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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT XVII, LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART II).

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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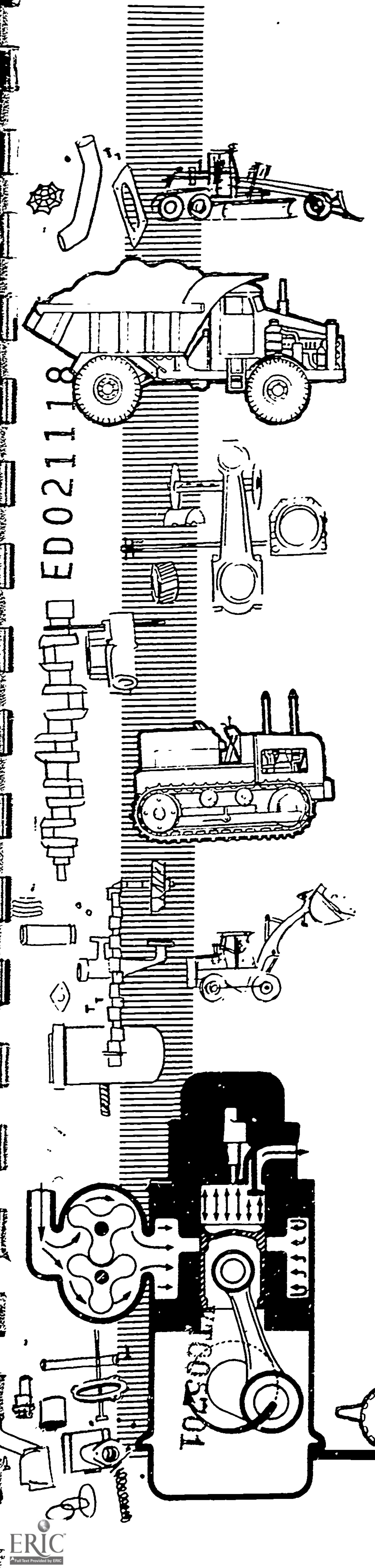
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATING PRINCIPLES AND THE SERVICING AND TESTING PROCEDURES FOR ALTERNATING CURRENT (AC) GENERATORS AND REGULATORS USED ON DIESEL POWERED EQUIPMENT. TOPICS ARE REVIEW OF ALTERNATOR PRINCIPLES, ALTERNATOR SERVICING AND TESTING, ALTERNATOR REGULATOR OPERATING PRINCIPLES, AND PERIODIC REGULATOR SERVICING AND GENERAL TROUBLESHOOTING OF THE CHARGING SYSTEM. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "AC GENERATORS II--REGULATOR AND FIELD RELAY OPERATING PRINCIPLES AND ALTERNATOR TESTING" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)



STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 2

LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART II)

UNIT XVII

SECTION A	REVIEW OF ALTERNATOR PRINCIPLES
SECTION B	ALTERNATOR SERVICING AND TESTING
SECTION C	ALTERNATOR REGULATOR OPERATING PRINCIPLES
SECTION D	PERIODIC REGULATOR SERVICING AND GENERAL TROUBLESHOOTING OF THE CHARGING SYSTEM

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SECTION A -- REVIEW OF ALTERNATOR (AC GENERATOR) PRINCIPLES

The addition of electrically operated accessories has increased the need for a more reliable automotive generator; one that is capable of developing a considerable output of electrical energy -- not only at slow vehicle speeds, but also at engine idle.

To meet the increased demand for electrical energy during slow speed and at engine idle, Delco-Remy and several other companies have developed a relatively new diode rectified AC generator called the DELCOTRON (General Motors trademark) or simply ALTERNATOR. For the most part, alternators are small and lightweight, but they are high in performance and output. They are designed and constructed to give long periods of trouble-free service with a minimum amount of maintenance.

The rotor is mounted on a ball bearing at the drive end and on a roller bearing at the slip ring end. Each bearing has a grease reservoir which eliminates the need for periodic lubrication.

Only two brushes are required to carry current through the two slip rings to the field coil, which is mounted on the rotor. The brushes are extra long and under normal operating conditions will provide extended periods of service.

The stator windings are assembled on the inside of a laminated core that forms part of the alternator frame.

Six rectifier diodes are mounted in the slip ring end frame and are connected to the stator windings. These diodes replace the separately mounted rectifier assembly used in some older types. The diodes act to change the alternator AC voltage to the DC voltage, which appears at the BAT (output) terminal on the alternator. A capacitor, or condenser, mounted in the end frame protects the diodes from high voltages.

The major parts of the alternator are the rotor assembly, the stator assembly and the two end frame assemblies. To better understand how these parts function to produce voltage and current, let's review briefly a few alternator principles.

THE ROTOR ASSEMBLY -- The ROTOR ASSEMBLY consists of the field winding, two iron segments with interlacing fingers called "poles", the shaft and two slip rings. See Figure 1. When these parts are assembled by a press fit onto the shaft, the rotor assembly is completed. The rotor is supported by prelubricated bearings at each end of the shaft, a ball bearing at the drive end frame and a roller bearing in the opposite end frame; see Figure 2.

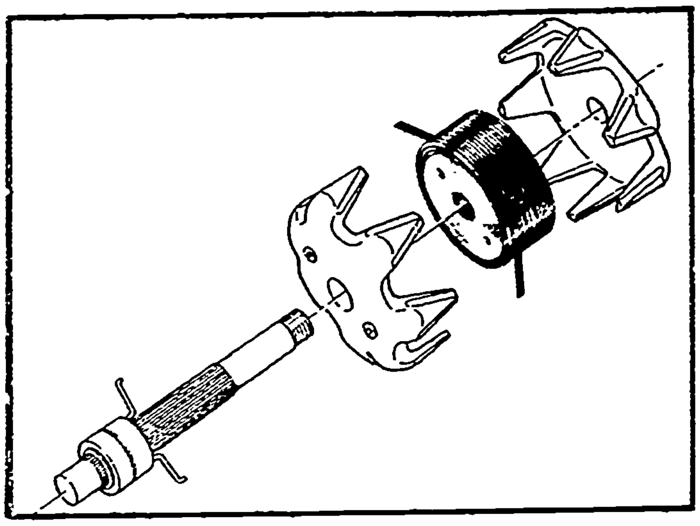

Fig. 1 Rotor components

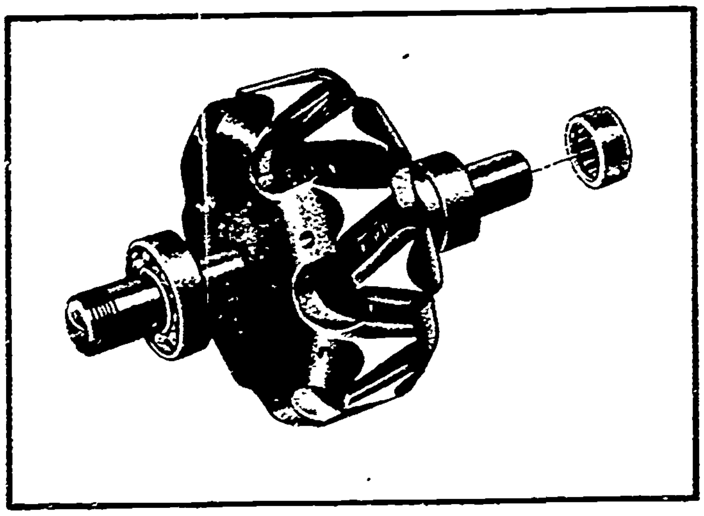

Fig. 2 Rotor assembly

The electromagnetic principle is used in the design of the field winding. The field winding consists of many turns of wire wound over an iron spool. When current is passed through the field winding, an electromagnet is formed and a magnetic field is produced.

The two slip rings, upon which the brushes ride, are mounted on one end of the rotor shaft and are attached to the leads from the field coil. When the ignition (or diesel engine ON-OFF) switch is first closed, current from the battery passes through one brush, through the slip ring upon which the brush rides, and then through the field coil. After leaving the field coil, current continues through the other slip ring and brush before returning

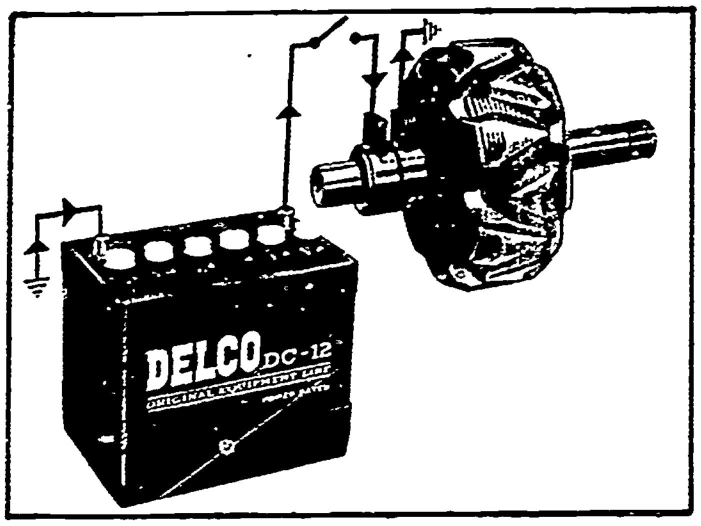

Fig. 3 Field current

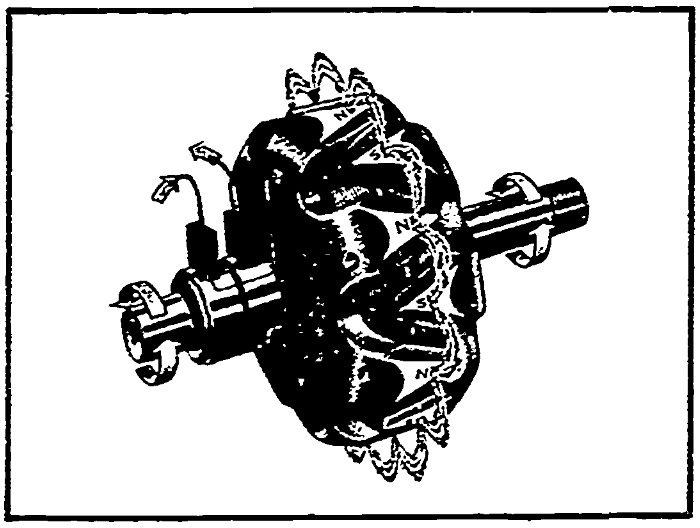

Fig. 4 Spinning magnetic field

to the battery through the ground return path. This flow of electrical energy through the field winding is called field current. See Figure 3.

When battery current flows through the field coil, a magnetic field is formed -- with a North magnetic pole in one rotor segment and a South magnetic pole in the other segment. As the rotor turns, a spinning magnetic field is produced. See Figure 4.

THE STATOR ASSEMBLY -- The most basic STATOR is a single loop of wire. As the magnetic field from the spinning rotor cuts across this wire, an electrical pressure or voltage is produced in the loop. The faster the rotor turns, the greater the voltage will be. Increasing the number of loops in the stator winding also increases the voltage; see Figures 5 and 6.

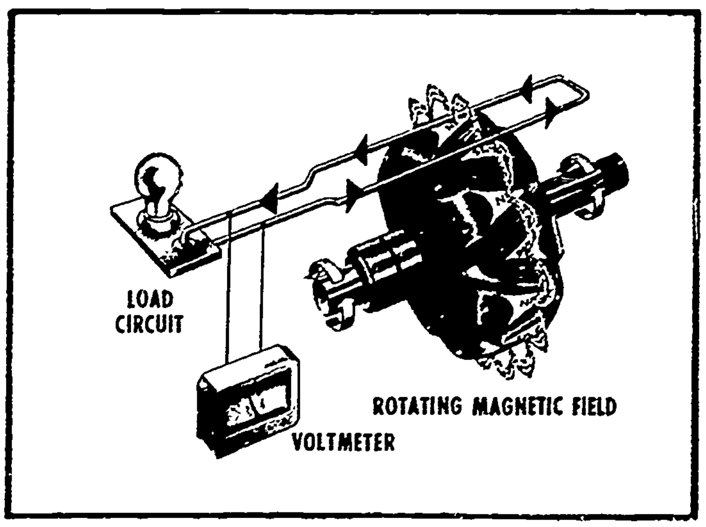

Fig. 5 Rotor and basic stator

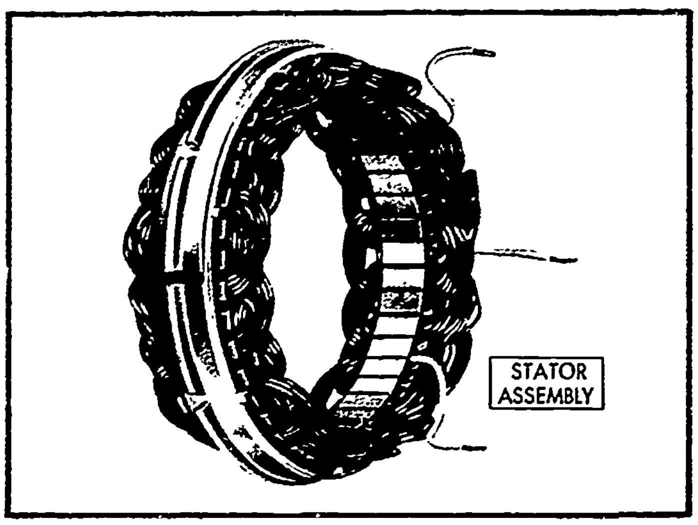

Fig. 6 Stator assembly

The stator assembly is made up of a laminated iron frame and three stator or output windings which are wound into slots of the frame. The stator assembly is sandwiched between the two stationary end frames of the alternator. See Figure 6. Inside the stator assembly is the rotor. A very small air gap is left between the rotor poles and the stator laminations. As the rotor turns, the alternate North and South poles pass each loop in the stator windings; voltage and current are induced in the windings.

Since the stator windings are influenced alternately by the North and South poles of the spinning magnetic field, an oscillating voltage is produced. This oscillating voltage causes the current in the stator windings to flow first in one direction and then in the other. This type of flow is called alternating current -- hence the name alternator, or simply AC generator. The voltage that produces this type of current is called AC voltage.

Since the battery and other electrical accessories in the system operate on direct current (flow only in one direction), it is necessary to change the AC to DC. This is the job of the rectifying diodes. A diode is an electrical device which allows current flow freely in one direction, but prevents flow in the other. It acts much like an electrical check valve.

Six diodes are located in the end frame assembly nearest the slip rings. Three of these diodes are negative and are mounted directly in the end frame. Three positive diodes are mounted into a heat sink, which is insulated from the end frame. See Figure 7. These six diodes (three positive and three negative), change AC from the stator windings to a flow of DC, which appears at the output terminal of the alternator. Thus, the rotor, stator, and diodes act together to produce DC voltage which appears at the BAT (output) terminal.

Next, let's compare the alternator we have just discussed with a typical DC generator and discuss the primary differences. See Figure 8. The alternator has only one field coil, which is located on the rotor shaft. This field coil is surrounded by the poles of the rotor segments. Since it

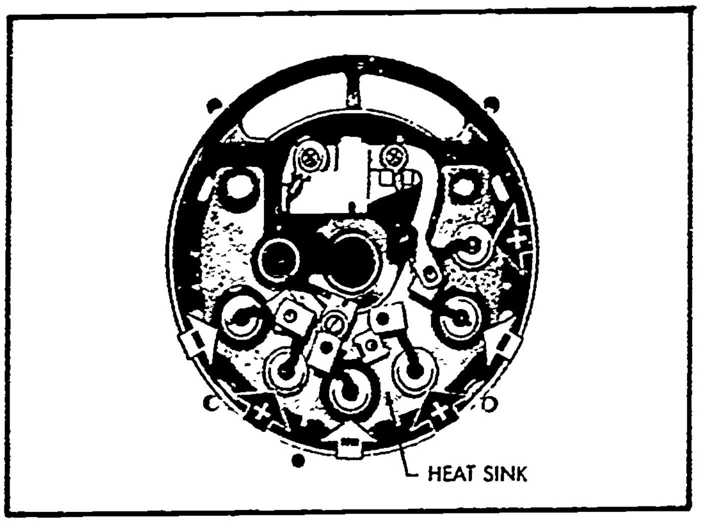

Fig. 7 End frame assembly and diodes

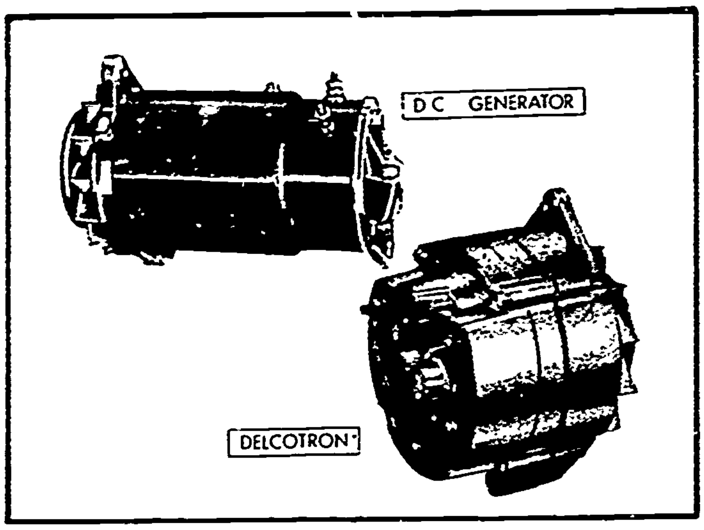

Fig. 8 Comparing AC and DC generators

is part of the rotor assembly, the field coil turns with the rotor. See Figure 9. In a DC generator, two or more field coils are wound around pole pieces attached to the field frame. Therefore, the field coils are stationary and do not revolve. See Figure 10.

The stator windings in the alternator are attached to the stator frame and carry output current. They perform the same function as the rotating windings in the armature of a DC unit. See Figure 11.

The brushes in the alternator are connected in series with the field coil and carry only a low field current. In the DC generator, the brushes are connected through the commutator to the armature windings and carry the

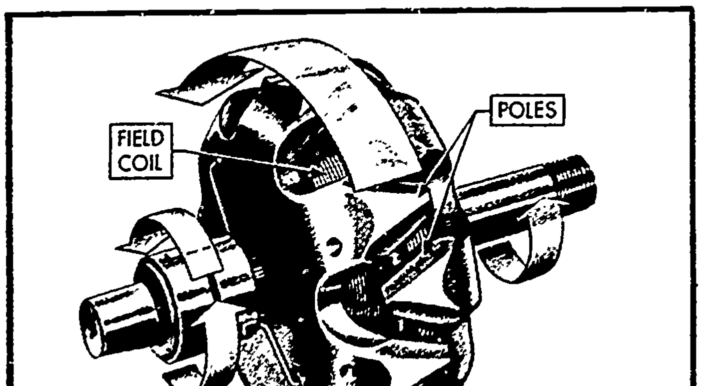

Fig. 9 Rotor assembly

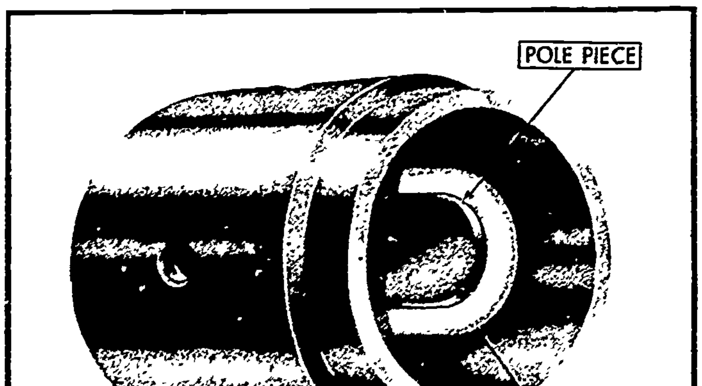

Fig. 10 DC generator fields and poles

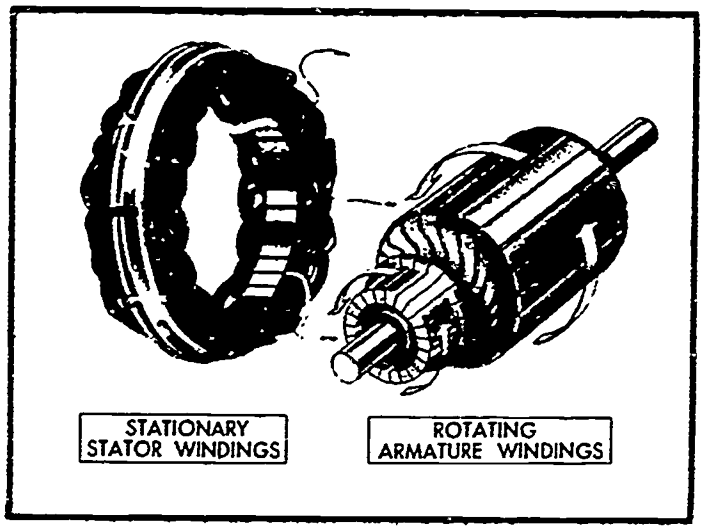

Fig. 11 Stator and armature

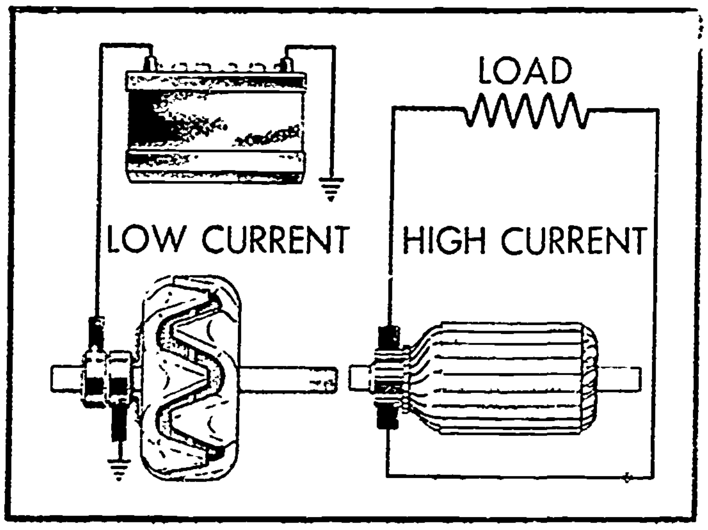

Fig. 12 Field and output current

total generator output. Since low current is carried by the brushes in an alternator, their life is greatly improved over those of a conventional DC generator unit. See Figure 12.

SECTION B -- ALTERNATOR SERVICING AND TESTING

NOTE: The alternator should never be removed from the vehicle for servicing until tests have shown it to be defective. Reference always should be made to the manufacturer's maintenance manuals for a complete troubleshooting guide.

Briefly, here are a few typical procedures for testing the alternator and the individual components, to determine if they are defective.

Connect a jumper lead from the field terminal to the output terminal. Also connect a voltmeter, ammeter and a carbon pile load in the circuit as shown in the wiring diagram in Figure 13. If the alternator does not provide rated output at the speed specified in the manufacturer's maintenance manuals, it is defective and must be removed and disassembled for further checks.

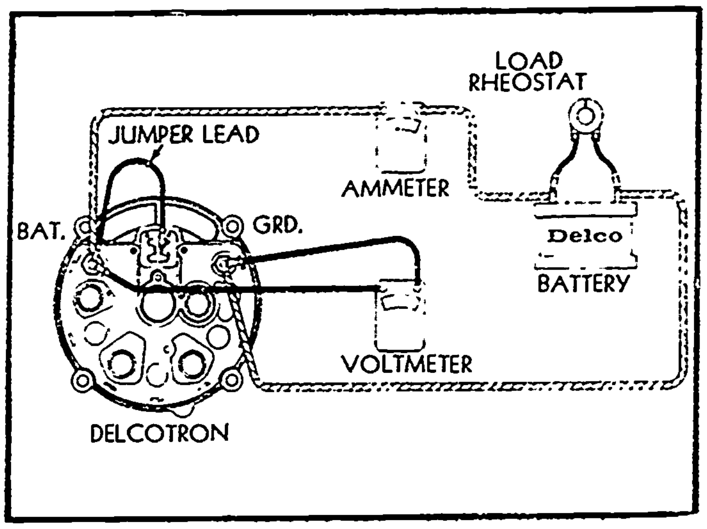

Fig. 13 Wiring diagram

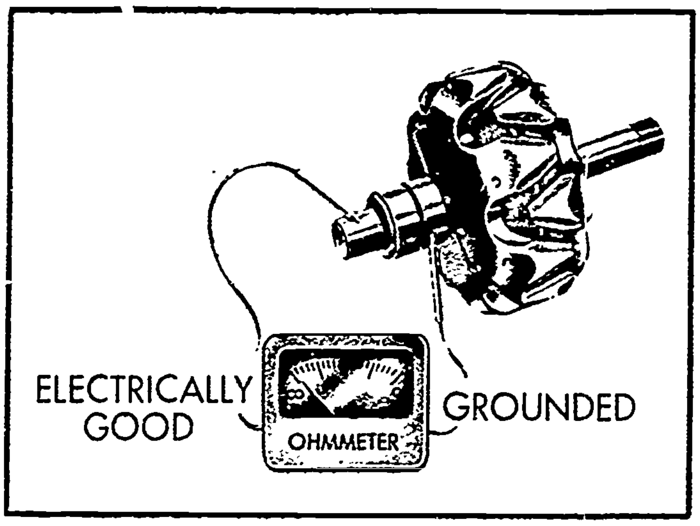

Fig. 14 Using ohmmeter

The rotor may be checked for grounds by connecting an ohmmeter or a 110 volt test lamp from either slip ring to the shaft. A high ohmmeter reading indicates the winding is okay, whereas a low reading indicates a ground. A test lamp, when connected from either slip ring to the shaft, will light if the rotor winding is grounded. See Figure 14. To check the rotor for shorts and opens, connect an ohmmeter to both slip rings. An ohmmeter reading below the specified resistance value indicates a short, whereas a reading above the specified value indicates an open. If the test lamp does not light when connected to both slip rings, the winding is open. See Figure 15.

The stator winding may be checked for opens after it has been disconnected from the end frame. If the ohmmeter reading is low, or if the test lamp lights when connected between any two stator leads, the stator winding is electrically good. See Figure 16. A high ohmmeter reading or a lighted test lamp connected between any one of the leads and the stator frame, indicates the winding is not grounded. It is not practical to check the stator for shorts due to the very low resistance of the windings. See Figure 17.

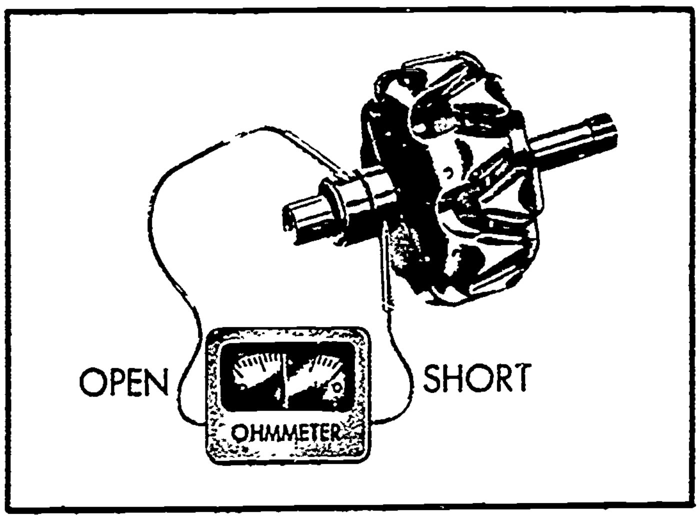

Fig. 15 Using ohmmeter

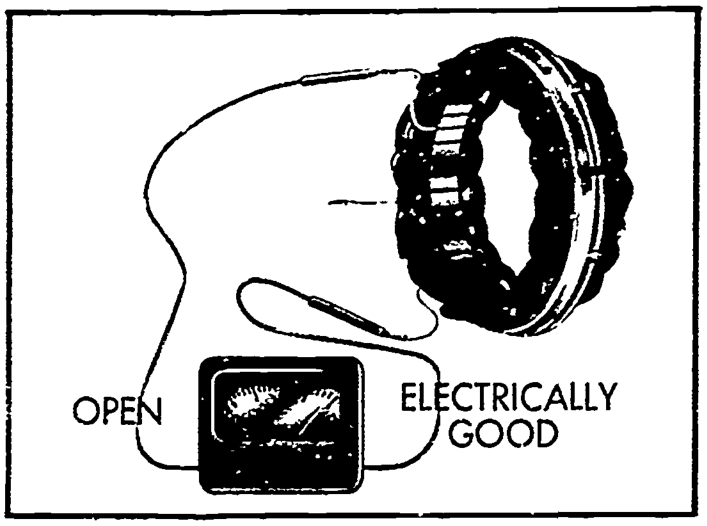

Fig. 16 Using ohmmeter

With the stator windings disconnected, each diode may be tested with an ohmmeter by connecting one test lead to the diode lead, and the other test lead to the diode case. Note the reading. Then reverse the ohmmeter leads and again note the reading. If both readings are very low or very high, the diode is defective. A good diode will give one low and one high reading. See Figure 18.

Another method of testing each diode is to use a low voltage test lamp (with a battery of not more than 12 volts on 12 volt systems,for example). Connect one of the test leads to the diode lead, and the other test lead to the diode case. Then reverse the test lead connections. If the lamp lights in both checks, or if the lamp fails to light in both checks, the diode is

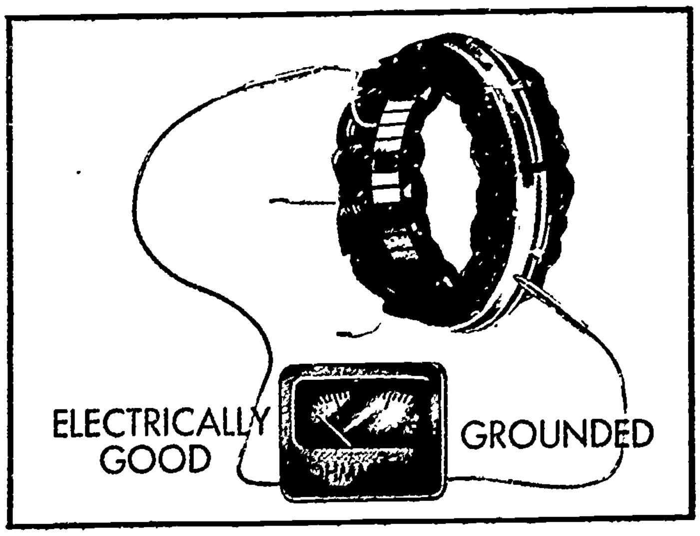

Fig. 17 Using ohmmeter

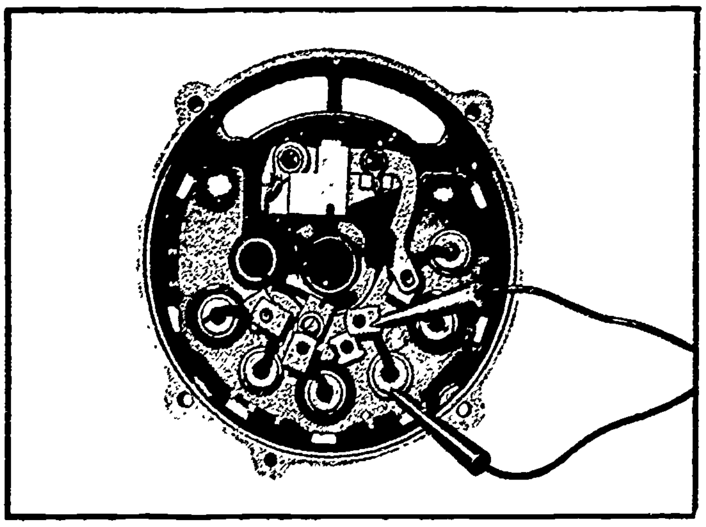

Fig. 18 Using ohmmeter

defective; when checking a good diode, the lamp will light in only one of the two checks.

SECTION C -- ALTERNATOR REGULATOR OPERATING PRINCIPLES

At the present time, most alternators are controlled by one of three types of double contact voltage regulators:

1. A three unit assembly
2. A two unit assembly
3. A single unit assembly

An exception to the above is the transistor controlled and the transistorized regulators that will be covered in a later unit.

The THREE UNIT REGULATOR contains a double-contact type voltage regulator unit, a field relay unit and an indicator lamp relay unit. It is used in charging systems utilizing either an indicator lamp or ammeter.

The TWO UNIT REGULATOR contains a double contact type voltage regulator unit and a field relay unit. It is used in charging systems utilizing either an indicator lamp or an ammeter. However, the external circuitry on various applications may differ. This two unit regulator is not interchangeable with the three unit regulator.

The SINGLE UNIT REGULATOR has a double contact voltage regulator unit and is used only in charging systems equipped with an ammeter. A special ignition switch, or diesel engine ON-OFF switch is used to energize the field circuit.

The double contact type voltage regulator unit used in all three types of regulators, operates to limit the alternator voltage to a preset value by controlling the alternator field current. The field relay unit in the two and three unit regulators connects the alternator field coil and the winding of the voltage regulator unit to the battery when the relay contact points are closed. It disconnects them when the contact points are opened. The field relay unit of the two unit regulator may also act as an indicator lamp relay on some applications.

The circuitry of charging systems using indicator lamps and relays is such that the indicator lamp lights when the ignition switch or diesel ON-OFF switch is first turned on. Then, when the alternator develops voltage and begins to furnish power to the electrical system, the indicator lamp goes out. This indicates that the charging system is operating normally. If the alternator fails to furnish power at any time, the indicator lamp comes on, indicating that there is trouble in the charging system.

SECTION D -- PERIODIC REGULATOR SERVICING AND GENERAL TROUBLESHOOTING OF THE CHARGING SYSTEM

Normally, no periodic servicing is required for the regulator. However, if the contact points of a voltage regulator unit have excessive resistance or a tendency to stick, this can cause erratic regulator operation, and in turn, can affect the electrical performance of the alternator. When this condition exists, the contacts should be cleaned. Sooty or discolored contact points are normal, even after a relatively short period of operation. This is not an indication that cleaning is necessary. The contacts should be cleaned if the system voltage fluctuates, as evidenced by an unsteady voltmeter reading when checking the voltage setting. However, a check should first be made to determine if the unsteady voltage is being caused by loose connections elsewhere in the system.

The contacts of the voltage regulator are made of soft materials and should be cleaned with a fine abrasive paper. A strip of No. 400 silicon carbide paper or its equivalent, folded over and then pulled back and forth between the contacts is recommended as a satisfactory cleaning method. After

cleaning, the contacts should be washed with trichlorethylene or alcohol to remove any residue. If the voltage control has not improved, repeat the cleaning process.
CAUTION: Never use a file, emery cloth or sandpaper to clean double contact type voltage regulator points.

WIRING CIRCUIT -- The wiring circuit is just as important a part of the charging circuit as the electrical units themselves. Undersize wire or loose connections between the regulator, terminals and the junction block will cause a high charge rate to the battery. High resistance, resulting from loose or corroded connections between the junction block and the battery, will cause a lowering of the charging rate.

A visual inspection often will reveal much useful information relative to the condition of the charging system. Periodically, all wiring should be visually inspected for frayed or damaged insulation. Faulty wiring should be replaced. All terminals should be checked for loose or corroded connections. Terminals should be cleaned and tightened if necessary.

The terminals of the Delco-Remy three unit regulators are the screw type. Terminals on the one and two unit regulators are of the slip-connection type. A special connector body on the vehicle wiring harness is keyed to mating slots in the regulator base to insure proper connections. Also, a projection on the connector body serves to latch the assembly together. This prevents disconnections caused by vibrations. The assembly is disconnected by a slight lifting of the latch.

GENERAL TROUBLE-SHOOTING OF THE CHARGING SYSTEM -- Alternator charging circuits are completely different from direct current charging circuits. Therefore, very few of the troubleshooting checks used for direct current systems can be used for alternator systems. Before attempting to troubleshoot, it is wise to observe the following precautions. Failure to do so can result in burned out alternator diodes and vehicle wiring.

When installing a battery make absolutely sure that the ground polarity of the battery and the ground polarity of the alternator are the same. The ground polarity of most alternators is noted on a name plate or is engraved on the alternator in a conspicuous place. If an alternator of the wrong polarity is connected into the charging system, or if the battery terminals are reversed during installation the battery is directly shorted through the diodes. Consequently, the diodes and the vehicle wiring are endangered by high current flow. A burned wiring harness and burned-"open" diodes probably will result.

When connecting a booster or slave battery, make certain to connect the negative battery posts together and the positive battery posts together (in parallel). Failure to observe this precaution will result in the same damage as previously described.

When connecting a charger to the battery, connect the battery charger positive lead to the positive battery post and the charger negative lead to the negative battery post. Failure to follow this precaution will result in the same damage as described in the first precaution.

Never operate the alternator on an open circuit. With no battery or electrical load in the circuit (open circuit), the alternator can build up high voltage which may damage the diodes and could be extremely dangerous to anyone who might accidentally touch the alternator output terminal. Before making tests or on-the-vehicle checks, it is important to make sure that all connections in the circuit are clean and secure.

Do not short across or ground any of the terminals of the alternator or regulator. A circuit set up by purposely grounding or shorting any of the alternator or regulator terminals can cause serious electrical malfunctions that might endanger components of the electrical system. When analyzing and troubleshooting the charging system, it is wise to follow established procedures as described in the Service Bulletin pertaining to the equipment involved.

Do not attempt to polarize the alternator. Unlike the DC generator, alternator polarity cannot be lost or changed. Any attempt to polarize, therefore will be of no value and may cause damage to the diodes, wiring harness and other system components. If there is any doubt as to the polarity of a particular alternator, refer to Manufacturer's Specification Bulletins and name plate data. Or, connect a battery to the field circuit only. Rotate the rotor slowly, in either direction, and note the polarity of the voltage as measured by a voltmeter between the alternator output terminal (insulated) and the alternator ground terminal.

Complaints or troubles involving the charging system usually include either an overcharged or undercharged battery. Excessive water usage is an indication that a battery is being overcharged. In cases of extreme overcharge, the electrolyte level may be far below the top of the plates. Since only the portion of the plates that is covered with electrolyte is useful in developing voltage, the battery may not have sufficient capacity to crank the engine or to power the electrical accessories. Furthermore, a certain amount of permanent damage results.

Water usage in such cases exceeds the normal -- one ounce of water per cell per 1000 miles of driving (or 24 hours on vehicles equipped with engine hour meters). Water usage must, therefore, be noted over a reasonable service period to ascertain whether or not the battery is being overcharged. During hot weather and other unusual driving conditions, the battery may require an excessive amount of water. However, when the vehicle is returned to a normal driving schedule, the water consumption should return to a normal amount. It is NOT necessary to lower system voltage in this case.

In cases where overcharging is caused by extremely high system voltage, the high voltage also may damage voltage-sensitive accessories such as light bulbs. To prevent this and to correct the overcharged battery condition, the system voltage must be lowered by either an adjustment of the voltage regulator or correction of any trouble in the charging circuit.

An undercharged battery is one that runs down or becomes discharged because of insufficient charging. In extreme cases the battery will not have sufficient capacity to develop enough voltage to crank the engine or to power the electrical accessories. In such cases there will be almost no water usage.

To correct an undercharged condition, the system voltage must be raised by either an adjustment of the voltage regulator of by correction of any trouble in the system.

The following procedure indicates the steps to follow in order to locate the trouble that exists in the system. For a more thorough and accurate check, refer to the applicable Service Bulletin.

OVERCHARGED BATTERY -- Step #1: Check the battery condition. Fill the battery to the proper level with water. Then light load test (described in the unit on batteries) the battery to determine if there is a shorted cell. Batteries with internal short circuits will accept a high charge rate and use water excessively. If this condition is found, replace with a good battery. Check for improved battery charging performance (decreased battery water usage) over a reasonable service period.

Step #2: If the battery is not the source of trouble, check the condition of the wiring. Visually inspect all connections to make sure they are clean and tight. Visually inspect for damaged wiring. Repair or replace as the need indicates. Check for improved battery charging performance (decreased battery water usage) over a reasonable service period after faulty wiring or connections are repaired.

Step #3: If neither the battery nor the wiring is the source of trouble, check the regulator. Connect a voltmeter across the battery terminals. (It must be understood that the battery is fully charged, since it is in an overcharged condition. Do not substitute a partially charged battery in the vehicle for this check.) Start the engine and run at fast idle (about 1500 rpm).

Note the voltmeter reading. If the reading is 16 volts or above, proceed to Step #5. If the reading is less than 16 volts, the voltage setting for the type of operating (or driving) being done is too high and must be lowered (Step #4).

Step #4: Before adjusting the voltage regulator setting, stabilize the temperature by continuing to run the engine for 15 minutes with the voltmeter still connected across the battery. Remove the lead from the "V" terminal of three unit regulators with screw-type terminals. (Note that this lead is connected to the battery. Therefore, do not permit it to touch ground.) Remove wiring connector body from one unit and two unit regulators. Remove regulator cover. Reconnect the wiring or the wiring connector body to regulator and note voltmeter reading. This reading will differ from the one noted with the regulator cover on. Adjust the regulator by turning the adjusting screw counterclockwise to decrease the voltage setting. The regulator should be adjusted to bring the voltage reading within the 13.2 to 15.2 volt range. Lower the voltage until it is within this range. CAUTION: The spring support may not return when the screw is backed off. In this case, turn the adjusting screw counterclockwise until there is ample clearance between the screw head and spring support. Then carefully bend the spring support up until it touches the screw head. Final setting of the unit should be by increasing the spring tension, never by reducing it. Do not let the tool touch ground while making this adjustment. If no adjustment is possible, install a new regulator.

Step #5: If the voltage reading in Step #3 is 16 volts or above, follow the procedure described in Step #4 without the 15 minute warmup period and adjust the regulator to the 14.5 to 15 volt range.

If no adjustment of the regulator is possible, replace the regulator and check for improved battery performance over a reasonable service period. If adjustment can be made, follow the complete procedure of Step #4 including the 15 minute warmup period.

Step #6: After the regulator setting has been adjusted, remove lead from the "V" terminal of a three unit regulator (or remove wiring connector body from one unit and two unit regulators). Replace regulator cover. Reconnect wiring or wiring connector body to regulator and note voltmeter reading. A voltage reading of 13.5 to 15.2 volts is within the permissible range. However, the setting should now be lower than when first noted in Step #3.

Step #7: Remove test instruments and check battery for improved charging performance (decreased battery water usage) over a reasonable service period. At a later date it might be necessary to repeat this procedure to lower the voltage setting even further.

UNDERCHARGED BATTERIES (discharged or rundown) -- Step #1: Check the fan belt. Check physical condition and belt tension. Tighten belt according to vehicle Manufacturer's Specifications or replace if necessary. A slipping belt may not drive the alternator at sufficient speed to keep the battery charged. After correction, check for improved battery charging performance over a reasonable service period.

Step #2: Check battery condition. A battery which is sulfated, or which has an intermittent "open at a terminal post or in one of the cell connectors, will remain in an uncharged condition under normal operating conditions. Therefore, when a chronically undercharged battery is discovered, a thorough check of the battery should be made by means of the light load test. Replace with a good battery, if necessary, and check for improved battery performance over a reasonable service period.

Step #3: Check for undesired grounded circuits. To check the complete vehicle electrical system for an unwanted ground, disconnect the ground cable from the battery and connect a voltmeter between the ground cable and battery ground post. Make sure all lights and accessories are off and that the vehicle electrical clock is wound. If the voltmeter then reads battery voltage, there is a ground which must be traced and eliminated. Any reading less than battery voltage indicates current leakage across the top of a dirty or corroded battery and the battery should be cleaned. A near zero reading is desired.

Many discharged batteries are caused when the vehicle operator leaves electrical accessories on for an extended period. A run down battery can be expected in these cases and is no indication of a faulty charging system.

Step #4: If none of the above conditions has been encountered, check the condition of the charging system wiring. Visually inspect all connections to make sure they are clean and tight. Visually inspect for damaged wire. Repair or replace as needed. Check for subsequently improved battery performance.

Step #5: Check alternator output. Before making this test, make sure the battery is charged sufficiently to crank the engine if the engine is battery started. Connect a voltmeter across the battery terminals. Start the engine and run at about 1500 rpm. Turn on high beam headlights and high speed heater blower or other electrical accessories. If the voltage reading is 12.5 volts or more, turn off accessories and stop engine. The alternator is assumed to be in satisfactory condition. Alternator output and the regulator should be checked in accordance with Step #7.

If the voltage reading is less than 12.5 volts, decrease engine speed to idle and check the alternator as described next (Step #6).

Step #6: Check alternator output. Remove connector from the alternator "F" (field) terminal and place a jumper lead from the BAT (output) terminal to the "F" terminal of the alternator. Slowly increase engine speed from idle to about 1500 rpm.
CAUTION: Do not permit voltage to exceed 16 volts as engine speed is increased. Note voltmeter reading. A voltage of less than 12.5 volts means that the alternator is defective and it should be replaced or repaired.

The battery performance should then be checked over a reasonable service period. A voltage of 12.5 volts or more after a few minutes of alternator operation means that the alternator is all right. Stop the engine, turn off lights and other accessories, remove the jumper lead and reconnect the connector body to the alternator. The cause of the battery undercharge is in the regulator, which should be checked and adjusted as indicated in the next step.

Step #7: There are a number of methods that can be used in checking the voltage regulator. Two such methods will be described and the testing equipment available will determine which method can advantageously be used.

Method (A) is a testing procedure based upon the use of either a fully charged battery or a 1/4 ohm resistor of the type that can be switched in and out of the battery circuit (by means of a battery post adapter). The undercharged battery itself may be fully recharged and used for this test, or a known fully-charged battery may be substituted for the complaint battery. Either a fully charged battery or a resistor of the type described above must be used. Otherwise the testing procedure will not be valid.

Also required is a voltmeter and the necessary hand tools to fit the regulator cover and the adjusting screws.

Method (B) is a testing procedure based upon the use of a 1/4 ohm resistor of the type used in checking DC generators, and a test adapter with the necessary jumper leads (UMS Test Harness Kit #1302). Also required is a voltmeter and the necessary screwdrivers to fit the regulator cover and the adjusting screws.

METHOD (A) -- (a) Place a voltmeter across the fully charged battery or between the battery ground post and the alternator side of the 1/4 ohm resistor, which is placed on the battery insulated post. Start engine with 1/4 ohm resistor switched "out" of the circuit and run at about 1500 rpm.

Note the voltmeter reading after the 1/4 ohm resistor has been switched back into the circuit. If the reading is 13.2 volts or less, proceed to step (c). If the reading is greater than 13.2 volts, the voltage setting is still too low and must be raised.

(b) Adjust voltage regulator setting. Continue to run engine for 15 minutes with voltmeter placed across the battery or across the battery and 1/4 ohm resistor. Remove lead from "V" terminal of three unit regulators with screw-type terminals. (Note that this lead is connected to the battery. Therefore, do not permit it to touch ground). Remove wiring connector body from one and two unit regulators. Remove regulator cover. Reconnect wiring or wiring connector body to regulator and again note voltmeter reading. This reading will differ from the one noted with the cover on. Adjust regulator by turning the adjusting screw clockwise, to increase the voltage setting. Voltage should be raised about .3 volt from the setting noted with the cover off. This increase should bring the regulator within the 13.2 to 15.2 volt range. If it does not, increase setting to that range.

CAUTION: The spring support may not return if the screw is backed off. In this case, turn the adjusting screw counterclockwise until there is ample clearance between screw head and spring support. Then carefully bend spring support up until it touches the screw head. Final setting of the unit should be by increasing spring tension, never by reducing it. Do not let the tool touch ground while making this adjustment. If no adjustment is possible, install new regulator.

(c) If voltage reading in Step (a) is 13.2 volts or less, follow the procedure described in Step (b) without the 15 minute warmup period and adjust the regulator to within the 14.5 to 15 volt range.

If no adjustment of the regulator is possible, replace regulator and check for improved battery performance over a reasonable service period. If an adjustment can be made, then follow the complete procedure of Step (b) including the 15 minute warmup period.

(d) On regulators that have been adjusted, remove lead from "V" terminal of three unit regulator or remove wiring connector body from one and two unit regulators. Replace regulator cover. Reconnect wiring or wiring connector body to regulator and note voltmeter reading. A voltage reading of 13.5 to 15.2 volts is within the permissible range. However, the setting should be higher than that first noted in Step (a).

(e) Remove test instruments and check battery for improved charging performance over a reasonable service period. At a later date it may be necessary to repeat this procedure to raise the voltage setting even further.

METHOD (B) -- (a)Disconnect battery ground strap and connect a 1/4 ohm resistor (25 watt) between the alternator BAT (output) terminal and the lead attached to it. On three unit regulators (with screw-type terminals) disconnect existing lead from regulator "V" terminal and connect a jumper lead between the alternator output terminal and the regulator "V" terminal. On one and two unit regulators, disconnect wiring harness connector at the regulator and insert test adapter at the regulator. Connect the "F" lead and the number 2 lead of the adapter to the vehicle wiring harness connector body. On vehicles equipped with an indicator lamp, connect the number 4 adapter lead to the vehicle connector. Connect a jumper from the BAT (output) terminal of alternator to the number 3 terminal of the regulator adapter. Place voltmeter between the number 3 terminal of the adapter and ground, and reconnect the battery ground strap.

Start engine and run at about 1500 rpm. If voltage is 13.2 volts or less proceed to Step (c). If voltage is above 13.2 volts, the voltage setting for the type of driving being done is too low and must be raised.

(b) Before adjusting the voltage regulator setting, continue to run engine for 15 minutes for proper regulator warmup. Then remove lead from the "V" terminal of three unit regulators with screw-type terminals. (Note that this lead is connected to the battery. Therefore, do not permit it to touch ground.) Remove wiring connector body from one and two unit regulators. Remove regulator cover. Reconnect wiring to regulator and note voltmeter reading. This reading will differ from the first one taken. Adjust regulator by turning adjusting screw clockwise to increase voltage setting.

Voltage should be raised about .3 volt from the setting noted with the cover off. This increase should bring the regulator into the 13.2 to 15.2 volt range. If it does not, increase setting to that range. CAUTION: The spring support may not return if the screw is backed off. In this case, turn adjusting screw counterclockwise until there is ample clearance between screw head and spring support. Then carefully bend spring support until it touches the screw head. Final setting of the unit should be by increasing spring tension, never by reducing it. If no adjustment is possible, install a new regulator.

(c) If the voltage reading in Step (a) is below 13.2 volts, follow the procedure described in Step (b) without the 15 minute warmup period and adjust the regulator to the 14.5 to 15 volt range.

If no adjustment of the regulator is possible, replace regulator and check for improved battery performance over a reasonable period. If an adjustment can be made, then follow the complete procedure of Step (b) including the 15 minute warmup period.

(d) On a regulator that has been adjusted, remove the test leads and replace regulator cover. Reconnect wiring to regulator, and note voltmeter reading. A voltage reading of 13.5 to 15.2 volts is permissible. However, the setting should be higher than that first noted in Step (a).

(e) Remove test instruments and check battery for improved charging performance over a reasonable service period. At a later date it may be necessary to repeat this procedure to raise the voltage setting even further.

DIDACTOR PLATES FOR AM 2-17D

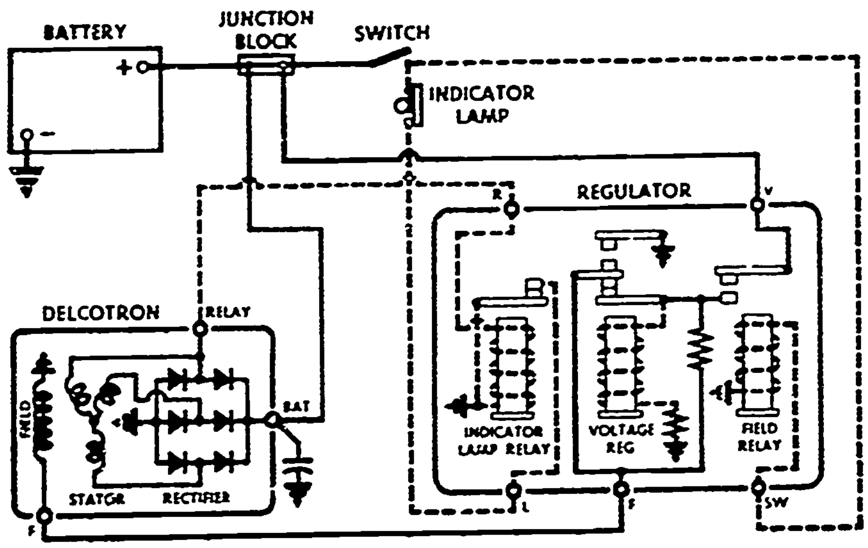

Plate I Three unit regulator (used with indicator lamp)

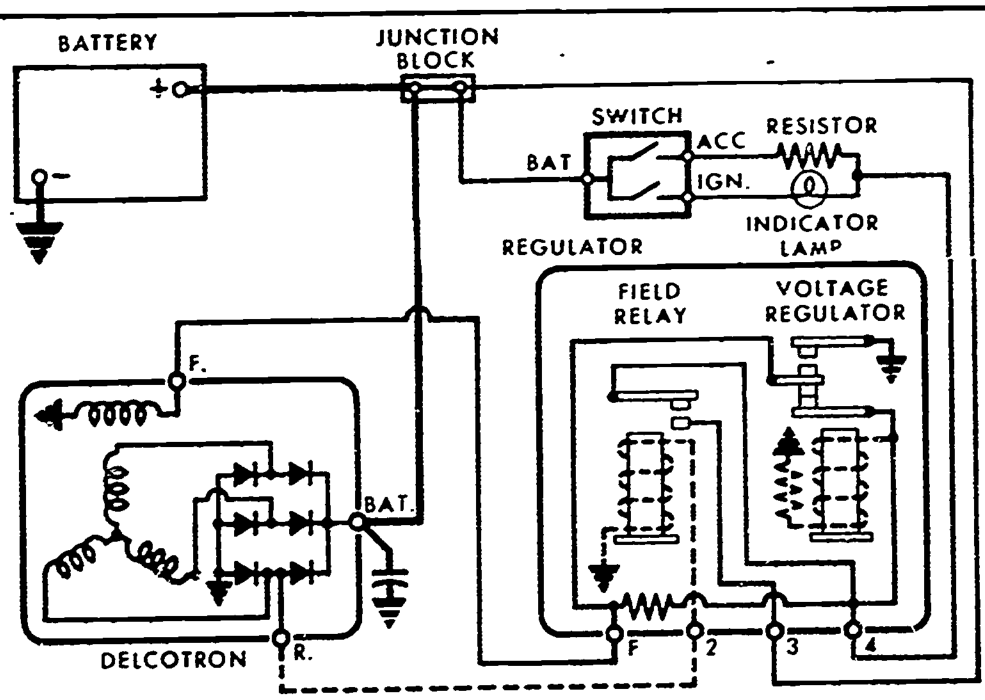

Plate II Two unit regulator (with indicator lamp)

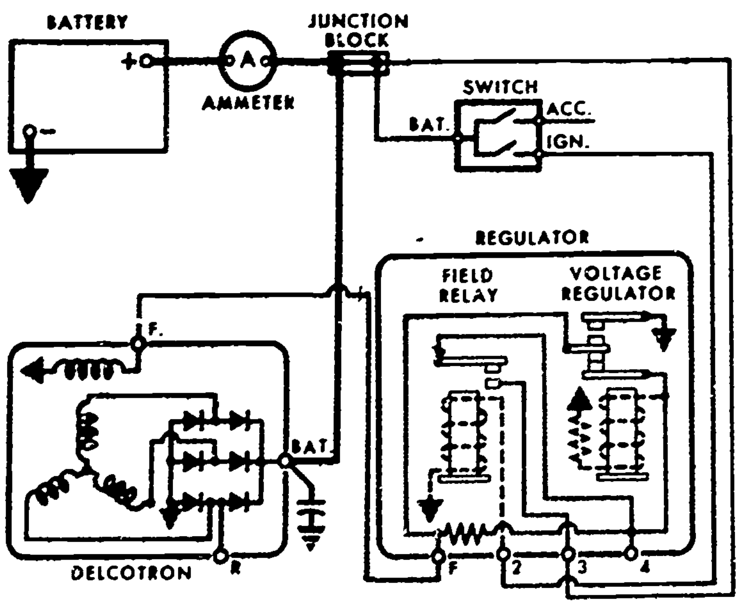

Plate III Two unit regulator (with ammeter)

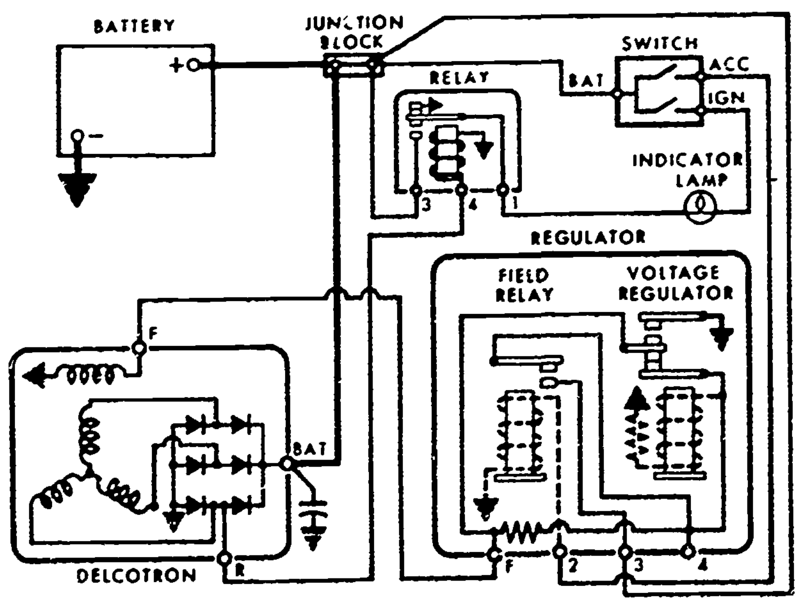

Plate IV Two unit regulator (with indicator lamp and separate field relay unit)

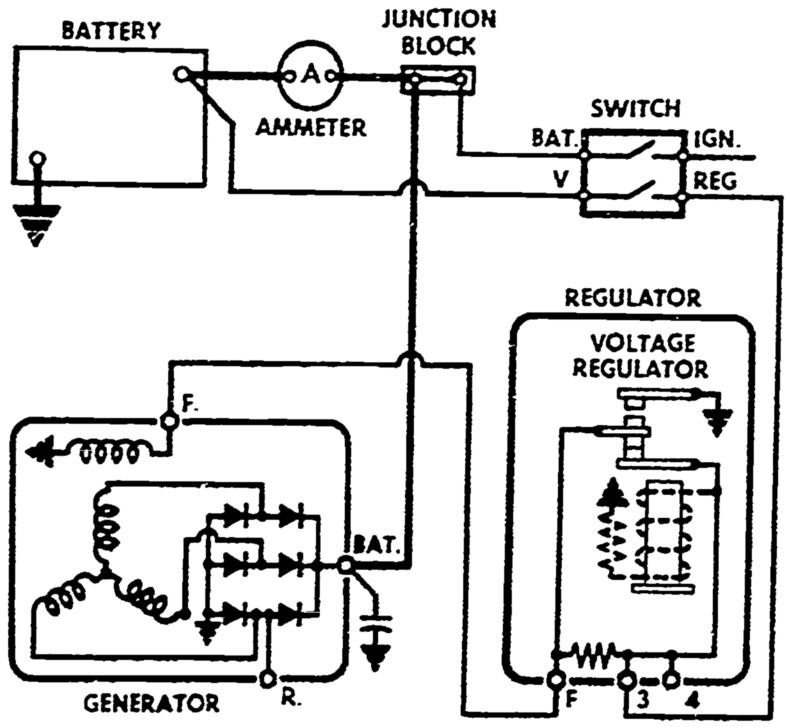

Plate V Single unit regulator (used with ammeter)

CONDITIONS WHICH MAY INDICATE TROUBLE IN ELECTRICAL SYSTEM		
Indicator lamp fails to come "ON" when switch is closed, prior to engine starting	-------	Indicator lamp Burned OUT (?)
Indicator lamp REMAINS "ON" or COMES "ON" during normal vehicle operation	-------	Trouble somewhere in the electrical system
Fully-charged battery and consistently HIGH charge rate indicated on Ammeter	-------	Trouble somewhere in the electrical system (Battery may become OVERcharged)
Battery in LOW state of charge and consistently LOW charge rate indicated on Ammeter	-------	Trouble somewhere in the electrical system (Battery will remain UNDERcharged)
(Fully-charged battery and LOW rate of charge is NORMAL condition.)		

Plate VI

CONDITION	MAY BE CAUSED BY
UNDERCHARGED BATTERY	1. Defective battery 2. Slipping alternator drive belt 3. Excessive resistance in circuit 4. Excessively LOW voltage regulator setting 5. Malfunction of Field Relay unit 6. Defective alternator (shorts, opens, grounds)
OVERCHARGED BATTERY	1. Defective battery 2. Excessive resistance in circuit 3. Excessively HIGH voltage regulator setting

Plate VII Abnormal battery conditions

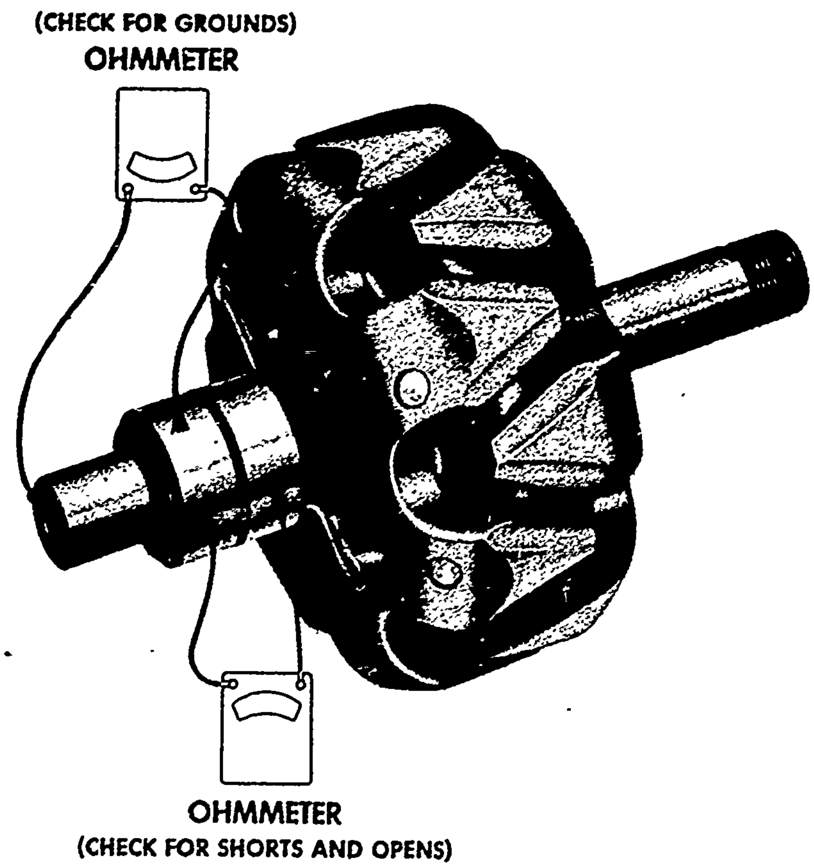

Plate VIII Field coil tests

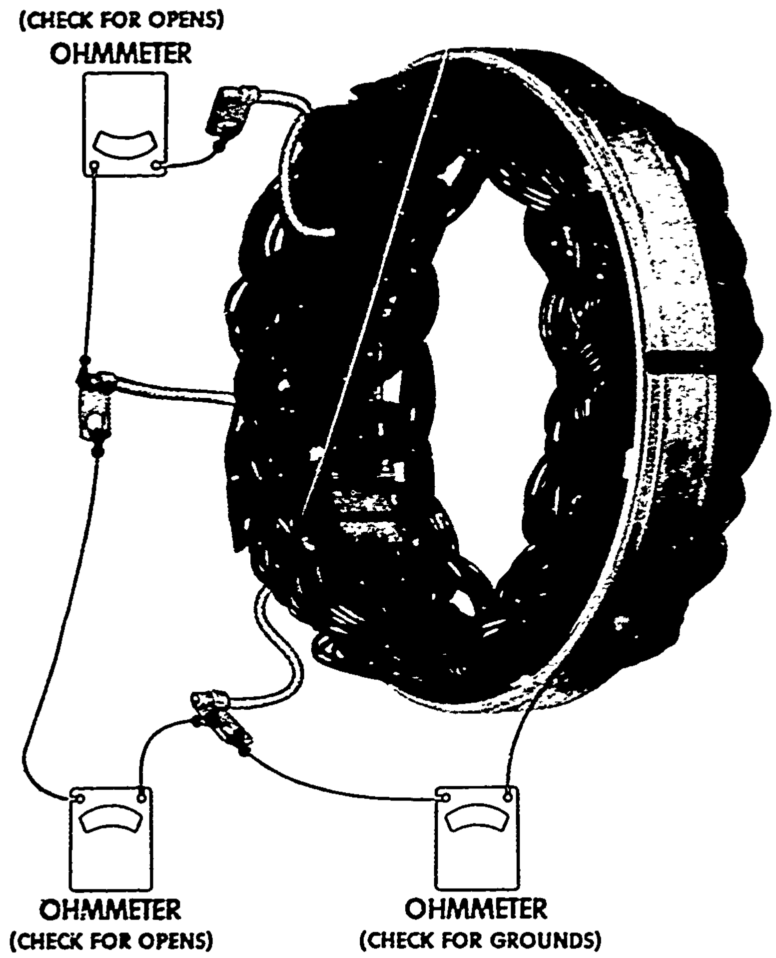

Plate IX Stator winding tests

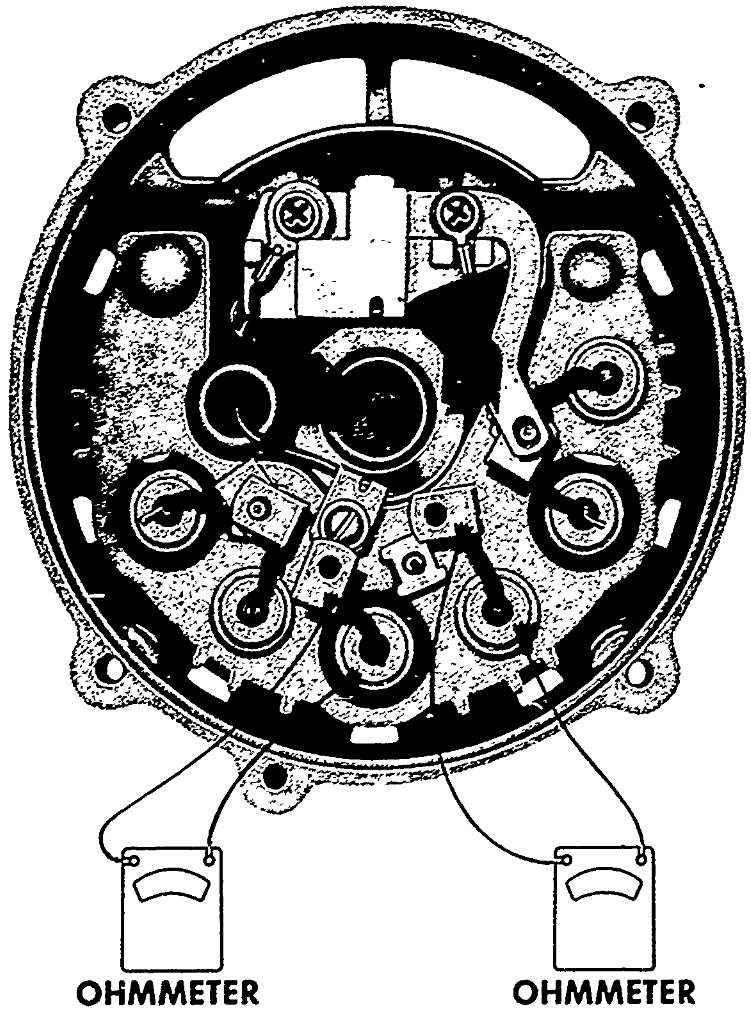

Plate X Diode tests

DIDACTOR

AM 2-17D
10/16/67

0

AC GENERATORS II --
REGULATOR AND FIELD RELAY OPERATING PRINCIPLES and ALTERNATOR TESTING

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A 1

Check to see that timer and index are OFF

1

In this film we will continue our discussion of fundamental principles of operation for automotive AC generators and system components. We will concentrate here on the voltage regulator and the field relay unit.

We will also discuss Alternator Testing Procedures.

Press A 2

1-1

2

In the previous film we learned that current passing through the field coil of an AC generator creates magnetic lines of force. Plate I illustrates a typical wiring diagram for an electrical system including an alternator and a three unit alternator regulator.

Note that if the switch is closed, either battery current or alternator current can flow in the alternator field coil.

Press A 3

1-2

3

As the switch is closed, battery current flows to the alternator field coil first. Then as the vehicle engine starts, and alternator rotation speed increases, the alternator itself supplies current to the field coil.

At the moment the vehicle starting switch is closed, __________ flows to the alternator field coil.

A. battery current 5
B. alternator output current 4

1-3

4

Incorrect.

At the instant the vehicle starting switch is closed, the alternator is not turning. Therefore, no alternator output current is being created.

Not until the vehicle engine turns over does the alternator begin to generate current.

Press A 5

1-4

5

OK.

As alternator speed increases, more field current is created. This increases the field magnetism and alternator voltage climbs even higher.

Since electrical system wiring, lights, relays and contact points may be damaged by EXCESS voltage, some means of voltage control is required.

Press A 6

1-5

6

A VOLTAGE REGULATOR is used, therefore, to limit alternator voltage to safe levels through the entire range of operating speeds.

The alternator is designed so that an external means of CURRENT control is unnecessary. By design, the alternator is capable of delivering only a given amount of current at any given regulated voltage.

Press A 7

1-6

7

A ______(1)______ unit must be used with an alternator, but a ______(2)______ unit is unnecessary.

A. (1) current regulator (2) voltage regulator 8
B. (1) voltage regulator (2) current regulator 9

1-7

8

You are incorrect.

At any given regulated voltage, the alternator is capable of generating only a certain amount of current. Therefore, if a means of controlling the voltage is provided, a CURRENT regulator is UNnecessary.

Press A 9 1-8

9

OK.

There are several different alternator regulator designs in use. The functions of these regulators are basically the same for all. They differ mainly in the number of units housed in the regulator case, and in the way they are wired into the vehicle electrical system.

Plates I - V show the various types commonly in use. Press A 10 1-9

10

The voltage regulator unit in each of the various alternator regulators operates to limit alternator voltage to pre-set values.

Note that the points in the voltage regulator units illustrated in Plates I - V are all the DOUBLE CONTACT TYPE.

A three unit alternator regulator is used in vehicles equipped with an ______________ .

A. ammeter 11
B. indicator lamp 12 1-10

11

Incorrect.

See Plate I. The alternator regulator illustrated is a THREE UNIT type. The three units included in the regulator are:

1. The FIELD RELAY unit
2. The VOLTAGE REGULATOR unit
3. The INDICATOR LAMP RELAY unit

This type of regulator is used in vehicles equipped with an INDICATOR LAMP on the vehicle instrument panel.

Press A 12 1-11

12

OK.

When the starting switch is closed, (before the engine starts) battery current flows through the indicator lamp and the indicator lamp relay points, to ground. This causes the indicator lamp to light and indicates that the alternator is not operating.

With the vehicle engine at rest, the indicator lamp relay contact points are normally ______________ .

A. closed 14
B. open 13 1-12

13

Incorrect.

The indicator lamp relay points are normally CLOSED with the vehicle engine at rest. When the starting switch is closed (and before the engine starts) current flows from the battery through the switch and indicator lamp. (See Plate I.) It then flows down to the regulator (L) terminal, up through the closed contact points, and then directly to ground.

Press A 14 1-13

14

OK. See Plate I.

As the engine starts and the alternator begins to operate, current flows from the alternator relay terminal to the regulator (R) terminal, through the indicator lamp relay windings, to ground. This creates magnetism in the relay which soon overcomes the spring tension which has been holding the contact points closed.

Press A 15 1-14

15

As the indicator lamp relay points open, the circuit is broken and the indicator lamp goes out. This indicates that the alternator is producing current.

If trouble should develop in the electrical system and cause the voltage at the alternator relay terminal to drop to a low level, spring tension will again close the indicator lamp relay points. This will cause the indicator lamp to ______________ .

A. go out 16
B. light up 17 1-15

16

Incorrect.

During normal vehicle operation, sufficient current usually flows in the indicator lamp relay coils to hold the relay contact points OPEN. As long as the points are open, the indicator lamp remains OUT.

If trouble in the electrical system develops and alternator output drops to a low level, the magnetism at the relay coil is not strong enough to hold the points open. If this occurs the points will close, due to spring tension, and the indicator lamp will LIGHT UP.

Press A 17

1-16

17

OK.

In systems with a TWO UNIT regulator and an indicator lamp (Plate II), the field relay points close, and the indicator lamp goes out as the vehicle engine is started and the alternator begins to produce current.

If you would like to review this section, press A. 2

Otherwise, press B. 19

X(C)-18

2-17

18

OK.

If the indicator lamp comes on during normal vehicle operation, it indicates that the alternator is producing low levels of current, or no current at all.

Let's have a quick review of this first section, since you have made an error on a question or two.

Press A 2

1-18

19

In the preceding section we said that the indicator lamp circuit is activated by closing the vehicle starting switch (see Plate I).

Also when the switch is closed, the FIELD RELAY winding is connected directly to the battery.

Current flows from the battery through the field relay winding, creating magnetism which causes the field relay points to CLOSE.

Press A 20

2-19

20

With the field relay points closed, current can then flow directly from the battery to the regulator (V) terminal (see Plate I). From there it flows through the closed contact points, and through the voltage regulator contacts to the regulator (F) terminal.

The current then flows on to the alternator (F) terminal, through the field coil and to ground.

Press A 21

2-20

21

Current in the alternator field coil produces magnetism which activates the poles of the rotor. As the vehicle engine begins to turn over, alternating current is induced in the stator windings. This current is rectified by the alternator DIODES, and DC voltage appears at the alternator output terminal.

A diode normally allows current to flow ____________ ____________.

A. first in one direction, then the other 22

B. in one direction only 23

2-21

22

Incorrect.

You may recall that a diode has been described as a one way gate for current, or as an electrical check valve. A diode normally allows current to pass freely in one direction, but blocks current flow in the opposite direction.

Press A 23

2-22

23

OK.

See Plate I. As the rotation speed of the alternator increases, voltage at the alternator output (BAT) terminal increases also. This increases the current flow through the field relay contact points (closed) and through the voltage regulator shunt winding. Increased current in the voltage regulator winding causes the LOWER contacts to separate (open).

Press A 24

2-23

24

As the lower voltage regulator contacts open, the field current is then directed through a resistance (indicated by  in Plate I). This reduces the current flowing in the alternator field coil.

Reducing the alternator field current will cause alternator output to ____________.

A. increase 25
B. decrease 26

2-24

25

No.

The amount of field current determines the strength of the field magnetism in the alternator.

Lowering the field current weakens the field magnetism, and fewer lines of force are available to cut across the stator windings. This causes the alternator output to DEcrease.

Press A 26

2-25

26

OK. With decreased alternator field current, the voltage at the alternator BAT terminal DEcreases.

When the voltage decreases sufficiently, spring tension overcomes the weakened magnetism of the voltage regulator winding and the lower contacts CLOSE again.

The cycle we have described then repeats many times per second to limit alternator voltage to a pre-set level at relatively low alternator speeds.

Press A 27

2-26

27

If alternator rotation speed goes even higher, much more current flows through the voltage regulator shunt winding. This causes magnetism to increase to such an extent that the UPPER contact points close.

When the upper contacts close, the field current is shorted out, and NO current flows in the alternator field winding.

Shorting out the field current will cause the voltage at the alternator BAT terminal to ______________.

A. decrease 29
B. increase 28

2-27

28

Incorrect.

Anything that reduces the field current in an alternator will cause an immediate drop in output -- the voltage that appears at the alternator BAT terminal.

Press A 29

2-28

29

OK.

As alternator voltage decreases, the magnetism of the voltage regulator winding weakens, and spring tension pulls the upper contact points OPEN.

This causes the field current to build up again, and the upper contacts re-close if alternator speed continues to be high.

The cycle repeats many times per second to limit the alternator voltage to a pre-set level at high alternator speeds. Press A 30

2-29

30

At relatively low operating speeds, the ____(1)____ voltage regulator contacts operate to keep the voltage at a safe level. At high speeds, the ____(2)____ contacts regulate the voltage of the alternator.

A. (1) upper (2) lower 31

B. (1) lower (2) upper 32

2-30

31

You are incorrect.

The lower contacts of the voltage regulator unit are closer to the regulator shunt winding than are the upper contacts. It requires less magnetic force to OPEN the lower contacts than it does to CLOSE the upper contacts.

At LOW speeds, the LOWER contacts regulate the voltage. At higher speeds, the UPPER contacts do the job.

Press A 32

2-31

32

OK.

The principles of operation for the voltage regulator unit described here are fundamentally the same, regardless of the type of alternator regulator.

In SINGLE UNIT regulators (Plate V), the voltage regulator lower contacts and a resistance between the (3) and (F) terminals perform the function of the field relay unit found in other models.

If you would like to review Alternator Voltage Regulation, press A. Otherwise, press B.
19 34

3-32

X (C)-33

33

OK. The lower contacts regulate the alternator voltage at low speeds; the upper contacts regulate the voltage at high speeds.

Since you had trouble with a question or two in this section, let's review the operation of the field relay unit and the voltage regulator unit.

Press A 19

2-33

34

INTRODUCTION TO ALTERNATOR TESTING

The remainder of this film will be devoted to testing procedures for alternators.

Just as in systems with DC generators, certain symptoms indicate trouble in the systems equipped with AC generators.

Press A 35

3-34

35

Trouble in the electrical system may be indicated in several different ways. One symptom which usually appears early is ABNORMAL BATTERY CONDITION. It is wise to check the battery FIRST when trouble-shooting any automotive electrical system.

Trouble in the system may be indicated by any of the following:

1. UNDERcharged battery
2. OVERcharged battery
3. Unusual operation of the indicator lamp or ammeter

Press A 36

3-35

36

Some of the more obvious indications of electrical system troubles are listed in Plate VI.

Which of the following are UNdesired combinations of battery STATE OF CHARGE and CHARGING RATE?

A. Low state of charge and low charging rate 38
B. High state of charge and low charging rate 37
C. High state of charge and high charging rate 38
D. A and B above 39
E. A and C above 40

3-36

37

You are incorrect. (See Plate VI.)

High state of charge and low charging rate is the NORMAL, desired combination of factors.

A high state of charge coupled with a consistently HIGH charging rate usually is an indication of trouble.

A low state of charge is, of course, undesirable under any conditions.

Press A. Try the question again. 36

3-37

38

Your answer is correct, but it is incomplete. (See Plate VI.)

UNdesirable combinations of battery state of charge and charging rate include BOTH of the following:

1. Low state of charge and low charging rate
2. High state of charge and high charging rate

Press A 36

3-38

39

Only part of your answer is correct. (See Plate VI.)

A low state of charge coupled with a low charging rate is, of course, UNdesirable -- it may lead to a seriously undercharged battery. A seriously undercharged battery is an indication of trouble in the electrical system.

A relatively HIGH state of charge and a LOW charging rate is the NORMAL (desired) condition.

Press A 36

3-39

40

Good.

Electrical system malfunctions usually result in either an overcharged or an undercharged battery. Some of the common causes for abnormal battery conditions are shown in Plate VII.

Excessive resistance somewhere in the system may result in ____________________.

A. an undercharged battery 41
B. an overcharged battery 41
C. either of the above 42

3-40

41

Your answer is correct, but it is incomplete.

Depending on where it occurs in the system, excessive resistance may cause either an increase or a decrease in the normal charging current.

INcreased charging current over an extended period will cause an OVERcharged battery; DEcreased charging current will cause an UNDERcharged battery.

Press A 42

3-41

42

OK.

Excessive resistance is one of the four major types of electrical system malfunctions. Service of the electrical system should include a visual inspection for poor or loose connections, corroded connections and frayed or broken wiring and insulation -- all of these are common sources of abnormally high resistance.

Press A 43

3-42

43

If the alternator does not provide its rated output at the speed specified by the manufacturer, and if the trouble is not revealed by visual inspection, the alternator may have to be removed and disassembled for further checks.

If excessive resistance is not the problem, the source of trouble may be a short, an open or a ground somewhere in the alternator. Let's look at the testing procedures for those malfunctions in the various alternator components. Press A 44

3-43

44

FIELD WINDING TESTS

The field windings in the rotor assembly may be checked for shorts, opens and grounds with either an OHMMETER or a 110 volt TEST LAMP. Normal values for field coil resistance can be derived from manufacturers' specifications.

To test the field coil for OPENS, connect one ohmmeter or test lamp probe to each SLIP RING. See Plate VIII.

If the ohmmeter reading is abnormally high (infinite), or if the test lamp DOES NOT light, there is an OPEN circuit in the field coil.

Press A 45

3-44

45

In the test for opens in the alternator field coil, an ohmmeter will read extremely __(1)__ if the field coil contains an open. A 110 volt test lamp connected between the slip rings __(2)__ light if the field coil is open.

A. (1) high (2) will 47
B. (1) high (2) will not 48
C. (1) low (2) will 46
D. (1) low (2) will not 47

3-45

46

Both parts of your answer are incorrect.

If the field coil is open at any point, an ohmmeter connected across the slip rings will read extremely high (infinite). An open circuit is a source of extremely high resistance.

The resistance to current flow in an open field coil is so high that a test lamp connected across the slip rings WILL NOT light.

Press A 48

3-46

47

Only part of your answer is correct.

An open circuit is a source of extremely high resistance. If there is an open in the alternator field coil:

1. An ohmmeter connected across the slip rings will read EXTREMELY HIGH (infinite).
2. A 110 volt test lamp connected across the slip rings WILL NOT light due to the high resistance to current flow.

Press A 48

3-47

17

OK. 48

The connections for the ohmmeter are the same when the field coil is tested either for opens or for shorts. (See Plate VIII.)

To test the field coil for SHORTS, connect the ohmmeter across the slip rings. If the ohmmeter reading is BELOW that specified by the manufacturer, the field coil is SHORTED.

Press A 49

3-48

49

An ohmmeter is connected across the slip rings of an alternator rotor assembly.

An extremely high reading will indicate that the alternator field coil is ___(1)___. An excessively low reading will indicate that the coil is ___(2)___.

A. (1) open (2) shorted 51

B. (1) shorted (2) open 50

3-49

50

Incorrect.

When an ohmmeter is connected across the slip rings of an alternator rotor assembly:

1. An extremely HIGH reading indicates an OPEN in the field coil.

2. An excessively LOW reading (below manufacturer's specifications) indicates a SHORT in the field coil.

Press A 51

3-50

51

OK.

The alternator field coil may be tested for grounds by using either an ohmmeter or a 110 volt test lamp. The connections are different from those in the tests for opens and shorts. See Plate VIII.

To test the field coil for GROUNDS, connect one ohmmeter probe (or test lamp probe) to EITHER of the slip rings. Connect the remaining probe to the rotor SHAFT or to one of the SEGMENTS.

Press A 52

3-51

52

With the ohmmeter (or test lamp) connected between one of the slip rings and the rotor shaft, the reading normally will be extremely high (infinite). The test lamp should not light.

If the ohmmeter reading is extremely LOW, or if the lamp lights, there is an undesired GROUND somewhere in the field coil.

Press A 53

3-52

53

If there is an undesired ground in the alternator field coil, an ohmmeter connected between one of the slip rings and the rotor shaft will read extremely ___(1)___. A 110 volt test lamp connected in the same way ___(2)___ light if there is an undesired ground in the field coil.

A. (1) high (2) will 55

B. (1) high (2) will not 54

C. (1) low (2) will 56

D. (1) low (2) will not 55

3-53

54

No.

An extremely high (infinite) ohmmeter reading or an UNlighted test lamp, indicates the ABSENCE of undesired grounds in the alternator field coil

If the ohmmeter reading is extremely LOW, or if the lamp LIGHTS UP, then there is an undesired ground in the field coil.

Press A 56

3-54

55

Only part of your answer is correct.

If there is an undesired GROUND in the alternator field coil:

1. An ohmmeter connected between one slip ring and the rotor shaft will read extremely LOW.

2. A 110 volt test lamp connected in the same way WILL light up.

Press A 56

3-55

56

OK.

A grounded circuit provides an undesired low resistance path to ground for the current. The ohmmeter reads low if there is an undesired ground in the field circuit. The test lamp will glow brightly due to the low resistance to current flow.

If you would like to review the Introduction to Alternator Testing and Field Winding Tests, press A. 34

Otherwise, press B. 58
X(C)-57

4-56

57

OK.

If the field coil is grounded, the ohmmeter will read extremely LOW and the test lamp WILL light.

You have made an error or two on the questions in this section. Let's have a quick review of the Introduction to Alternator Testing and Field Winding Tests.

When you answer all these questions correctly, we'll discuss tests for the stator windings.

Press A 34

3-57

58

STATOR WINDING TESTS

To check the stator windings, it is necessary to detach the three leads (terminal ends) from the end frame assembly and separate the stator assembly from the end frame.

The stator windings may be tested with either an ohmmeter or a 110 volt test lamp.

Press A 59

4-58

59

Keep in mind that there are three sets of stator windings. An open, a ground or a short can occur in any of the three.

To test the stator windings for OPENS, connect the ohmmeter or test lamp between any two of the stator winding terminal ends. See Plate IX.

If the ohmmeter reads extremely high, or if the test lamp fails to light, then there is an OPEN.

Press A 60

4-59

60

If a 110 volt test lamp LIGHTS UP when connected between two terminal ends of a stator winding assembly, it indicates that there ______________.

A. is an open in one of the windings 61
B. are no opens in any of the windings 62
C. are no opens in at least two of the three windings 63

4-60

61

You are incorrect.

A LIGHTED test lamp (or a LOW ohmmeter reading) indicates that there are NO opens in the circuit formed by the two windings being tested.

It does not, however, indicate the absence of opens from all three windings.

Press A 63

4-61

62

Not necessarily.

A LIGHTED test lamp (or a LOW ohmmeter reading) does indicate the absence of opens -- but only in the circuit formed by the two windings being tested.

Testing only two windings does not assure that the third winding is free from opens.

Press A 63

4-62

63

OK.

Even if you test two of the windings and find no opens, it still is necessary to test the third winding.

Merely remove one of the probes from either of the first two windings tested, and touch it to the terminal end of the yet untested winding.

Then if the lamp does not light, or if the ohmmeter reads extremely high, you will know that there is an OPEN in the third winding.

Press A 64

4-63

64

For the purposes of identification, we will again refer to the windings as (A), (B) and (C).

The following are the results obtained in a lamp test for open stator windings:

(A) and (B) tested together --- LAMP LIGHTS

(B) and (C) tested together --- NO LIGHT

From these results, we know that ______________ contains an OPEN.

A. winding (A) 65
B. winding (B) 65
C. winding (C) 66

4-64

65

Incorrect.

When windings (A) and (B) were tested together, the test lamp lit up. That means that there are NO opens in the A-B phase of the stator assembly -- no opens in winding (A) and none in winding (B).

But when the B-C phase was tested, the lamp DID NOT light. That means that there IS an open in the B-C phase.

Since we already know that winding (B) is free from opens, the open must be in winding (C).

Press A 66

4-65

66

OK. The A-B phase did not contain an open, but the B-C phase did. Therefore, winding (C) is open.

To test the stator windings for GROUNDS, connect the ohmmeter between any one of the terminal ends and the stator assembly frame. See Plate IX.

If the ohmmeter reading is extremely low, or if the test lamp lights up, then the winding being tested contains an undesired GROUND.

Press A 67

4-66

67

In a stator assembly ohmmeter test for grounds, the following results were obtained:

Winding (A) --- HIGH reading
Winding (B) --- LOW reading
Winding (C) --- HIGH reading

From these results, we know that ______________.

A. windings (A) and (C) are free from grounds, but winding (B) contains an undesired ground 69

B. winding (B) is free from grounds, but both windings (A) and (C) contain undesired grounds 68

4-67

68

No.

If an ohmmeter (or 110 volt test lamp) is connected between any stator winding lead and the stator assembly frame, a LOW reading (or a LIGHTED test lamp) indicates the presence of a GROUND in the winding being tested.

In the example given, only winding (B) gave a low reading. That means that winding (B) contains an undesired ground, but windings (A) and (C) are free from grounds.

Press A 69

4-68

69

OK.

It is very difficult to locate a SHORT in the stator windings because of their low resistance. Special laboratory equipment is required to make a positive check. However, if the alternator fails to supply its rated output, and ALL other electrical system tests are NORMAL, a shorted stator winding is indicated.

If you would like to review Stator Winding Tests, press A. 58

Otherwise, press B. 71 X(C)-70

5-69

70

OK.

Because of the normal low resistance in the stator windings, it is extremely difficult to test them for SHORTS. A shorted stator winding is indicated, however, if the alternator fails to supply its rated output, and ALL other electrical system tests are normal.

Since you had trouble with at least one question, let's have a quick review of Stator Winding Tests.

Press A 58

4-70

71

DIODES

The diodes used in alternators are fairly rugged components -- when handled properly.

Impacts should be avoided, since a diode contains a thin wafer of active material which may crack. Excessive bending of the diode lead should be avoided also, since this may crack the glass insulator and allow moisture to enter the diode.

Press A 72

5-71

72

Avoid pulling the diode lead, since this may result in a break in the soldered joint (inside) between the diode lead and the wafer (die) of active material.

The diode is subject to SHORTS and OPENS.

Let's see how diodes are tested.

Press A 73

5-72

73

The test for shorts and opens in the diodes may be performed with either an ohmmeter or a low voltage test lamp.

CAUTION: A 110 VOLT TEST LAMP MUST NEVER BE USED TO TEST DIODES!

110 volts would instantly burn out the diodes. The test lamp voltage should not exceed 12 volts (on 12 volt systems).

Press A 74

5-73

74

DIODE TESTS

A diode test will reveal whether or not the diode is DEFECTIVE -- it is unnecessary to know specifically whether the trouble is a SHORT or an OPEN. If a diode is found to be defective for any reason, it must be replaced. Diodes are not serviceable.

High voltage _________ damage a diode.

A. will not XX
B. will 75

(Only the correct answer will move the film.) 5-74

75

OK.

To test the diodes with an OHMMETER, use the lowest meter scale range and a 1 1/2 volt cell. The tests are performed with the diode leads disconnected.

To test a diode mounted in the heat sink, connect one ohmmeter probe to the diode CASE. Connect the other ohmmeter probe to the disconnected diode lead. See Plate X.

Press A 76

5-75

76

Note whether the reading is very high or very low. Then reverse the ohmmeter probes and again note the reading.

If BOTH readings are either very high or very low, then the diode is defective and must be replaced.

In an ohmmeter test, a good diode will read very _________________.

A. high in both directions 77
B. high in one direction and very low in the other 78
C. low in both directions 77

5-76

77

You are incorrect.

A GOOD diode will read very high in one direction and very low in the other. Remember that a diode allows current to pass in one direction only.

This means that current can flow freely in one direction (very low resistance), but will be blocked from flowing in the opposite direction (very high resistance).

Press A 78

5-77

78

OK.

The ohmmeter test for diodes mounted in the end frame is exactly the same. See Plate X.

Connect one ohmmeter probe to the diode CASE and the other to the diode lead. Note the reading. Reverse the connections and note the reading again.

If both readings are approximately the same, the diode is _____________.

A. defective 80
B. good 79

5-78

79

No.

If both ohmmeter readings are nearly the same (both HIGH or both LOW), the diode is DEFECTIVE.

In a good diode the two readings are different -- one is high, the other low.

Press A 80

5-79

80

OK.

If a test lamp is used to check the diodes, the test probes are connected in exactly the same way as in the ohmmeter test.

To check a diode mounted in the heat sink, connect one test lamp probe to the diode case. Connect the other test lamp probe to the ____________.

A. heat sink 81
B. end frame 82
C. diode lead 83

5-80

81

No.

The heat sink diode cases are in contact with the heat sink. It is meaningless to connect one test lamp probe to the diode case and the other to the heat sink. The test lamp would not light, but this would mean nothing with regard to the diode test.

Press A 83

5-81

82

No.

If one test lamp probe is connected to the case of a heat sink diode, and the other probe to the end frame, the lamp will not light. The heat sink and the end frame are insulated from each other, so an open circuit exists between them.

AN UNlighted test lamp in this instance would have no meaning with regard to testing the diode.

Press A 83

5-82

83

OK.

First connect the test lamp between the diode case and the diode lead (as in Plate X). Note whether the lamp LIGHTS or not. Then reverse the leads and again note whether or not the lamp lights.

If the lamp lights in both directions, or if it fails to light in both directions, the diode is ____________.

A. good 84
B. defective 85

5-83

84

No.

If you obtain the same results in BOTH directions -- lamp ON in both directions, or lamp OFF in both directions -- the diode you are testing is DEFECTIVE and must be replaced.

Press A 85

5-84

85

OK.

If the diode is good, the test lamp WILL light when the probes are connected in one way, but it WILL NOT light when the connections are reversed.

To check a diode mounted in the end frame, connect the test probes to the diode case and to the ____________.

A. diode lead 86
B. heat sink XX
C. end frame XX

(Only the correct answer will move the film.)

5-85

86

OK.

Remember to place the probes of the ohmmeter or test lamp carefully when checking diodes.

Keep in mind that diodes may be damaged by improper handling and excess voltage.

If you would like to review Diodes and Diode Testing, press A. 71

Otherwise, press B. 88 X(C)-87

5-86

87

OK.

Since you have made an error on a question or two in this section, let's have a brief review of Diodes and Diode Testing.

Read carefully and take your time in selecting your answers.

Press A 71

5-87

88

Congratulations! You have successfully completed this film.

If you would like to review the three sections on Alternator Testing, press A. 34

Otherwise, press REWIND.

5-88

INSTRUCTOR'S GUIDE

Title of Unit: LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART II)

AM 2-17
10/5/67

OBJECTIVES:

1. To review the operating principles of alternators and alternator regulators, and their relation to each other.
2. To discuss the construction of the alternator, including the rectifier assembly, the function of the diodes and their relation to each other.
3. To compare the alternator with the DC generator and discuss the primary differences.
4. To introduce the student to alternator servicing and testing.
5. To discuss alternator regulator servicing and general troubleshooting of the charging system.

LEARNING AIDS suggested:

Visual aids:

Delco-Remy Training Charts and Manuals

9011-A "DELCOTRON" Generator

DR-5221 Periodic Maintenance and Circuit Checks

Models:

Any alternator components or assemblies that could be brought into the classroom for disassembly and discussion. Ammeter, voltmeter and ohmmeter as well as a diode tester may be demonstrated.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What purpose do the brushes serve in an alternator?
2. What is the name given to the diodes as an assembly?
3. What is the purpose of the diodes in an alternator?
4. What is the purpose of the capacitor, or condenser, mounted in the end of the alternator?
5. What part of the alternator is associated with the electromagnetic principle?
6. How is an electromagnet formed in an alternator?

7. What purpose do the two slip rings serve in the alternator?
8. How does the alternator field circuit compare to the field circuit in a DC generator? (Location? Rotating? Stationary?)
9. Explain how the field circuit is energized in an alternator and in a DC generator. What is meant by "self excited" and "externally excited"?
10. How is current transferred to the stator winding?
11. When testing alternator components for opens and grounds with a test lamp, what is indicated if the test lamp does not light when connected to both slip rings of the rotor?
12. Is it practical to check the stator winding for shorts with an ohmmeter? Explain.
13. What is the condition of a diode checked with an ohmmeter, when you connect one test lead to the diode lead and the other test lead to the diode case, note the reading and then reverse the leads, you find that the readings are the same? Is the diode defective or electrically good?
14. Explain what is meant by a three unit regulator, a two unit regulator and a single unit regulator. How do they differ?
15. Why is it unnecessary to have a cutout relay in alternator charging circuits?
16. Explain how alternator current is limited to a safe value.
17. Why is it important to have battery and alternator ground polarity the same when installing a battery?
18. What is the correct procedure for connecting a booster slave battery?
19. What is meant by the precaution: never operate the alternator on an open circuit?
20. Why is it unnecessary to polarize an alternator?
21. When running an alternator output test by jumping the field from the output terminal, why is it important to watch the engine speed and the voltage reading?
22. When looking for the cause of an undercharged battery, if the alternator checks all right, what is the probable cause of the undercharged condition?

23. Is there any difference in the charging voltage at the voltage regulator with the cover on or off? Explain.

24. Why is it necessary to run the engine 15 minutes before making any adjustments on the voltage regulator?