Principles of Car Lighting by Electricity

A Discussion of Various Methods and Tools Used in Locating Troubles in Generators and Other Equipment

By C. W. T. Stuart

AT large and congested railroad terminals it is not an easy matter for an electrician to persuade a train director to drill a car out of a regular run for electrical repairs. Usually, if the generator fails, the removal of the belt is suggested, or, in case of a total failure, that is, both generator and battery, the emergency candle lamps are pressed into service. This, no doubt, assists the train director to keep trains moving on time, but on the other hand, it gives the car lighting department a lower percentage of efficiency.

For example, the efficiency of electric car lighting is figured on the number of car arrivals with lights o. k.

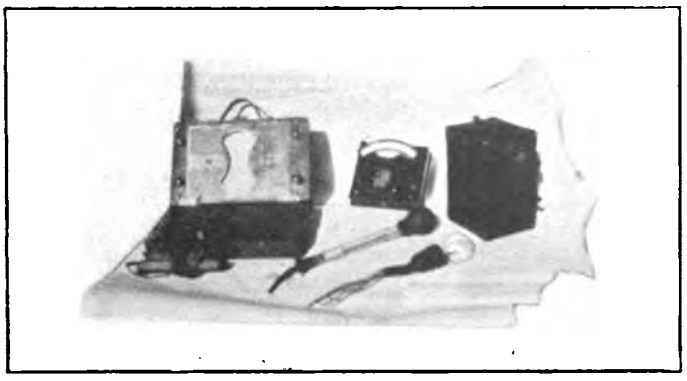

Fig. 1—Group of Testing Instruments Consisting of a Voltmeter, Ammeter, Magneto, Hydrometer and Test Lamp

over the total car arrivals. If a car arrives at a terminal with a defective car lighting equipment and is drilled out of service and repaired, the failure list would only show one failure due to that particular defect, but if this same car is not drilled out of service and repaired, until after it has made ten trips, then the failure list would show ten failures due to a single defect in this individual car lighting equipment.

Therefore the electrician at a terminal, in an effort to keep down the number of car lighting failures, must have some quick method of not only locating trouble, but also of making repairs.

A car lighting equipment consists of a number of parts connected by wires and operating as a unit. Each part has its function and therefore may be tested individually. The five instruments that are used in testing are magneto, test lamp, voltmeter, ammeter, and hydrometer. See Fig. 1.

The cadmium test piece and thermometer used in testing battery capacity have been described and demonstrated in a previous article and will be omitted in this article to avoid confusion.

Most inspecting and testing is made with the car standing, when the generator is inoperative. In this position, the current to the lights is furnished by the storage battery. Upon the arrival of a car, the inspector switches on the lighting circuits thereby placing a discharge load on the battery. He then inspects the individual lamps and fans in the various circuits throughout the car.

By this time, the battery voltage has had an opportunity to settle and the inspector takes a voltage reading across the two battery wires and the two lighting circuit wires at the switchboard.

The battery voltage reading at this point for a 16 cell lead battery should be approximately 2 volts per cell or a total of 32 volts, and for a 25 cell Edison battery approximately 1.28 volts per cell or a total of 32 volts, when the battery is fully charged and with fair sized lamp load. The lamp voltage on cars equipped with a lamp regulator should read approximately 2 volts less than the battery voltage. If it is more the lamp regulator is out of adjustment (and should be adjusted by placing the battery on charge). The inspector then inspects the generator regulator coils and if they are warm it is an indication that the generator has been operating and if the generator belt and pulleys are o. k. he passes on to the next car.

The yard electricians have more of an opportunity to inspect the equipment when the trains are backed into the yards for cleaning, ice water, etc. A yard electrician receiving a car with a defective lighting equipment would first turn on all lighting switches and take a voltage test at the switchboard. If the battery voltage is o. k. and the lamps do not burn then he proceeds at once to find the trouble on the lighting circuits. On the other hand, if the battery voltage is low he would proceed to the battery compartment and take an individual cell voltage and hydrometer reading and examine the battery fuses and connections. Not finding any defect in the battery other than a discharged condition, the next step would be to place the battery on charge and inspect the generator and regulators. Trouble on a generator or regulator can usually be located by giving the generator what is known as the motoring test. This test consists of removing the belt from the pulley and operating the generator as a motor from the battery by closing the automatic switch by hand. The machine is started with full field and is brought up to the maximum speed by increasing the field resistance with the carbon pile on the regulator panel. At maximum speed the field resistance is suddenly reduced to a minimum and the automatic switch released. The momentum of the armature revolving in a strong magnetic field causes the automatic switch to close automatically indicating that the machine is acting as a generator. The ground test of the entire system is taken by grounding first the positive and then the negative brushes of the generator to the generator frame with a small piece of wire while the lights are burning and the generator turning over as a motor. The motoring and ground test will sometimes, but not always, locate the trouble.

If the motoring test fails to show the source of trouble,

then the two circuits, that is, the armature and field circuits should be tested individually.

The armature and main generator circuit is connected in series with the battery circuit and may be traced through the regulator, generator, and connecting wires. A quick but crude way of testing this circuit is to remove the generator fuse, close the automatic switch and then flash the circuit by rapidly inserting and removing the generator fuse. An arc upon removing this fuse will

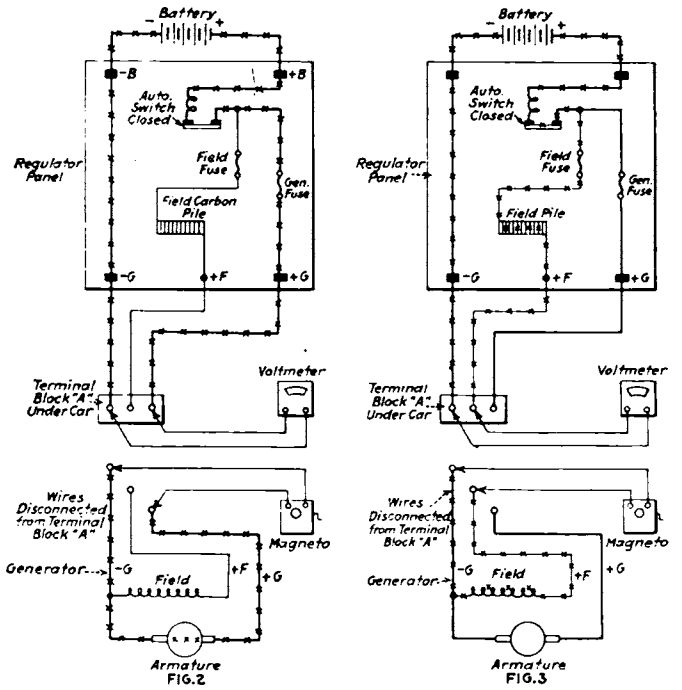

Fig. 2—Testing Armature Circuit with Voltmeter and Magneto from Under Car

Fig. 3—Testing Field Circuit with Voltmeter and Magneto from Under Car. Circuits Through Which Magneto and Voltmeter Current Pass Are Marked with Crosses

indicate a closed circuit and vice versa. This operation will blister the fuse clips therefore it is well in making this test to have a small knife switch mounted on a set

Fig. 4—General View of Battery Repair Room

of fuse blades arranged in place of the generator fuse so that the switch blades take the arm instead of the fuse clips. Upon inspecting an armature circuit for defects not the following: That the generator fuse is not blown, that all connections are tight, commutator is clean and brushes making good contact. If the commutator is rough and burned, it is usually due to either short brushes, dirty brushes sticking in the brush holders or

Fig. 5—Lifting Irons Carrying Set of Edison Batteries

high mica between the commutator segments. Flat spots in the commutator are usually caused by open armature coils. Also note that the armature is not grounded by

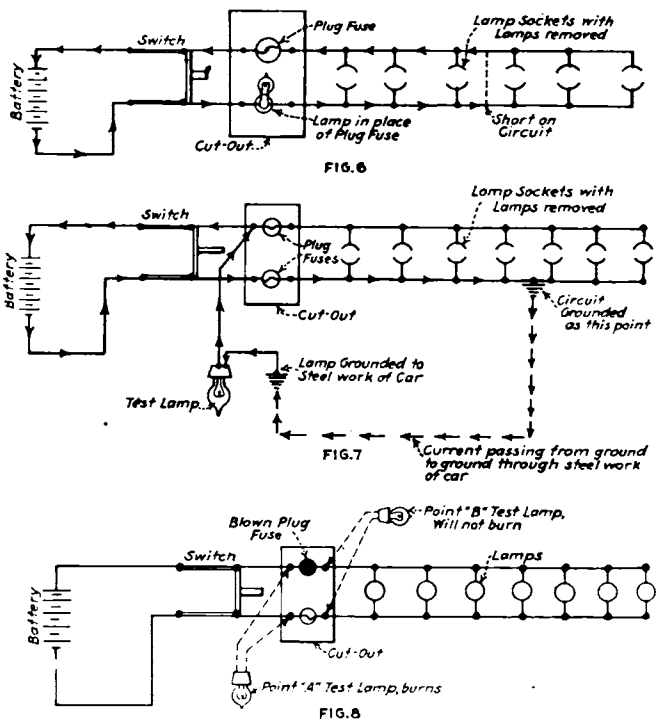

Fig. 6—Locating Short Circuit by Having a Lamp Burning Through the Short as an Indicator

Fig. 7—Locating Ground by Having Test Lamp Burning Through Ground as an Indicator. Path of Current Shown by Arrows

Fig. 8—Locating Open by Use of Test Lamp

testing with the magneto from the commutator to the armature shaft or armature core.

The field circuit may be traced through the regulator, the generator and the connecting wires. This circuit includes the field carbon pile, field fuse, and field coils. A quick way of testing this circuit is to remove the generator fuse, close the automatic switch, and then remove the field fuse. If there is an arc at the fuse clips

when the field fuse is removed, it will indicate a closed circuit and vice versa. Upon inspecting a field circuit for defects the following should be noted:

That the field fuse is not blown.

That all connections are tight.

That the field carbon discs are clean and that none are missing.

That each field coil is producing a magnetic field of the correct polarity.

The last named may be ascertained by connecting, with the armature removed, and the field coils energized, the adjacent pole shoes with a piece of bar iron. Like poles will repel each other while unlike poles will attract, therefore if the field coils are connected properly the adjacent poles will be unlike and there will be a strong attraction when connected through the iron test piece.

In an effort to locate a ground or open in a field or armature circuit, the circuits may be divided into two sections at the terminal block under the car. The three generator wires may be disconnected from the terminal block and the circuits tested to the terminal block with a voltmeter, and from the terminal block through the interior of the generator with a magneto. To make this test, disconnect the three generator wires at the terminal block under the car, close the automatic switch and take a voltage test at the terminals across the field and generator wires, as shown in Figs. 2 and 3. A voltage reading at this point indicates that the armature and field circuits are closed through the generator regulator and connecting wires to the terminal block and vice versa.

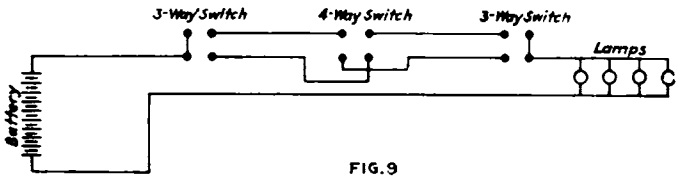

FIG. 9

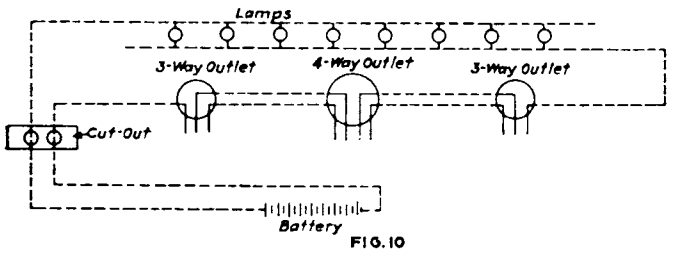

FIG. 10

Fig. 9—Diagram of Three and Four Way Circuit

Fig. 10—Diagram of Three and Four Way Circuit Showing Lamps Overhead, Battery Under Car and Wires Protruding at Switch Outlets

Then the field and armature circuits inside the generator may be tested with a magneto across the three wires that are disconnected from the terminal block and lead into the generator, as shown in Figs. 2 and 3. A ring of the magneto across the wires at this point will indicate a closed circuit and vice versa.

In locating trouble on a car lighting equipment, the lifting coil, the voltage regulating coil, and the lamp voltage regulating coil circuits should be tested also. Each circuit includes a resistance unit in series with the coil and by energizing the circuit, accomplished by closing the automatic switch, turning on the lamps, etc., a closed circuit will be indicated by the heating of these respective resistance units.

A cell voltage reading frequently indicates a dead cell, but that does not always mean that such a cell is defective because the efficiency of the individual cells in a battery

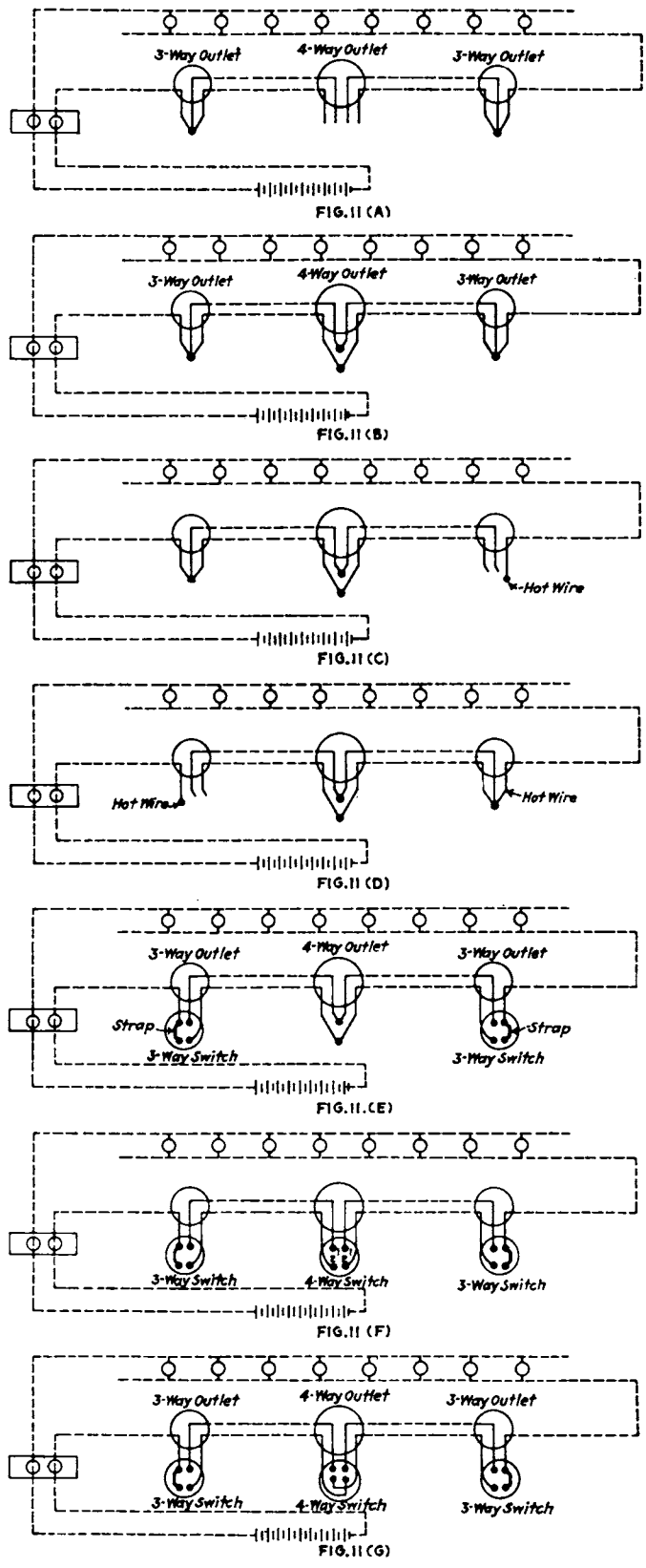

Fig. 11—(A) Tie the Three Wires Together at Each Three Way Switch. (B) Tie the Wires at the Four Way Outlet in Two Pairs. (C) Pick Up Hot Wire at Three Way Outlet. (D) Pick Up Hot Wire at Second Three Way Outlet. (E) Connect Wires to Three Way Switches, Connecting the Hot Wire to the Strap at Each Switch. (F) Connecting Wires to Four Way Switch. (G) If Switches Do Not Operate Correctly, Cris-Cross One Pair of Wires at the Four Way Switch.

vary, that is, one cell will reach a state of full charge or discharge ahead of another, etc. Therefore, when an individual cell voltage reading of a lead battery shows five cells dead and the others reading around 1.8 volts per cell, would not necessarily mean that these five cells were defective. It may have been that this particular battery

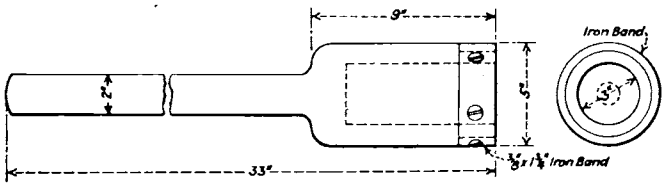

Fig. 12—Wooden Leg for Use in Removing and Applying Armatures

was permitted to remain in a discharged condition for some time and that these five cells were sulphated heavier than the others, thereby requiring the additional charging to break down the sulphate. The proper thing to do in this case would be to place the battery on charge for a time and then take another cell voltage and hydrometer reading on discharge. If the cell voltage did not rise during the charge then there is no doubt that the cells are defective and should be repaired.

Defective cells should be taken to a battery repair room, as shown in Fig. 4, the covers taken off and the elements removed from the tanks. Sediment is washed out of the

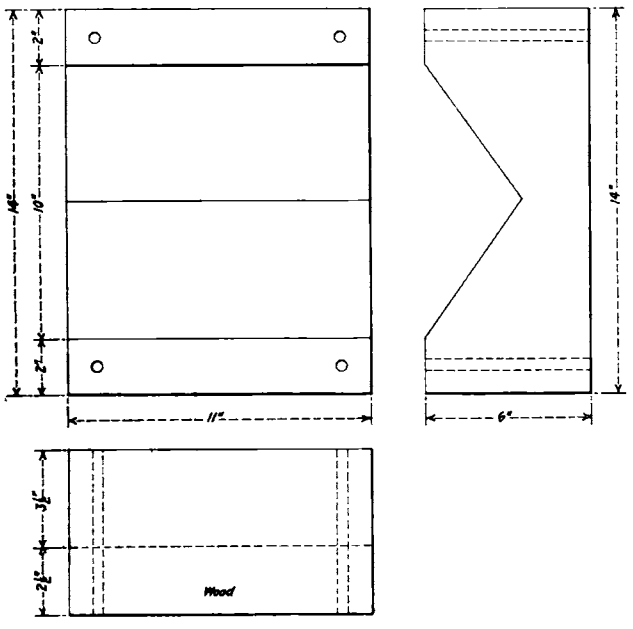

Fig. 13—Block for Supporting Armature on Truck and Work Bench

bottom of the tank. Positive and negative plates are also washed and separaters and insulators should be inspected and renewed if found defective. The plates if buckled should be straightened and the cells reassembled. In an emergency a defective cell may be shunted out of circuit without having any serious effect other than lowering the voltage to the lamps when the car is standing and current is being supplied from the battery. This, however, should not be practiced when it is possible to change the crate.

A dry cell, that is, one from which the acid had leaked out through a small hole in the lead tank, would open the battery circuit. In this case, upon switching on the lighting circuits the lamps would not burn due to the circuit being open at the dry cell. The cell voltage reading in this case would be normal until you reached the dry cell and then you would get a full voltage reading, because instead of placing the voltmeter across one cell as intended you would have it across the opening in the battery circuit. It is therefore very important when taking a cell voltage reading in an effort to locate a dry cell that the voltmeter leads are connected to the high and not low scale of the voltmeter.

Should a battery arrive with an open circuit due to a wire connector breaking off at a battery post, it may either be repaired in the battery house with the lead burning outfit or at the car with the burning arc which will be described further on in this article.

Fig. 14—Care Should Be Used in Transporting Armature on the Truck

A cell voltage reading of an Edison battery would be taken in a similar manner to that of the lead battery, but when a defective cell is found it is replaced by one from stock and forwarded to the Edison factory for repairs. The care of the Edison battery in the railroad battery repair room is limited to cleaning, painting, oiling, flushing, renewal of solution and charging. Fig. 5 shows a set of Edison car lighting batteries in a battery repair room in the act of being painted by the dipping process.

Testing for Grounds, Shorts and Opens

Trouble on a lighting circuit is usually, a short circuit, a grounded circuit or open circuit.

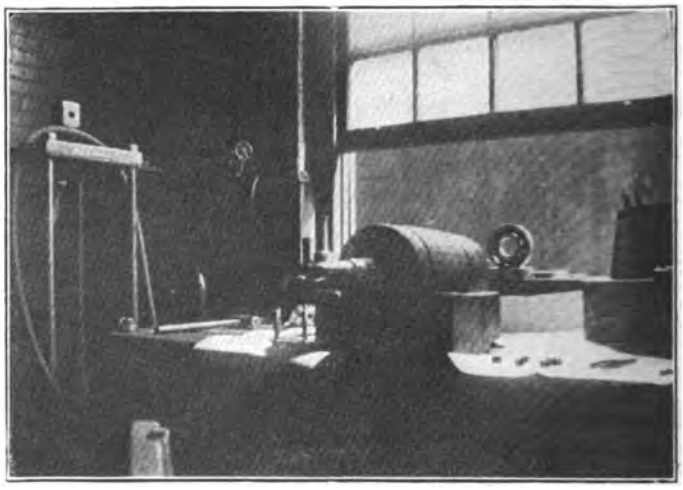

Fig. 15—A Wood Block Makes a Good Armature Support on the Work Bench

Short Circuit: A method of locating a short on a lighting circuit is as follows:

First—Remove the lamp from each socket in the circuit.

Second—Screw a lamp in the branch block in place of the blown plug fuse.

Third—Turn the circuit switch to the "on" position and the lamp will burn by receiving the flow of current through the short in the circuit as shown in Fig. 6.

Fourth—Disconnect each fixture and branch of the circuit and the lamp by failing to burn will be an indication that the short has been removed from the circuit.

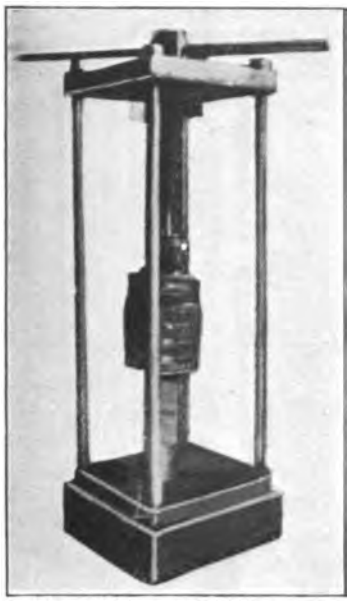

Fig. 16

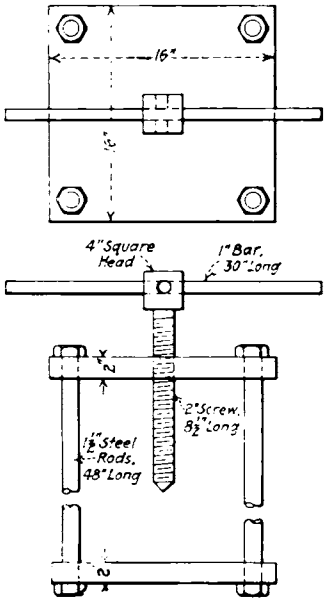

Fig. 17 (a)

Figs. 16 and 17(a)—Armature Hand Press

Grounded Circuit: A method of locating a ground on a lighting circuit is as follows:

First—Remove the lamp from each socket in the circuit.

Second—Connect a test lamp at the switchboard. Connect one side of the lamp to the side of the circuit that is not grounded and ground the other side of the test lamp to the steel work of the car.

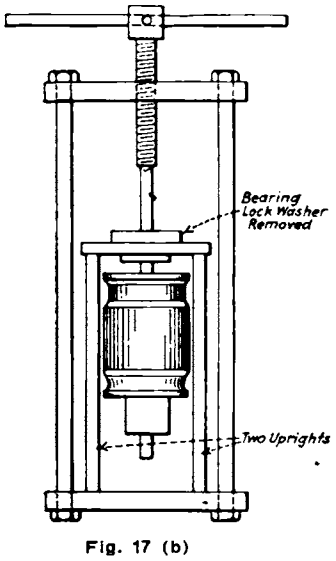

Fig. 17 (b)

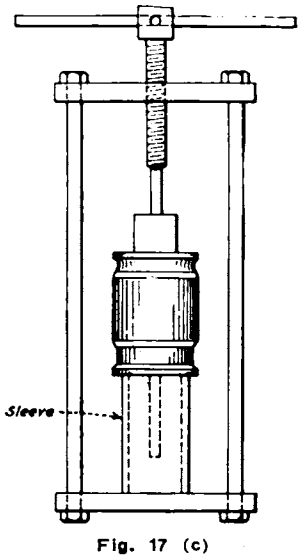

Fig. 17 (c)

Fig. 17(b)—Pressing Pulley End Bearing Off the Shaft
Fig. 17(c)—Pressing Shaft from Armature

Third—Close the lighting circuit switch and the test lamp will burn by receiving the flow of current through the ground in the circuit as shown in Fig. 7.

Fourth—Disconnect each fixture or branch of the circuit, and when the grounded section is removed from the circuit, the test lamp will indicate same by failing to burn.

Open Circuit: A method of locating an open in a lighting circuit is to test the circuit at various points throughout its entire length, starting at the switchboard with a test lamp.

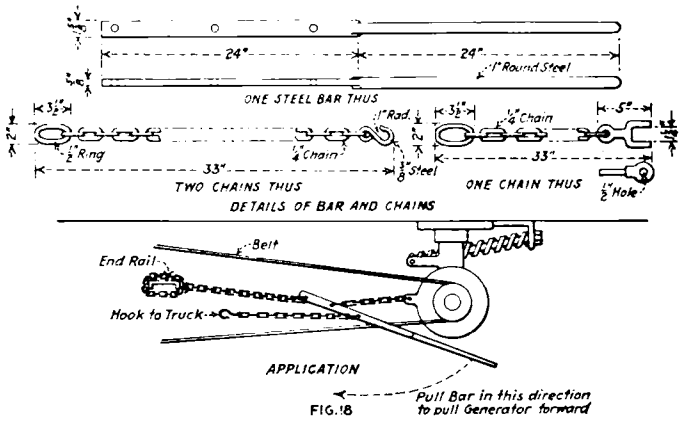

Fig. 18—Device for Use in Removing and Applying Axle Generator Belts to Body Hung Generators

The lamp burning when connected across the circuit at *A*, Fig. 8, will indicate that the circuit is closed to that point. If the lamp burns when connected at *A* and fails to burn when connected at *B* then the circuit is open at the cutout, possibly a blown plug fuse or a broken wire. In like manner an open can be located at any point throughout the circuit.

Testing and Connecting a Three- and Four-Way Lighting Circuit

The three- and four-way circuit has been introduced to train lighting within the past few years and has been a stumbling block to many a car lighting man. The wiring scheme as shown in the diagram of a three- and four-way circuit, Fig. 9, is easy to understand, but the difficulty is experienced in testing out and connecting the switches when the wires are concealed in the conduit with only the ends projecting at the switch outlet boxes, as shown in Fig. 10.

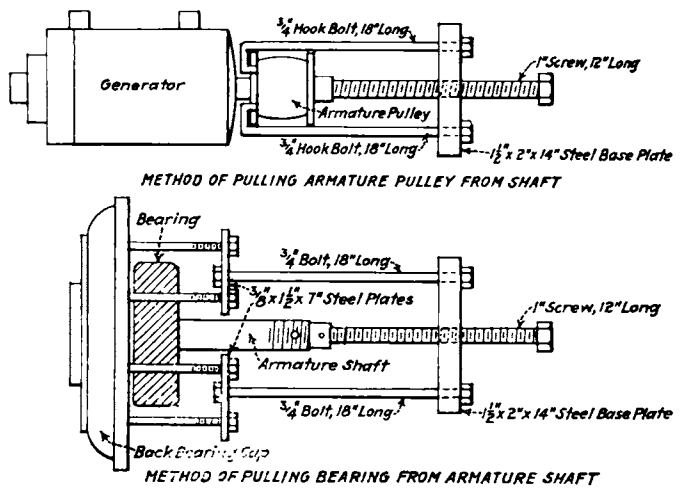

Fig. 19—Pulley and Bearing Puller

A method of procedure in connecting the switches to

such a circuit is shown step by step in the diagrams *A, B, C, D, E, F, G,* Fig. 11.

Start with all three switches disconnected, as shown in Fig. 10:—*First Step*—Connect the three wires together at each three-way outlet as shown in diagram *A,* Fig. 11.

Second Step—Connect the four wires at the four-way

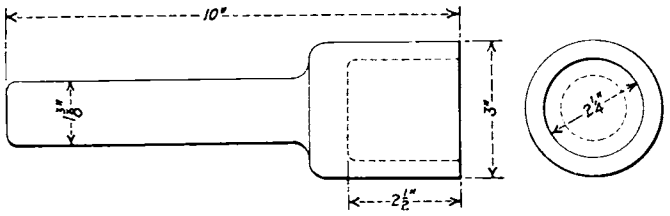

Fig. 20—Armature Pulley Driving Iron

outlet into two pairs, selecting the pairs that close the circuit and light the lamps, as shown in diagram *B.*

Third Step—Pick up the hot wire at one of the three-way outlets. The hot wire will be the one that will light the lamps when connected to either of the other two wires, as shown in diagram *C.*

Fourth Step—In like manner pick up the hot wire at the other three-way outlet, as shown in diagram *D.*

Fifth Step—Concert the two three-way switches, as shown in diagram *E,* connecting the hot wire to the strap of each switch.

Sixth Step—Mark the upper two connections on the

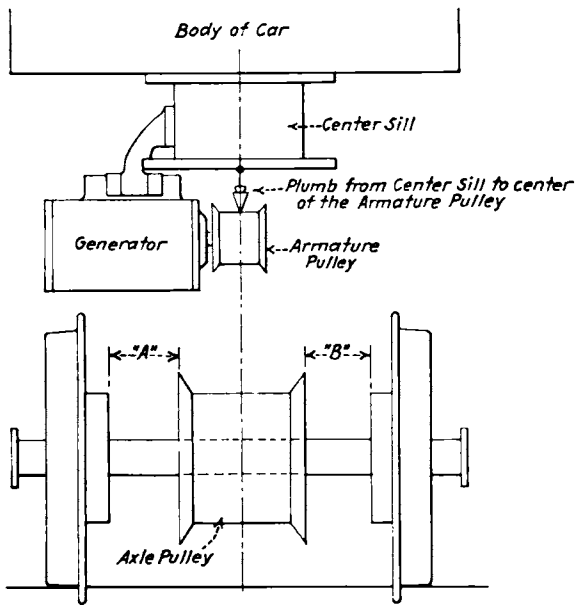

Fig. 21—Lining Up Axle Pulley on a Body Type Generator

four-way switch No. 1, and the lower two connections mark No. 2, and connect one pair of wires to the connections No. 1 and the other to connections No. 2, as shown in diagram *F.*

Seventh Step—With the four-way switch connected, as shown in diagram *F,* it can be plainly seen that on one point of the four-way it would be impossible to close the circuit from either of the three-ways. This can be corrected by criscrossing one pair of wires, either pair, No. 1 or pair No. 2, at the four-way, as shown in diagram *G.* The three- and four-way switches will then be connected correctly. If by chance one pair of wires were criscrossed in the operation of the sixth step, then the seventh step would be unnecessary.

Practical Stunts, Tools, Etc.

Tool for removing and applying armature.—Removing and applying an armature to a generator under a car without damaging the commutator is rather a difficult job, therefore some tool should be available with which the commutator end of the armature can be held steady as the armature passes in and out through the end of the housing.

A tool for this particular job is shown in Fig. 12 and

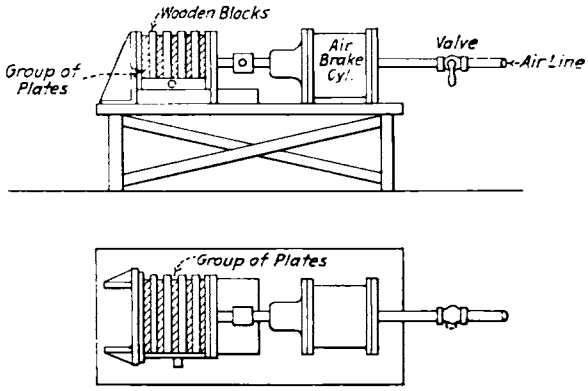

Fig. 22—Press for Lead Battery Plates

is nicknamed a "wooden leg," because of its resemblance to one. It is slipped over the commutator end of the armature shaft and is of sufficient length to allow for the passing of the armature through the end of the housing with one lift.

Protecting armature and commutator on truck in transit from car to shop and on bench in shop.—Rough handling of armature is rather expensive and can easily be avoided. Instead of one end of the armature resting on the corner of the commutator in the path of rolling bars, or other

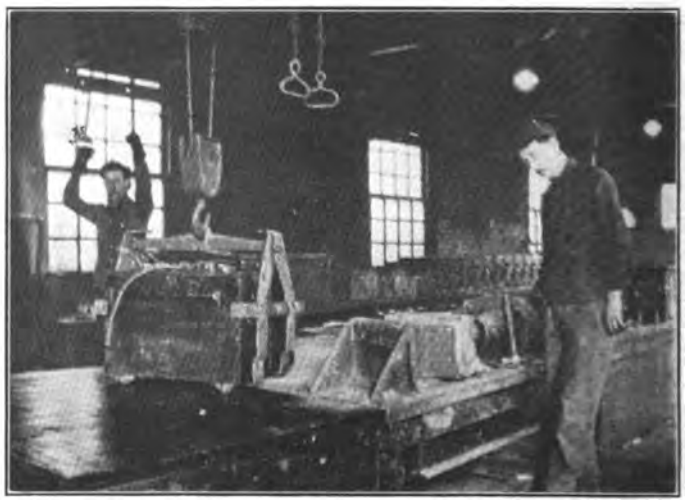

Fig. 23—View in Battery Room Showing Plate Press and Lifting Iron Carrying Two Crates of Lead Batteries

tools, while in transit or in the workshop, a truck or work bench should be equipped with some sort of carrier. Fig. 13 shows a block that may be used to support the armature on a truck, as shown in Fig. 14, and on the work bench as shown in Fig. 15. It may also be noted in Fig. 14 that a canvas band protects the commutator. This canvas band

will protect the commutator from being scarred in handling and can be quickly applied and removed.

Press for Removing Armature Shaft and Bearings

The pulley end bearing is usually forced upon the armature shaft under pressure and the shaft forced in the armature in like manner. Therefore when it becomes necessary to remove the bearing from the shaft or renew a shaft some device is needed that will perform the work without damage to the armature, shaft or bearing. Figs. 16 and

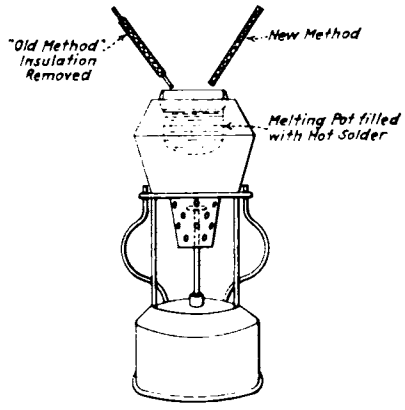

Fig. 24—Method of Tinning Wire Connectors Before Removing the Insulation

17 show a hand press that will remove and apply these parts. It is constructed from two 2 in. x 16 in. x 16 in. steel plates, four 1½ in. x 48 in. steel rods, one 2 in. x 8½ in. screw with 4 in. square head, one 1 in. x 30 in. steel handle bar and eight 1¼ in. hexagonal nuts.

To remove a bearing from the shaft.—To remove a bearing from the shaft, suspend the armature with pulley end head complete from head flange upon two wooden uprights, after removing thrust washer from armature shaft. Then by turning the 2 in. screw, Fig. 16, armature and shaft will be pressed in a downward direction free from head end bearing. Care should be exercised to have the two uprights the same length and screw and armature shaft in perfect line before pressing off bearing, otherwise there is danger of bending armature shaft.

Fig. 25—Battery Compound Melting Pot

To remove armature shaft from armature.—Invert the armature in the press, as shown in Fig. 17(c), resting core of armature upon sleeve. Then by removing thrust washer and turning the screw the armature shaft will be pressed in a downward direction free from the armature.

The armature shaft and bearing can be replaced in like manner by using sleeves that fit over the shaft. This stunt is a time saver and eliminates the danger of damage possible with the old method of sledging or bumping.

Device for use in removing and applying axle generator belts to body hung generator.—When an axle generator belt is found to be missing within a few minutes of train time, there is no time to be spared. If the generator is a truck suspended one, it can be easily pried forward with a bar and a new belt applied. Suppose, however, the generator is not truck suspended but, instead, it is a body hung machine. In this latter case a train detention is apt to result, unless some divice is at hand which can be easily applied to pull the generator forward and quickly put on a new belt.

Various types and makes of generators are now suspended from the car body, therefore the device must be one that can be used universally. An arrangement of this type which recommends itself by its simplicity, consists of a bar and three chains, Fig. 18. One of these chains is attached to the truck end rail and a second chain to the generator. The bar is then moved forward, as shown by the dotted line, Fig. 18, which movement pulls the generator forward. The third or remaining chain comes into play when the generator has been pulled forward. This chain serves to hold the machine forward while the belt is being applied.

This device is a great time and labor saver and may be used on any type of body hung generator. When equipped

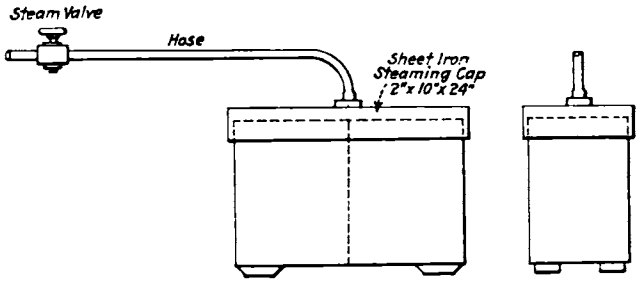

Fig. 26—Steam Caps for Removing Battery Covers

with this outfit one man can apply or remove a generator belt with ease so that a car detention due to a missing belt is a rare occurrence.

Pulley and bearing puller.—Armature pulleys, in addition to being driven over the tapered armature shaft, at times rust, making it a rather difficult job to remove them. The old method of removing them with a pinch bar, hammer and chisel was rather expensive because in most cases when the pulley was a tight fit the flanges were broken or the shaft bent.

A device for removing armature pulleys is shown in Fig. 19. It consists of an iron base plate 1½ in. x 2 in. x 14 in., two ¾ in. bolts and a 1 in. x 12 in. machine screw. This same device with the addition of two plates ⅜ in. x 1½ in. x 7 in., fitted to the back bearing cap, as shown in Fig. 19, will act as a bearing puller.

Pulley driving iron.—The armature pulley is keyed to the armature shaft with a tapered fit. Therefore, if the pulley is not driven home when applied, it will gradually work loose and result in the key cutting away the armature shaft and bore of pulley.

The old method of driving the pulley home by hammering on the pulley flanges has passed. It was possible to drive the pulley in place with a hammer when the generators were truck suspended and had pulleys with straight flanges. But the new body hung machines are equipped with tapered flanged pulleys and to attempt to drive them in place by hammering on the tapered flange is sure to result in the fracture of the flange.

A driving iron, as shown in Fig. 20, is a valuable tool

for this particular work. It fits over the nut on the pulley end of the shaft and delivers the shock of the hammer's blow to the heavy web of the pulley.

This prevents the possibility of breaking the flanges and the fact that the blow is distributed evenly around the circumference of the pulley bore eliminates the possibility of bending the armature shaft.

Lining up axle with a body suspended generator.—To line up the axle pulley with a body suspended generator plumb from the bottom of the center sill to the center of the armature pulley, as shown in Fig. 21, and note the relation of the center line of the pulley to the center line of the sill. If the center line of the armature pulley is 1 in. off the center line of the sill, then the axle pulley should be located 1 in. off the center of the axle. The relation of the center line of the pulley and the center line of the axle may be checked by measuring the distance *A* and *B*, Fig. 21.

Press for lead battery plates.—The press, Fig. 22, is designed for straightening buckled lead battery plates. It is made from material which is not expensive and which can be found in nearly every railroad shop. The essential parts of the press are an air brake cylinder, an iron base plate and two iron jaws, mounted upon a bench. One jaw is fixed to the base plate, while the other jaw is connected to the end of the piston rod and slides over the base plate, guided by two projecting lugs. The air which operates the press is controlled by a valve located in the air pipe feeding line at one end of the cylinder.

Fig. 22 and 23 illustrate the machine in operation with a group of plates under pressure. Wooden blocks are used as liners between the plates. The advantages of this press are the saving in time over ordinary methods and the effect of the slow steady pressure applied to the plates, which forces them back to their original shape

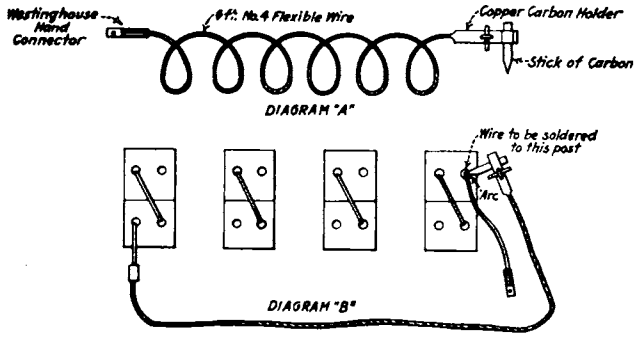

Fig. 27—Emergency Welding

without the damage which results from hammering or other crude methods.

Wire connectors for car lighting batteries.—Instead of skinning the ends of the wire and then tinning it, it is advantageous to tin the ends before removing the insulation. To make a car lighting battery lead take a piece of insulated wire of the proper length and dip the ends first into the soldering flux and then into a melting pot of solder. See Fig. 24. Allow it to cool and remove the insulation.

This has several advantages over the old method. The heat of the solder loosens the rubber insulation from the wire and makes it easy to remove and in case of flexible wire the strands are soldered together, making it impossible to separate them while removing the insulation.

Removing and Applying Battery Covers

Battery covers when applied are sealed with a compound to prevent the slopping of the acid. The compound is melted in a gas-heated pot, as shown in Fig. 25. The compound when hot is dipped from the heater and poured around the edge of the cover and allowed to cool. When hard it seals the space between the cover and the tank.

To remove the cover a steam cap is placed over the crate, as shown in Fig. 26. This cap measures 2 in. x 10 in. x 24 in., and is made of sheet iron. After a few minutes of steaming the compound softens and can easily be removed.

Emergency Welding.—Take a piece of No. 4 wire six feet long and attach a female Westinghouse battery hand connector to one end, and a copper carbon holder to the

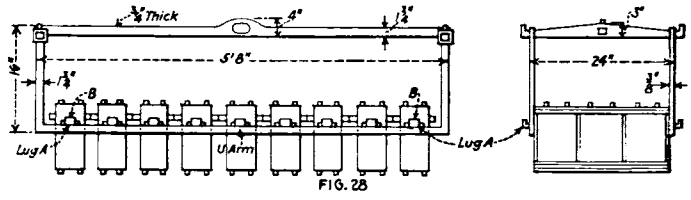

Fig. 28—Lifting Irons for Edison Battery

other end. Then place a piece of stick carbon about four inches long in holder. See diagram *A*, Fig. 27. This combination can be used for repairing an open circuit in a battery when the wire is broken off close to the terminal of the battery.

This connector is a practical time saver in a case of emergency, say when a car arrives at a terminal in a train in through service having a ten-minute lay-over, with an open in battery as above described. Instead of the present way of cutting out the entire crate, meaning a four-volt drop in battery, the wire could be permanently welded to battery terminal in a very few minutes, as follows:

Pull crate with broken lead out on battery box door far enough to reach post the wire is to be attached to, then place connector to close circuit of three adjoining crates, arranging so carbon point will close circuit through post in which lead is to be soldered. See diagram *B*. Fig. 27. Then by drawing an arc between point of carbon and post the lead can be readily welded in place.

Lifting Irons for Edison Batteries.—When cleaning Edison batteries it is very important that the bottoms of the cans should be clean and dry, as well as the top and sides. By the use of the lifting irons shown in Fig. 28, the battery can be lifted by the crane and the bottoms well cleaned. Considerable time can also be saved by moving the batteries from the drip rack, Fig. 5, to the bench and from the bench upon the truck, with these irons. The old method of sliding the crates when loading or unloading them from a truck, is undesirable, as there is danger of breaking the skids or pulling the wire connectors out of shape. Small wire hooks will hold the handles up and these irons can be readily placed under them. The details of the irons are shown in Fig. 28. Note that the lugs *A* on the U-irons slip into the end crate handles, as shown at *B*, thereby preventing shifting. The two long U-irons are punched from ⅜ in. boiler steel but the three top hangers are forgings. Fig. 23 shows another type of lifting iron carrying two crates of lead batteries.