state more correctly, its point of thermal transformation, is not very far above the melting point of the solder. Therefore, care should be exercised so the aluminum will not "burn." However, the danger of "burning" is less than of soldering the joint too cold.

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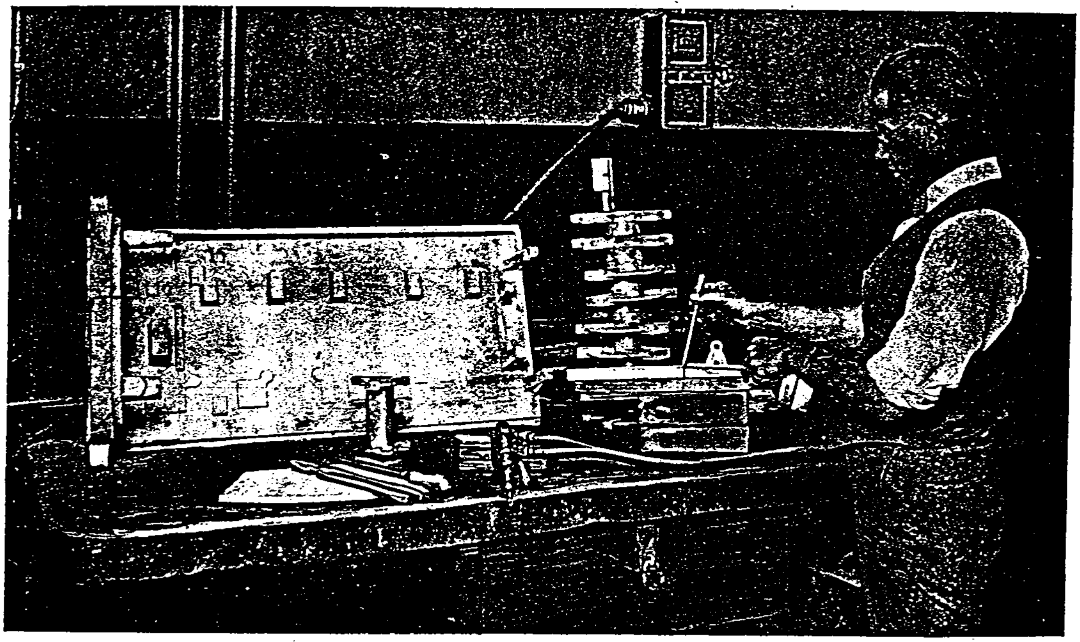


Skimming the Oxide from Aluminum Solder with an Iron Wire

DETAILED INSTRUCTIONS

Heat the parts to be soldered to the fusing temperature of the solder by means of a Bunsen burner or gas blow torch (the blow torch is recommended on account of its better temperature regulation). The temperature of fusing can be determined by applying the stick of solder to the metal. When the solder will flow freely on the surface, the temperature is about right.

Do not apply flame directly to the joint as the aluminum will oxidize especially heavily in the flame. Have the joint surfaces preferably horizontal. When properly heated, apply a little solder to the joint surface and *rub in vigorously* with a wire brush, file carding, or other sharp edged tool, which will serve to loosen the oxide under the solder and cause the solder to flow into the cleansed pores of the metal.

The wire brush rubs the solder into the surfaces, hence the solder must be in such a state that it will flow readily but not be hot enough to melt the upper fibers of the metal. There is a fairly definite temperature range for this work and any departure above or below this range will not secure the best results. After the first coating of solder has been rubbed *sufficiently* into the surface of the metal, more solder is added on both joint surfaces. This solder should melt and flow freely over the joint merging with the first layer. The solder will cover itself with a scum of oxide which should be skimmed off with a *preheated* iron knife or wire. A small wire, $\frac{1}{16}$ of an inch in diameter, pressed into a wood holder will give good results. Copper or brass wire should not be used as it might possibly contaminate the solder. Preheat this wire to above the melting point of the solder to avoid chilling the solder. Bring the two parts of the joint together in place and melt on enough additional solder to fill the joint. Pass the iron wire through the joint crack which procedure should effectively remove all the scale or scum, and allow to cool, holding the parts together if necessary. *Care must be taken to avoid an excess of solder on the joint planes before butting the parts together.*

Where not subjected to salt spray, alkali or humid climate, a solder containing five lb. tin, two lb. zinc, and four oz. of aluminum gives good satisfaction (70 per cent tin, 27 per cent zinc, 3 per cent aluminum).

Zinc-tin or zinc-tin-aluminum solders which are on the market may be used, such as 70 per cent tin, 30 per cent zinc or 54 per cent tin, 36 per cent zinc, 10 per cent aluminum. Aluminum in the higher percentages adds to the strength, but raises the melting point and makes the solder correspondingly sluggish.

Tin-zinc solders may be made by adding preheated tin to molten zinc. Tin-zinc-aluminum solders may be made by adding molten aluminum to the molten tin-zinc.

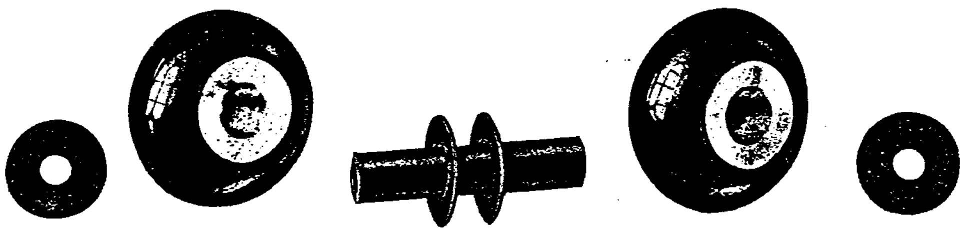
The strength of a butt-joint made carefully with these solders will show about the same strength as half and half solder and brass.

The melting point of these solders (except with aluminum above 3 per cent) is about 180 deg. to 200 deg. Centigrade.

PORCELAIN BOLT INSULATORS

For Railway Service

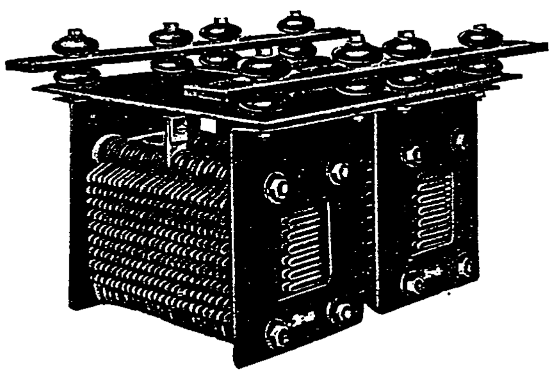
The porcelain bolt insulators described herein were developed primarily to provide a satisfactory and dependable means for insulating and supporting car resistors. They are also found suitable for additional applications, such as supporting contactors, reversers, circuit breakers, fuse boxes, and similar devices, on cars and electric locomotives. The insulator unit consists of two porcelain spools, four fibre packing washers, and a bakelite insulating tube.



Complete Insulator Unit—Disassembled

One of the principal difficulties to be met in the service for which these insulators are made is the accumulation of dirt, metallic dust, etc., to which they are subject. This, in conjunction with heat and moisture, tends to impair the dielectric strength of many materials, by carbonization, besides rendering the insulators themselves liable to destructive arc-overs. While these conditions cannot be avoided, their effects can be minimized by the proper selection of materials for, and the construction of, the insulators.

In the insulators under consideration, thorough attention has been given to both these points. Porcelain has been selected as the material for the spools, because it will not carbonize, even when subjected to a long standing accumulation of car brake dust, etc. As a further protection, the surface of the spools is highly glazed, making it difficult for dirt to settle on them, and rendering them easy to clean. Furthermore, the shape is such that they offer a long creepage surface, thus reducing the possibility of arc-overs. A fibre packing washer is inserted between the support and the porcelain to equalize the pressure between them.



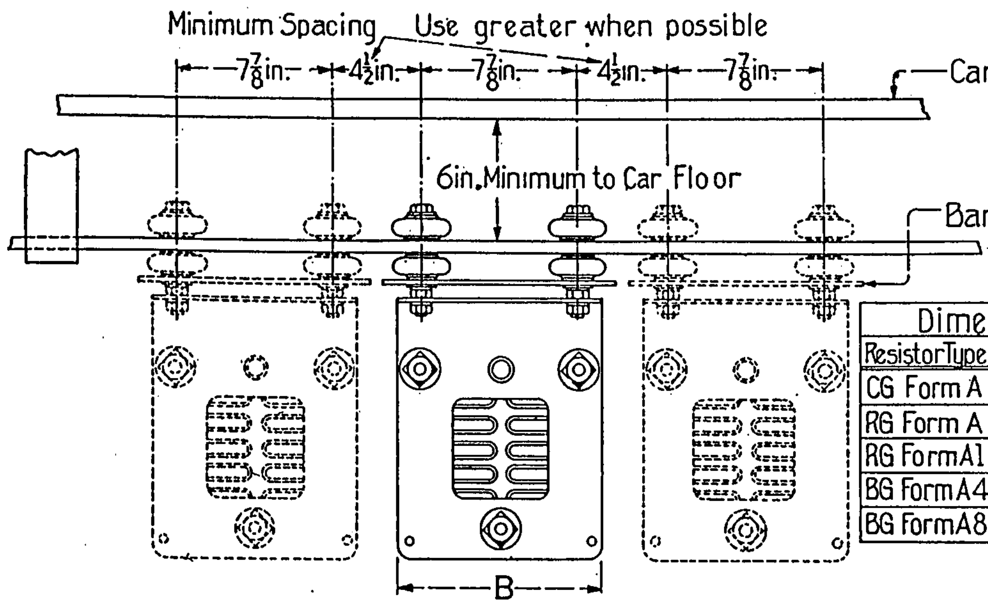
Showing Method of Supporting Resistors

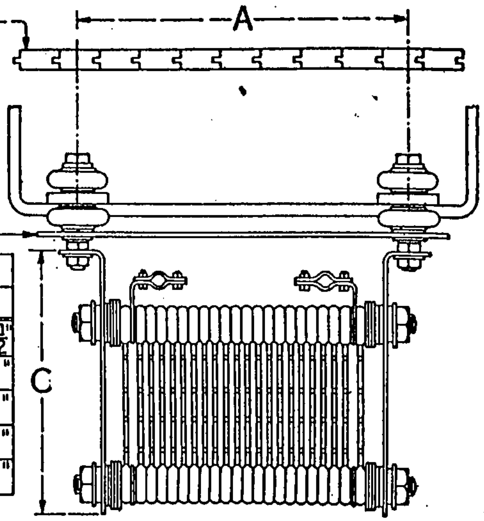
The catalog numbers in the following table apply to the complete unit. Bolts and nuts are not furnished because of the varying thickness of supports used.

Voltage	Size of Bolt in in.	Cat. No.	Net Wt. in Lb. (Approx.)
600	½	1803472G1	1
1500	½	1949194G2	2

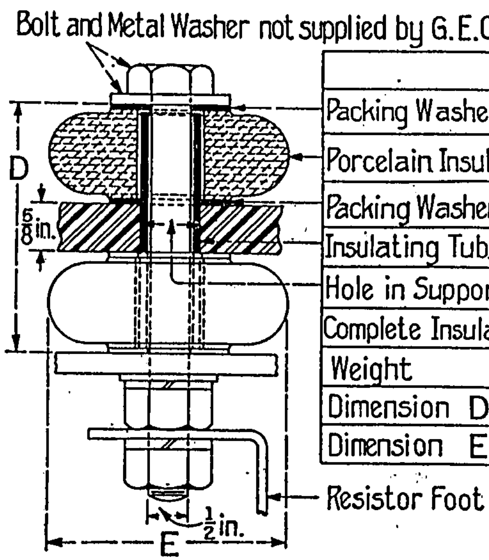
General Electric Company, Schenectady, N. Y.

SALES OFFICES IN ALL LARGE CITIES

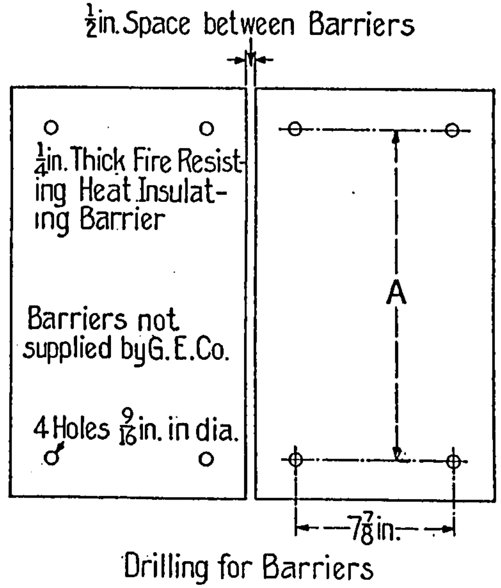




Dimensions			
Resistor Type	A	B	C
CG Form A	$16\frac{1}{2}$"	$10\frac{3}{4}$"	$13\frac{1}{2}$"
RG Form A	$16\frac{1}{2}$"	$10\frac{3}{4}$"	13"
RG Form A1	$23\frac{1}{8}$"	$10\frac{3}{4}$"	13"
BG Form A4	$16\frac{1}{2}$"	$10\frac{1}{4}$"	13"
BG Form A8	$23\frac{1}{8}$"	$10\frac{1}{4}$"	13"



	600 Volts	1500 Volts
Packing Washer	Cat. No. 1435581	Cat. No. 1435581
Porcelain Insulator	Cat. No. 450869	Cat. No. 450880
Packing Washer	Cat. No. 1435582	Cat. No. 1435796
Insulating Tube	Cat. No. 1803472P4	Cat. No. 1436075
Hole in Support	$\frac{13}{16}$ in.	$\frac{15}{16}$ in.
Complete Insulator	Cat. No. 1803472G1	Cat. No. 1949194G2
Weight	1 lb.	2 lb.
Dimension D	$3\frac{3}{8}$ in.	$4\frac{1}{8}$ in.
Dimension E	3 in.	$3\frac{1}{2}$ in.



Dimensions and Application of Porcelain Bolt Insulators, 600- and 1500-volt Service

The Initials of a Friend