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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT XX, TROUBLESHOOTING ELECTRICAL SYSTEMS.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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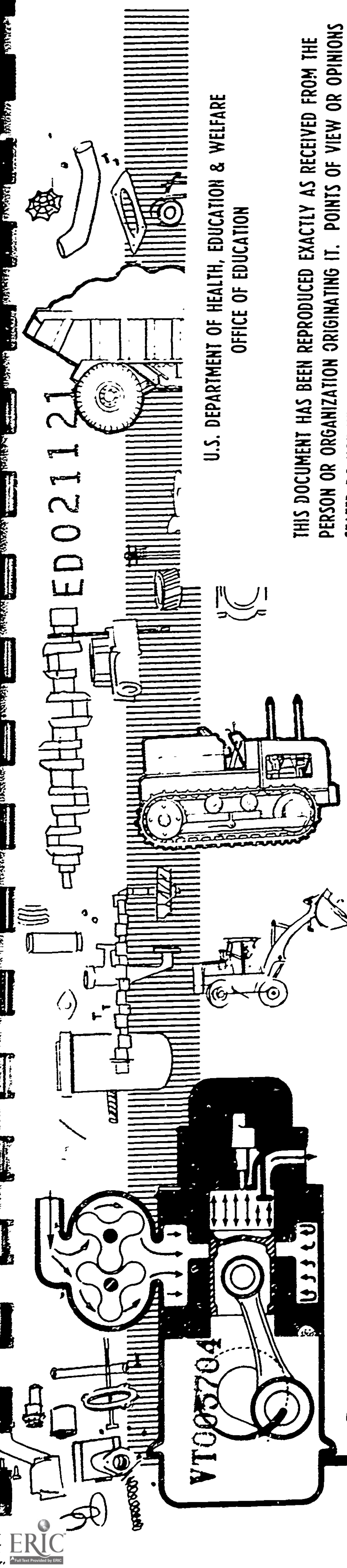
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO ACQUAINT THE TRAINEE WITH TROUBLESHOOTING PROCEDURES FOR DIESEL ENGINE ELECTRICAL SYSTEMS. TOPICS ARE (1) TROUBLESHOOTING ELECTRICAL SYSTEMS (INTRODUCTION), (2) TOOLS AND INSTRUMENTS FOR TROUBLESHOOTING, (3) THE BATTERY, (4) PERIODIC BATTERY SERVICING, (5) THE DC CHARGING SYSTEM, (6) PERIODIC REGULATOR SERVICING, (7) THE WIRING CIRCUIT, (8) GENERAL TROUBLESHOOTING OF THE CHARGING SYSTEM, (9) THE AC CHARGING SYSTEM, (10) THE CRANKING SYSTEM (ELECTRICAL), AND (11) GENERAL TROUBLESHOOTING OF THE CRANKING SYSTEM. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "TROUBLESHOOTING ELECTRICAL SYSTEMS (INTRODUCTION TO BASIC AND GENERAL PROCEDURES)" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 006 685 - 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

TROUBLESHOOTING ELECTRICAL SYSTEMS

UNIT XX

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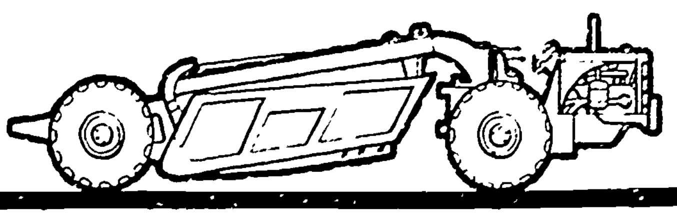

HUMAN ENGINEERING INSTITUTE

SECTION A -- TROUBLESHOOTING ELECTRICAL SYSTEMS (INTRODUCTION)

The troubleshooting procedures covered in this Unit are aimed at the types of electrical equipment commonly used on passenger cars and light trucks. They may apply equally well to similar equipment used in other applications, since the treatment is general and the equipment is very much alike. Being general and basic in nature, the test procedures are not intended to cover all aspects of troubleshooting. For detailed procedures applying to specific types of equipment, reference should be made to the manufacturer's specifications and service bulletins pertaining to the equipment in question.

This Unit presents an approach to servicing electrical equipment as performed on-the-vehicle. It is the intent first to present the periodic maintenance requirements of each component of the electrical system and, secondly, to present a basic troubleshooting approach to the electrical system.

The objective of a troubleshooting procedure is to isolate the cause of trouble in a particular part of the system. As an example, if the battery is consistently discharged, an effective checking procedure should determine if the defect is in the battery, in the generator or alternator, in the regulator or in the wiring.

Since the battery is a part of each electrical system, battery maintenance and testing procedures are covered in sections separate from the individual system checks. The battery sections (Sections C and D), should be considered as part of each of the other sections. When analyzing trouble in any of the systems, the battery should be checked first.

SECTION B -- TOOLS AND INSTRUMENTS FOR TROUBLESHOOTING

Many types of tools and instruments are used in the service field to check the mechanical and electrical condition of the various types of automotive electrical equipment. Special tools and instruments have been developed by many of the test equipment manufacturers. They are often designed to perform one or a group of tests. This type of equipment usually provides a quick and accurate method for a specific check (or series of checks). However, since this speciality test equipment is not commonly found in all service or repair centers, this Unit will refer, as much as possible, to the basic instruments used in electrical equipment testing procedures.

The three most commonly used instruments are the voltmeter, the ammeter and the ohmmeter.

THE VOLTMETER -- Voltage is the force or electrical pressure in a circuit. It is similar to the water pressure in a hose (as shown in Figure 1). The instrument used to measure the electrical pressure is called a voltmeter, and measurement is given in units called volts.

The accuracy of the reading obtained from the voltmeter will, of course, depend upon the accuracy of the meter used. Voltmeter scales should be calibrated in one-tenth of a volt divisions, as settings with a one-tenth volt variation are often specified. Greater accuracy is desired in the voltmeter than in any other electrical checking instrument.

Voltmeters are always connected across, or parallel, with the circuit or part of the circuit. They measure the difference in electrical pressure between the points where the voltmeter leads are attached. As an example, a voltmeter connected across the battery posts (one lead

to one battery post and one lead to the other battery post) measures the difference in electrical pressure between the two terminals -- this is battery voltage.

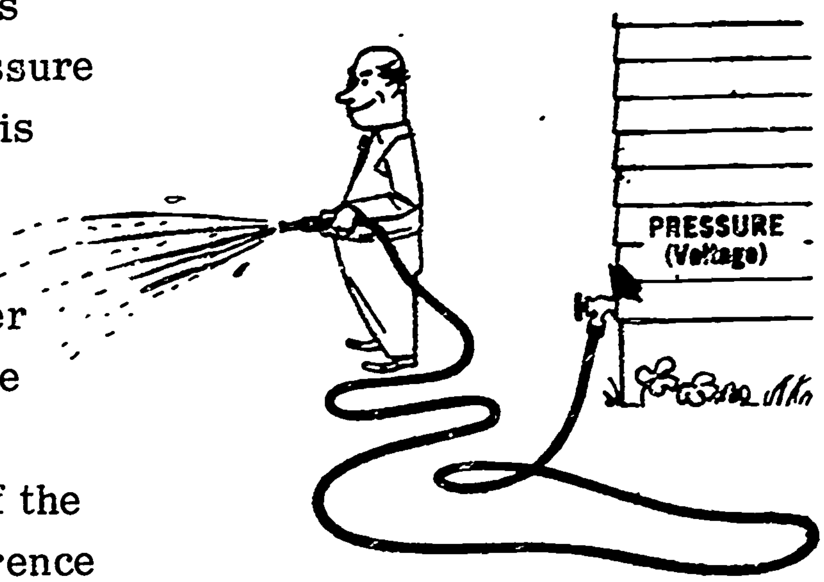

Fig. 1 Pressure (voltage)

As another example, a voltmeter connected across a resistor (one lead to one side of the resistor and one lead to the other side of the resistor) will indicate the difference in voltage from one side of the resistor to the other.

As a third example, a voltmeter connected across a portion of a circuit (one lead to a point in the circuit and one lead to the return side of the circuit) will measure the voltage difference across that portion of the circuit. Stated another way, the voltmeter measures the voltage available at that point in the circuit.

THE AMMETER -- Current is the movement of electrical particles in a circuit, similar to the quantity of water that flows in a water hose. The amount of current flow in a circuit depends on both the voltage or electrical pressure available to push it, and on the amount of resistance encountered in the circuit. The instrument used to measure the amount of current flow is called an ammeter. Measurement is given in units called amperes.

Ammeters are connected in series with the circuit in which the current is to be measured. Often, external shunts are provided so that only a small portion of the total current passes through the instrument itself. See Figure 2.

THE OHMMETER -- Resistance is that property of the wiring or electrical

units which resists (limits) the flow of current in a circuit, and which causes voltage losses (electrical pressure drops) around the electrical circuit. This is similar to the resistance or obstruction in the water hose, shown in Figure 3. Resistance is measured directly by an ohmmeter, and the measurement is gi-- n in units called ohms.

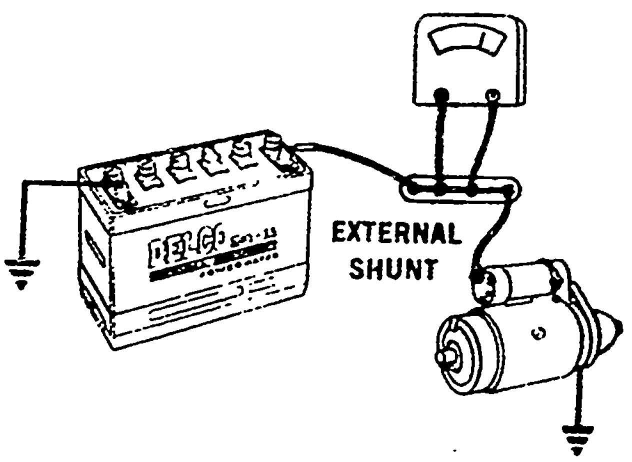

Fig. 2 External shunt with ammeter

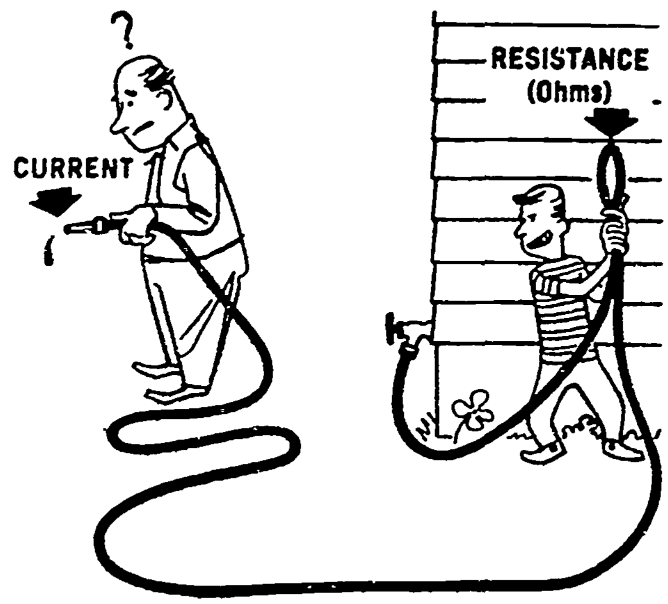

Fig. 3 Resistance (ohms)

Excessive resistance in a circuit can be caused by poor connections, frayed wires, partially broken wires, or undersize wires or cables. Excessive resistance will restrict the flow of current, and an excessive drop or decrease in voltage will exist across the resistance. Excessive resistance, therefore, can be detected by a voltmeter as well as by an ohmmeter.

Ohmmeters are connected across the unit or portion of the circuit in which the resistance is to be measured. The ohmmeter has its own power source, usually a small battery, which forces current through the circuit to be measured. Any circuits or paths for current flow, which are parallel with the circuit to be measured, must be disconnected to prevent an erroneous reading on the ohmmeter. Also, since the ohmmeter has its own power source, it should never be used on circuits that have their own power source connected. An external power source

can force current through the ohmmeter, giving an erroneous reading and perhaps damaging the meter.

When making on-the-vehicle checks, the ohmmeter is rarely used because of the problems of parallel paths and external power sources. The voltage drop method can be used to detect excessive resistance that might occur in the vehicle. When the voltage drop is higher than expected, the resistance also is higher than it should be, and the cause of high resistance should be corrected.

SECTION C -- THE BATTERY

When electrical trouble is experienced in any circuit, the battery cannot be overlooked as a possible source of trouble. Since a visual inspection and a few quick electrical checks readily will reveal the condition of the battery, it always is advisable to start any circuit check with the battery. Otherwise, a component of some circuit which fails to function properly, may be unjustly condemned.

For example, if the battery has a shorted cell, overcharging will probably result. In this case, the generator, alternator or regulator will appear to be at fault. If a battery cell has an open or high resistance connection, cranking motor operation also will be affected, but replacing the cranking motor will not cure the trouble. If the battery is badly sulfated, consistently low specific gravity readings, slow cranking, and possibly poor ignition performance during starting may be experienced. In any case, neither the cranking system nor the ignition system should be blamed.

Since the battery is common to all the electrical systems, it is logical that it should be checked first. If it is proven to be defective, it should be replaced. If it is found merely to be undercharged or overcharged, further checks of the circuits are indicated.

SECTION D -- PERIODIC BATTERY SERVICING

A large number of premature battery failures can be eliminated if four important points are considered:

1. Correct application
2. Proper activation
3. Correct installation
4. Periodic servicing

CORRECT APPLICATION -- Long and troublefree service can be anticipated only when the ampere hour capacity is balanced with the electrical load. The use of an undersize battery will result in poor performance or early failure. When the battery is replaced, the replacement battery should be at least equal to the original battery in ampere hour rating.

PROPER ACTIVATION -- Proper activation of dry charged batteries is extremely important. Improper activation always results in poor performance or early failure. The full charge hydrometer test, which was covered in the Unit on batteries, (AM 2-13), can help you determine if the battery has been properly activated. For 12 volt dry charged batteries (of less than 100 ampere hour capacity; activated with electrolyte at a temperature under 60 F) and for batteries which are expected to go into immediate operation in below freezing weather, it is recommended that a warm-up charge of 15 amperes for a ten minute period be given.

CORRECT INSTALLATION -- Correct installation of a battery also is important, since the case or cover can be broken by improper handling or installation. The hold-down bolts should be kept tight enough to prevent the battery from shaking in its holder. This could damage the battery case. However, they should not be tightened to the point where the battery case will be placed under a severe strain.

The battery should be installed in its carrier with the positive and negative posts in proper position. Reversing the battery polarity can lead to generator or alternator, regulator, or ignition problems.

When connecting battery cables, the ground strap should be connected last to prevent arcing. Cable clamps should be cleaned to insure good, low resistance connections. A coating of petrolatum should be applied to the battery posts and cable clamps to prevent corrosion.

The battery carrier should be clean and free from corrosion before installing a battery. Corrosion on the carrier will accelerate the rate of corrosion growth on the battery. The carrier also should be in sound mechanical condition, so that it will adequately support the battery and keep it level.

PERIODIC SERVICING -- A battery is a perishable item which requires periodic servicing. Therefore, a good maintenance program for the battery will insure the longest possible battery life.

Battery servicing is covered in Unit AM 2-13, Section E -- BATTERY INSTALLATION, SERVICING AND TESTING.

SECTION E -- THE DC CHARGING SYSTEM

The DC charging system consists of the generator, the regulator, the battery and wiring. The individual units comprising the charging system will be discussed, since the functioning of an individual unit may be affected by other units in the system.

GENERATOR -- The generator supplies electricity when driven mechanically by the engine. The generator must supply current both to the battery, (to keep it in a charged condition), and to any connected

electrical load. When the standard generator is either at rest or is operating at an extremely slow speed (such as at engine idle), electrical power is supplied by the battery only -- not by the generator. When the generator is operating at low speeds, electrical power is supplied to the electrical system by the generator, or by both the generator and the battery, depending upon generator speed and the amount of the electrical system load. At medium and high speeds, the generator alone supplies the electrical energy to recharge the battery and to power the electrical system.

There are two basic internal electrical circuits used with DC generators -- the "A" circuit and the "B" circuit.

"A" circuit generators can be identified by tracing or observing the connections at the generator brushes and field coils. If the field coil lead is connected to the INSULATED brush inside the generator, the generator is of the "A" circuit type.

If the generator field coil is connected to the GROUNDED brush inside the generator or to the generator frame, the generator is of the "B" circuit type.

Since the two systems require different procedures for checking and adjusting, it is important to know which circuit is being used. The regulator must be compatible with the generator, as the two types -- "A" and "B" circuits-- are not interchangeable.

Generators with HINGE CAP OILERS should have eight to ten drops of medium weight engine oil added at each vehicle lubrication period. Do not over-oil, as this might wash out the grease that is packed into the bearings. Generators without hinge cap oilers are lubricated at the time of manufacture for several thousand miles or several hundred hours of maintenance-free operation. However, at engine overhaul or every 12 months, the bearings should be cleaned, inspected and re-lubricated in accordance with manufacturer's specifications.

Periodically, the FAN BELT should be examined for wear or glazing due to slipping and bottoming in the pulley. Replace the belt, if necessary. Loose or slipping belts quite often are the cause of a run down battery. Tighten the belt according to the vehicle manufacturer's specifications, if necessary.

Check the generator pulley for side play and for freeness of rotation to determine the condition of the bearings. If the BEARINGS are rough, worn or have excessive side play, remove the generator for servicing or replacement.

From the commutator end of the generator, inspect the BRUSHES for wear and for freeness of movement in the brush holders (if possible without removing from vehicle). If brushes are half worn, they should be replaced. The commutator should be inspected at the time of brush replacement.

Burned spots on the commutator bars may indicate a defective ARMATURE. In such a case, the armature should be removed from the generator and checked for the cause of the burned bars. The commutator may have developed a glazed, oxidized or dirty surface. In this case, the commutator must be cleaned with No. 00 sandpaper or with a brush seating stone. In extremely bad cases, it may need to be turned down on a lathe. High mica between the commutator bars will cause rapid brush wear and arcing. Undercutting of the mica is indicated in this case. Thrown solder indicates that the generator has become overheated. The generator should be checked for the cause of this overheating.

After disconnecting and reconnecting generator or regulator leads, or after installing new units in the DC charging system, the generator must be polarized before the engine is started. On "A" circuit systems, this is done by momentarily connecting a jumper lead between the GEN and BAT terminals of the regulator. Failure to do this

may result in damage to the regulator since reverse generator polarity causes fluttering, arcing, and burning of the cutout relay contact points. On "B" circuit systems, polarizing is accomplished by disconnecting the field lead from the regulator terminal and momentarily touching it to the BAT terminal of the regulator.

REGULATOR -- Most DC generator regulators are three unit, vibrating contact types, consisting of a cutout relay, voltage regulator and current regulator.

The CUTOUT RELAY is a magnetically operated switch that connects and disconnects the generator to and from the battery at the correct times.

When the generator voltage becomes high enough for charging, the cutout relay magnetically closes. When the generator slows down and the generator voltage drops below the battery voltage, the cutout relay opens, protecting the battery from discharging through the generator.

The VOLTAGE REGULATOR limits the generator voltage to a safe value by regulating the generator field current. This prevents high charging system voltage from developing. Thus, the battery is protected from an overcharge, and the electrical accessories in the vehicle electrical system are protected from high voltage and its accompanying high current and heat.

The CURRENT REGULATOR limits the generator output current to a safe value by regulating the generator field current. This prevents excessively high output current from developing in the generator. The generator is protected from overheating by preventing current rates in excess of rated output.

SECTION F -- PERIODIC REGULATOR SERVICING

Normally, periodic service of the regulator is not required. However, an abnormal fluctuation of the charge indicator when in operation, or when the voltage or current regulator is being tested, indicates the possibility of an oxidized condition of the regulator CONTACT POINTS. This condition may cause a high resistance in the generator field circuit, which will reduce generator output. Reduced generator output can, in time, be the cause of an undercharged battery.

The contact points of the regulator will not operate indefinitely without some attention. It has been found that a majority of all regulator trouble can be eliminated by cleaning the current and voltage regulator contact points, although some readjustment may be necessary.

Tests which may indicate the need for contact point cleaning are as follows:

"A" and Double Contact Circuits

1. With the engine stopped, disconnect the battery lead from the regulator terminal marked BAT. Connect test ammeter leads to BAT terminal and battery lead (in series).

2. Turn on headlights. Start engine and adjust engine speed until test ammeter reads exactly five amperes.

3. Disconnect field lead from regulator "F" terminal and ground the lead. If ammeter reading increases more than two amperes, oxidized contact points are indicated. Regulator should be removed and contacts cleaned before proceeding to any other regulator tests.

   CAUTION FOR DOUBLE CONTACT REGULATOR: Never use a jumper to ground the generator or regulator field terminal when these units are connected and operating together. This might burn the contacts of the voltage regulator.

"B" Circuits

1. With the engine stopped, disconnect the battery lead from the regulator terminal marked BAT. Connect test ammeter leads to BAT terminal and battery lead (in series).

2. Turn on headlights. Start engine and adjust engine speed until test ammeter reads exactly five amperes.

3. Touch jumper lead between GEN terminal and "F" terminal of regulator. If ammeter reading increases more than two amperes, oxidized contact points are indicated. Regulator should be removed and contact points cleaned before proceeding to any other regulator test.

Because of the different materials used in the manufacture of contact points, care must be exercised when cleaning them. The material used in some contacts is soft and can be easily damaged unless the proper cleaning methods are used. Other contact materials are hard and require a different method of cleaning.

For example, the contact points used in double contact regulators and cutout relays are soft. They should be cleaned with a strip of No. 400 silicon carbide paper or its equivalent, folded over and then pulled back and forth between the contacts. 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 and washing process.

On standard regulators, the large flat contact of the voltage regulator unit is made of a hard material. It usually will require more attention than the mating contact, which is a soft material. Likewise, the large flat contact of the current regulator is hard. Contact points made of a hard material should be cleaned with a spoon or riffler file. All oxides should be removed so that the pure metal is exposed, although it is not necessary to file the surface perfectly flat in order to remove a cavity that may have developed. After filing the point, it should be thoroughly

washed with trichlorethylene or some other nontoxic solution.

The opposite, or mating contact point of the voltage regulator and current regulator is made of a soft alloy which does not oxidize. Consequently, this contact point may be cleaned with a strip of No. 400 silicon carbide paper or other fine abrasive material, followed by a thorough wash with trichlorethylene to remove any foreign material remaining on the contact surface. CAUTION: NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN CONTACT POINTS.

SECTION G -- THE WIRING CIRCUIT

The wiring circuit is just as important a part of the charging system as the electrical units themselves. Undersize wire or loose connections between the regulator and battery, or poor ground connections between the battery and the generator will cause a lowering of the charging rate to the battery. High resistance resulting from loose or corroded connections in the charging circuit (between the generator and regulator) will result in a high voltage at the generator and may cause premature failure of the regulator contacts.

PERIODIC WIRING SERVICE -- A visual inspection of the wiring system often will reveal much useful information regarding the condition of the charging system. All wiring should, periodically, 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.

Unwanted resistance in the circuit results in unwanted voltage losses. Excessive voltage drop in the charging circuit tends to keep the battery in an undercharged condition. To check for excessive voltage drop, resulting from loose connections or other high resistance not readily

visible in the charging circuit, proceed as follows:

EXCESSIVE VOLTAGE DROP CHECK -- STANDARD THREE-UNIT REGULATOR; "A" CIRCUIT AND DOUBLE CONTACT REGULATOR:

1. Insert test ammeter between the regulator BAT terminal and the battery lead.
2. Disconnect the field lead from the regulator "F" terminal and connect a 25 ohm, 25 watt variable resistance (with an open position) between this lead and ground of the regulator. Turn variable resistance to the open position.

   Double contact regulator caution: Do not ground "F" terminal of regulator.
3. Turn off all vehicle accessory loads.
4. Start and adjust engine speed to 1000 rpm.
5. Adjust the variable resistance unit until the ammeter indicates exactly 20 amperes. Do not allow voltage to exceed 16 volts. It may be necessary to place a carbon pile load directly across the battery to obtain the 20 ampere load without exceeding 16 volts.
6. Measure the voltage drops with the voltmeter in the position shown in Step 1 and Step 2 of Figure 4. The combined readings of Step 1 plus Step 2 should not exceed six-tenths or seven-tenths volt. If the voltage drop exceeds this limit, excessive resistance is indicated somewhere between the generator and the battery portion of the charging circuit (the cutout relay points are in a portion of this circuit).
7. Measure the voltage drop with the voltmeter in the position shown in Step 3 of Figure 4. The reading of Step 3 should not exceed two-tenths volt. If the voltage drop exceeds this limit, excessive resistance is indicated between the battery and generator return portion of the charging circuit.
8. Stop engine, turn on all lights and accessory loads (approximately 20 amperes). Measure voltage drop with the voltmeter in position shown in Step 4 of Figure 4. The reading of Step 4 should not exceed one-tenth volt. If the voltage drop exceeds this limit, excessive resistance is indicated between the body and frame of the vehicle, or between the frame and vehicle engine.
9. If excessive resistance is found in any of the above checks, check wiring for defects and replace if necessary. Clean and tighten all connections.

DC CHARGING SYSTEM

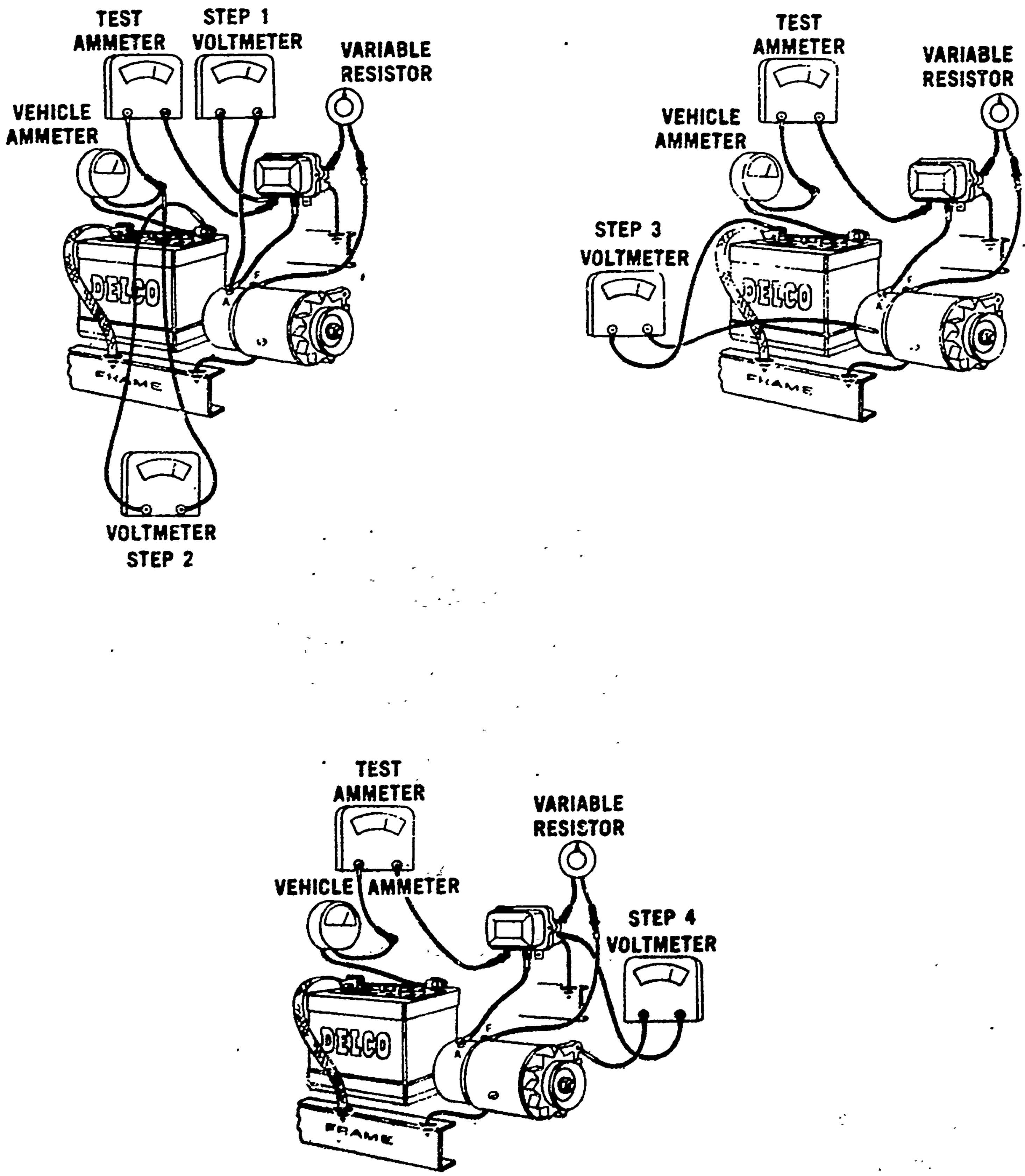

Fig. 4 Voltage drop checks

10. After completion of test, remove variable resistance from the field circuit and reconnect field lead to the "F" terminal of the regulator. Remove test ammeter and reconnect battery lead to the BAT regulator terminal.

STANDARD THREE UNIT REGULATOR; "B" CIRCUIT -- Test procedures and values are exactly the same as for the "A" circuit regulator check, except that the variable resistance is connected between the regulator GEN terminal and the field lead, which is removed from the regulator "F" terminal, as shown in Figure 5.

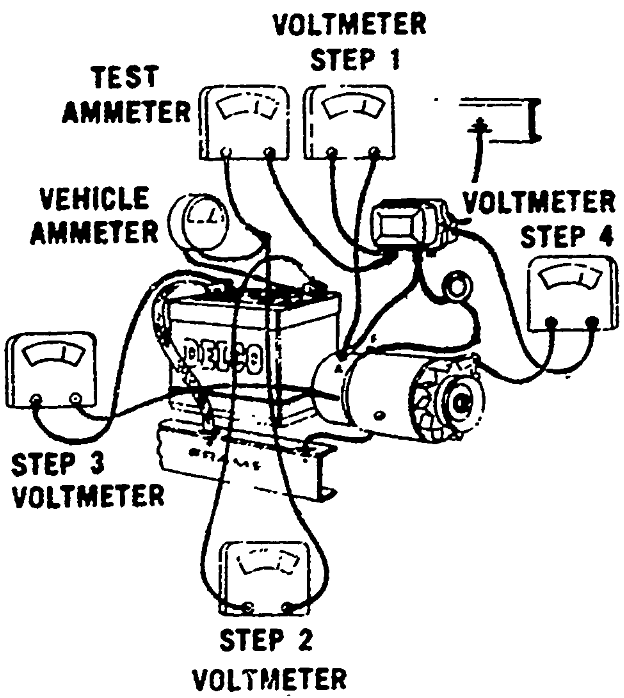

Fig. 5 Voltage drop checks

ALTERNATE METHOD FOR "A" AND "B" CIRCUIT SYSTEMS -- If a variable resistance is not available, the above tests still can be performed. The test procedures and values are exactly the same except as follows:

"A" circuit: Remove lead from "F" terminal of regulator and ground it. Obtain 20 ampere charging current by adjusting speed of vehicle engine.

"B" circuit: Remove lead from "F" terminal of regulator and touch to regulator GEN terminal. Obtain 20 ampere charging current by adjusting speed of vehicle engine. Do not allow voltage to exceed 16 volts.

SECTION H -- GENERAL TROUBLESHOOTING OF THE CHARGING CIRCUIT

To troubleshoot the CHARGING SYSTEM to determine which unit is at fault, the following procedure is suggested. It should be noted that trouble in the system usually will be evidenced by an undercharged or an overcharged battery.

DOUBLE CONTACT "A" AND "B" CIRCUITS -- Charge too low or no charge at all (evidenced by an undercharged battery):

1. Check for defective battery.
2. Check generator pulley and drive belt for slippage.
3. Connect voltmeter between "A" terminal of generator and a good ground,
4. Start engine and run at medium speed.
5. Note voltmeter reading.
   a) A reading of one to four volts indicates either an open field circuit or one with excessive resistance. Since the field circuit is made up of the generator, the wiring and the regulator; it will be necessary to determine which component of the circuit is at fault:
      1) On "A" circuit and double contact systems, remove lead from regulator "F" terminal, and momentarily touch to ground. On "B" circuit systems, disconnect the lead at the "F" terminal of the regulator and momentarily touch it to the regulator GEN terminal.

         If the voltage increases rapidly to system voltage or higher, the regulator is at fault and should be repaired or replaced.
      2) If the voltage remains low, remove the field lead at the "F" terminal of the generator, On "A" circuit and double contact systems, momentarily touch a jumper wire between the "F" terminal of the generator and ground.

On "B" circuit systems, momentarily touch the jumper lead between the "A" and "F" terminals of the generator. If the voltage increases rapidly to system voltage or higher, the wiring is at fault and must be repaired or replaced.

3) If the voltage remains low, the generator is at fault and must be repaired or replaced.

b) A reading of zero or very near zero volts, usually indicates a grounded armature circuit. Since the armature circuit is made up of the generator, the wiring, and the regulator assembly, it will be necessary to determine which component of the circuit is at fault.

1) On "A" circuit and double contact systems, remove lead from regulator GEN terminal.

On "B" circuit systems, remove lead from regulator GEN terminal and connect a jumper between the generator "A" and "F" terminals.

If the voltage increases rapidly to system voltage or higher, the regulator is at fault and should be repaired or replaced.

2) If the voltage remains at zero, remove the lead from the "A" terminal of the generator. (The jumper lead from the "A" to "F" terminals of the generator should remain in place on "B" circuit systems.)

If the voltage rapidly increases to system voltage or higher, the wiring is at fault and must be repaired or replaced.

3) If voltage remains at zero, the generator is at fault and must be repaired or replaced.

c) A reading of system voltage or higher indicates the possibility of an open charging circuit. The generator in this case is probably in operable condition but needs repair.

1) Move voltmeter lead to GEN terminal of the regulator. If voltage is zero at this terminal, the lead between the regulator and the generator is open and should be repaired or replaced. If the voltage at this terminal is the same as it was at the generator, the trouble may be in the regulator.

2) If the regulator is suspected, move the voltmeter lead to the BAT terminal of the regulator. If the voltage reading is one or two volts lower at this terminal than it was at the GEN terminal, the problem is in the regulator (cutout relay may need adjusting) and it should be repaired or replaced.

d) A reading equal to system voltage indicates the possibility of excessive resistance in the charging circuit. The check for excessive voltage drops or resistance in the wiring has been discussed previously. Often, a visual inspection of the wiring may disclose the cause of undercharge. Wiring should be checked for loose or corroded connections. Damaged or broken wiring may exist. Wiring at the generator, regulator, magnetic switch, starter relay, starter solenoid, battery, ground straps, and ammeter or indicator light may need to be included in this check. Inspect all wiring and connections. This may reveal the fault in the system.

e) A reading of system voltage at both the generator "A" terminal and the battery insulated post, accompanied by a chronically discharged battery may be eliminated by raising the voltage regulator setting.

CHARGE TOO HIGH (OVERCHARGED BATTERY):

1. This condition is indicated by light bulbs burning out or by excessive loss of battery water.
2. Start engine and run at medium speed, with voltmeter connected between "A" terminal of generator and a good ground.
3. Note voltmeter reading.

a) Disconnect wire attached to "F" terminal of the regulator. If voltmeter reading drops to around four volts, the regulator is at fault and must be adjusted, repaired or replaced. A simple adjustment of the regulator voltage setting might correct the difficulty.

b) With wire disconnected at the "F" terminal of the regulator, the voltmeter reading may remain at a high voltage. If this is the case, remove the lead at "F" terminal of the generator. If the voltage

now falls to about 4 volts, the field lead is grounded (on the "A" circuit systems), or is touching the lead attached to the "A" terminal of the generator in some non-insulated manner (on the "B" circuit system). The lead or leads must be repaired or replaced.

c) With the wire disconnected at the "F" terminal of the generator, the voltmeter reading may remain at a high voltage. If this is the case, the generator is at fault and must be repaired or replaced.

TAILORING THE VOLTAGE REGULATOR SETTING -- (Refer to applicable Service Bulletin for proper setting procedure). The desired voltage regulator setting is the one which keeps the battery in a satisfactory state of charge without causing excessive battery water usage. To obtain the desired setting, the voltage regulator setting must be tailored as follows:

1. When the battery uses too much water and the regulated voltage is above the normal range (as given in the specifications), lower the setting to a value within the upper portion of the normal range and check for an improved condition over a reasonable service period.

   NOTE: The normal range of voltage is specified at a given regulator ambient temperature. On most applications, the voltage regulator is designed to automatically change the voltage setting with a change in ambient temperature (temperature of air surrounding the regulator cover, one-quarter inch away from the cover). The voltage setting is always higher when the regulator is cold than when it is hot. This matches the charging requirements of the vehicle battery.

2. When the battery uses too much water and the regulated voltage is <u>within</u> the normal range, lower the setting two-tenths or three-tenths of a volt and check for an improved condition over a reasonable service period. Repeat until the battery remains charged with a minimum use of water.

3. When the battery is consistently undercharged and the regulated voltage is below the normal range, increase the regulator setting to the lower portion of the normal range and check for improved condition over a reasonable service period.

4. When the battery is consistently undercharged and the regulated voltage is within the normal range, increase the setting two-tenths or three-tenths of a volt and check for an improved condition over a reasonable service period. Repeat until the battery remains charged with a minimum use of water.

   NOTE: Avoid regulated voltage above 14.8 volts at 125 F (or equivalent) as this may cause damage to lights and other voltage sensitive equipment.

It rarely will be found necessary to use a voltage regulator setting outside the normal range in order to correct battery conditions. Batteries which do not respond to voltage regulator settings within the normal range usually will be found to be (1) batteries used in vehicles that are operated consistently at low speeds, or (2) batteries that have been improperly activated.

1. When a vehicle is operated consistently at low speed, the battery may remain undercharged even with a voltage regulator setting of 14.8 volts. Under these operating conditions, generator output and charging time may be insufficient to offset electrical loads on the battery. Periodic recharging of the battery from an outside source or replacement of the original generator with a special extra-output generator will be required in these cases.

2. Batteries suspected of having been improperly activated should be removed for a complete check. If the specific gravity at full charge is less than 1.230 in any cell, the battery either has been improperly activated or is worn out. In either case, it will give poor performance. However, when the specific gravity is above 1.310, the battery either has been filled with electrolyte of too high specific gravity, or electrolyte has been added in place of water. Either situation is harmful to the battery and will cause early failure.

SECTION I -- THE AC CHARGING SYSTEM

The AC charging system, consisting of alternator, regulator, battery and wiring has been discussed in detail in Units AM 2-16, AM 2-17 and AM 2-18. Additional information and established procedures to follow when analyzing and troubleshooting the charging system can be found in the Servicing Bulletin and/or Manufacturer's Specifications pertaining to the equipment involved. Also, for greater detail regarding disassembly and unit repair, refer to the appropriate Servicing Bulletin.

SECTION J -- THE CRANKING SYSTEM (ELECTRICAL)

The cranking system consists of the cranking motor, battery, wiring and control switches. The individual units comprising the cranking system will be discussed, since the functioning of an individual unit may be affected by other units in the system.

THE CRANKING MOTOR AND CONTROL SWITCHES -- The cranking motor converts the electrical energy of the battery into mechanical energy, which is used to crank the vehicle engine for starting. There are two basic types of cranking motor systems, and a few variations of each, (not counting air-starting systems and gasoline driven poney engines used for cranking heavy duty and off-highway equipment). These systems differ in their control switches and drive assemblies. The two basic systems are the solenoid switch controlled cranking motor and the magnetic switch controlled motor.

The solenoid switch controls the cranking motor by two means. It mechanically pulls the overrunning clutch pinion gear into mesh with the engine flywheel for cranking, and reverses the process after the

engine has started and the control switch is de-energized. The solenoid also electrically connects the battery to the motor to start the cranking process and disconnects the battery and motor when cranking is completed.

The magnetic switch controls the cranking motor by only one means. It electrically connects the battery to the motor to start the cranking, and disconnects the battery and motor when cranking is completed. The meshing and demeshing of the drive assembly and pinion gear with the flywheel is entirely the function of the drive assembly and motor.

PERIODIC MOTOR AND CONTROL SWITCH SERVICING -- No periodic lubrication of the cranking motor, solenoid, or magnetic switch is required. The cranking motor and brushes cannot be inspected without disassembling the unit. Therefore, no servicing is required between engine overhaul periods under normal operating conditions.

PERIODIC WIRING SERVICE -- A visual inspection often will reveal much useful information relative to the condition of the cranking system wiring. All wiring should, periodically, 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.

SECTION K -- GENERAL TROUBLESHOOTING OF THE CRANKING SYSTEM

If the cranking system does not perform properly, it is imperative that the battery be checked first. If the battery is defective, it must be replaced. If merely discharged, the battery must be recharged before further checks are made. The cranking system cannot be expected to

perform properly without sufficient electrical power from the battery, Defective, discharged, or undercapacity batteries cannot be expected to supply sufficient power to the cranking motor for good cranking performance,

Cranking troubles will usually be evidenced by:

1. The motor cranks slowly or not at all, even though the solenoid or magnetic switch operates properly.
2. The solenoid fails to shift the pinion into mesh with the ring gear, or the magnetic switch fails to close.

There are numerous factors that can cause the motor to crank slowly or not at all, even though the solenoid operates properly. These include:

1. Extremely cold temperatures and/or high oil viscosity or stiffness.
2. High compression ratios brought about by excessive carbon deposits.
3. A low capacity battery.
4. Tight motor bearings.
5. Hot engines that tend to diesel.
6. High resistance in the motor-to-battery wiring,

Although the cranking motor cannot be checked against specifications on-the-vehicle, a check can be made for excessive resistance in the cranking circuit. Before making this check, disconnect the primary lead to the distributor (or place the throttle in the closed position on diesel engines) to prevent the engine from starting; Then, with the engine cranking, measure the voltage losses across each part of the starting circuit, carefully noting the following procedure as shown in Step 1 through Step 5 of Figure 6,

Step 1: Connect the voltmeter across the insulated battery post and the solenoid battery terminal (or the battery terminal of the magnetic switch).

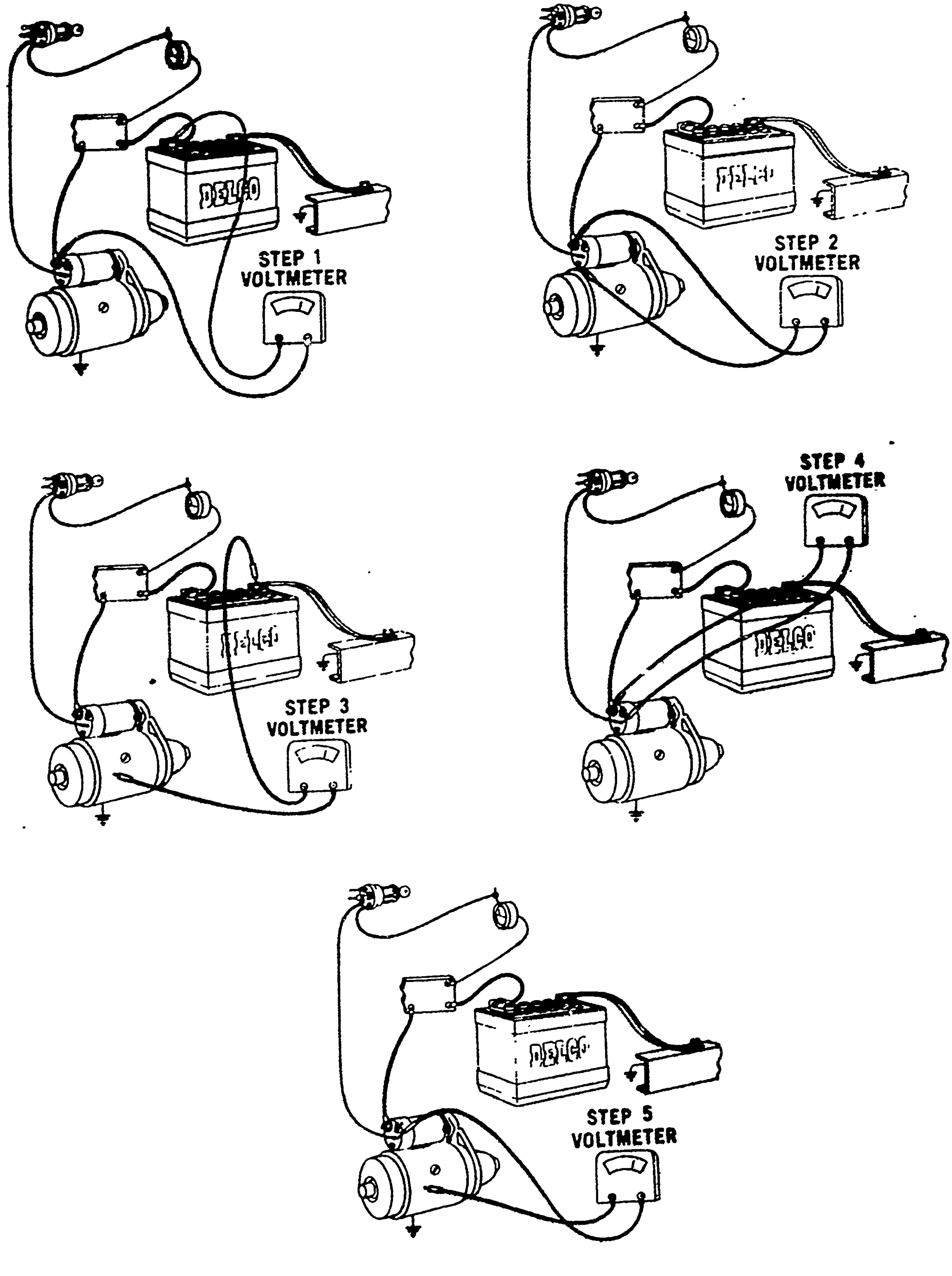

Fig. 6 Troubleshooting cranking system

If the voltage drop (voltmeter reading) exceeds approximately two-tenths of a volt, excessive resistance is indicated in this portion of the starting circuit. Check the terminals and connections at the battery and the solenoid or magnetic switch. Correct any poor connections that are in existence. Good metal-to-metal contact should be maintained at all terminal connections. Replace damaged wire, if necessary.

Step 2: Connect the voltmeter between the battery terminal of the solenoid or magnetic switch and the motor terminal of the solenoid or magnetic switch.

If the voltmeter reading exceeds approximately two-tenths of a volt, excessive resistance is indicated in this portion of the starting circuit. High resistance within either the solenoid or the magnetic switch is indicated by the high voltmeter reading. The solenoid or magnetic switch should be repaired if it is of the type which can be repaired, or replaced if high resistance is indicated. Badly burned terminals or contact discs within the solenoid or magnetic switch are the causes of the high resistance.

Step 3: Connect the voltmeter across the grounded post and the cranking motor frame.

If the voltmeter reading exceeds approximately two-tenths of a volt, excessive resistance is indicated in this portion of the starting circuit. High resistance between the battery post and the cranking motor frame is indicated. This high resistance can be caused by excessive paint or rust between the cranking motor and engine, between the engine ground and the chassis, between the chassis and battery ground strap, or between the ground strap cable and the battery post. The cause of this resistance should be determined, and proper repairs made in order to eliminate this unwanted resistance.

NOTE: It should be remembered that high voltage drop readings are not always a sure sign of excessive circuit resistance. Any condition that could cause abnormally high current draw, (such as shorted or grounded windings in the motor or solenoid), will cause the voltage drops to be proportionally higher. The defect, in this case, is in the motor or solenoid, and not in the external wiring. Nevertheless, if high voltage drops are encountered, the wiring should be inspected carefully as indicated by the voltmeter check on the previous page. All connections should be cleaned and tightened.

When the solenoid fails to pull in, or the magnetic switch will not close, the trouble may be due to excessive resistance in the solenoid or magnetic switch control circuit. To check this condition, close the starting switch and check the resistance as indicated below in Step 4.

Step 4: Connect the voltmeter across the magnetic switch or solenoid battery terminal and switch terminal.

If the voltage reading exceeds 2.5 volts on a 12 volt system, or 0.75 volt on a 6 volt system, excessive resistance is indicated in the solenoid or magnetic switch control circuit. High resistance connections could be present at the battery terminal leading to the starting switch, or at the terminals of the starting switch, neutral safety switch, or solenoid or magnetic switch. Tight, clean connections should be maintained at all these points in order that sufficient voltage can be present at the solenoid. A check for damaged wire in this circuit should be made. Replace if necessary.

Step 5: If the voltage in Step 4 does not exceed 2.5 volts and the solenoid or magnetic switch does not pull in or close, proceed by connecting the voltmeter across the magnetic switch or solenoid switch terminal and ground.

If the solenoid or magnetic switch does not feel warm, it should pull in or close whenever the voltage is 7.7 volts or more, on a 12 volt system. If the units are cool and will not operate at this or a higher voltage, the magnetic switch or solenoid is at fault and should be repaired or replaced.

With a good battery, and with the wiring and control units in good condition, any poor cranking performance most likely is due to the cranking motor. In this case, the motor should be removed from the engine and checked in accordance with the manufacturer's test specifications and applicable Service Bulletin.

0

AM 2-20D
10/4/67

TROUBLESHOOTING ELECTRICAL SYSTEMS
(INTRODUCTION TO BASIC AND GENERAL PROCEDURES)

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A 1

Check to see that timer is OFF

1

The procedures covered in this film are aimed at the type of electrical equipment commonly used on passenger cars and light trucks. They may apply equally well to similar equipment used in other applications since the treatment is general and the equipment is very much alike.

Press A 2

1-1

2

This film presents an approach to servicing electrical equipment as performed "on-the-vehicle". It is the intent first to present the periodic maintenance requirements of each component of the electrical system, and secondly, to present a basic troubleshooting approach for the electrical system.

Press A 3

1-2

3

The objective of a troubleshooting procedure is to isolate the cause of trouble in a particular part of the system. As an example, if the battery is consistently discharged, an effective checking procedure should determine if the defect is in the battery, the generator or alternator, or in the regulator or the wiring.

Press A 4

1-3

4

When analyzing trouble in any of the electrical systems, the battery should be checked ______________.

A. any time 5
B. last 5
C first 6
D. It makes no difference 5

1-4

5

You are incorrect. The battery should be considered part of <u>each</u> of the other systems and should be checked <u>first</u>. Otherwise, a component part of some circuit, failing to function properly, may be unjustly condemned. For example, if the battery has a shorted cell and over-charging results, the generator or alternator, or the regulator might appear to be at fault.

Press A 6

1-5

6

OK. The battery should be checked <u>first</u>, otherwise, a component part of some circuit, failing to function properly may be unjustly condemned.

The three basic instruments used in electrical equipment troubleshooting are ______________.

A. battery hydrometer, voltmeter and ohmmeter 7
B. voltmeter, ammeter and battery hydrometer 7
C. ammeter, voltmeter and ohmmeter 8

1-6

7

No, you are not entirely correct. The battery hydrometer is used for battery testing but it is not commonly used for troubleshooting.

Press A 8

1-7

8

OK. The battery hydrometer is used for testing batteries, but not commonly used for troubleshooting electrical systems.

Greater accuracy is desired in the __________ than in any other electrical checking instrument.

A. ohmmeter 9
B. ammeter 9
C. voltmeter 10

1-8

9

No, you are incorrect. Greater accuracy is desired in the voltmeter than in any other electrical checking instrument. Settings with a one-tenth volt variation are often specified.

Press A 10

1-9

10

OK. Greater accuracy is desired in the voltmeter. Settings with a one-tenth volt variation are often specified.

Voltmeters are always connected __________ with the circuit.

A. in series 11
B. in parallel 12
C. as a shunt 11

1-10

11

No, you are incorrect. Voltmeters are connected across or in parallel with the circuit or part of a circuit. They measure the difference in electrical pressure between the points where the voltmeter leads are attached.

Press A 12

1-11

12

OK. Voltmeters are connected in parallel with the circuit to measure the difference in electrical pressure between the points where the leads are attached.

The difference in voltage expected across a portion of the circuit is often called __________.

A. resistance 13
B. voltage rise 13
C. voltage drop 14

1-12

13

No.
Voltage drop is the term used most to describe the expected difference in the voltage across a portion of a circuit. The voltage drop is caused (in most cases) by resistance.

Press A 14

1-13

14

OK. Voltage drop is the term used to describe the expected difference in the voltage across a circuit. Voltage drop is normally caused by resistance, and is sometimes specified in testing procedures.

The amount of current flow in a circuit depends upon __________.

A. voltage and electrical pressure 15
B. the amount of resistance and the amperes 15
C. the voltage and the resistance in the circuit 16

1-14

15

No, you are incorrect. The amount of current flow in a circuit depends upon the voltage, or electrical pressure, available to push it, and the amount of resistance encountered in the circuit.

Press A 16

1-15

16

OK. The voltage and the resistance determine the amount of current flow in a circuit.

Ammeters are connected ________________ with the circuit in which the current is to be measured.

A. in series (often with external shunts) 18

B. in parallel (with no shunt connections) 17

X(C)- 16.1 2-16

16.1

OK. The amount of current flow in a circuit depends upon two things, the voltage and the resistance in the circuit.

Since you have missed one or more questions in this section, it is important that you go back for a review. Take your time, read the questions carefully, and think before you make your selection.

Press A 4 1-16A

17

No, you are incorrect.

Ammeters are connected in series with the circuit in which the current is to be measured. Often, external shunts are provided so that only a small proportional part of the total current passes through the meter.

Press A 18

2-17

18

OK. Ammeters are connected in series with the circuit in which the current is to be measured, and often with external shunts.

Resistance is the property of the wiring or electrical units which resists or limits ________________.

A. the flow of voltage in a circuit, and also causes current loss 19

B. the flow of current in a circuit, and also causes voltage drop 20

C. voltage, and can be detected by a voltmeter 19

2-18

19

No, you are incorrect. Resistance is the property of the wiring or electrical units which resists or limits the flow of current in a circuit and also causes voltage losses, or electrical pressure drops, around the electrical circuit, similar to the resistance or obstruction in a water hose.

Press A 20

2-19

20

OK. Resistance limits the flow of current in a circuit and also causes voltage drop, or voltage losses.

Since the ohmmeter has its own power source, what precaution should be observed when using it around circuits that may have parallel paths to an external power source?

A. None. The ohmmeter is a high resistance meter and would not be affected by another source of power. 21

B. Parallel paths or circuits must be disconnected to prevent erroneous readings or possible damage to the meter. 22

C. Do not connect an ohmmeter into a high voltage circuit. 21

2-20

21

No, you are incorrect. Since ohmmeters have their own power source they should NEVER be used on circuits that have an external power source which is connected. An external power source can force current through the ohmmeter giving an erroneous reading or, perhaps damaging the meter.

Press A 22

2-21

22

OK. Parallel paths or circuits must be disconnected to prevent erroneous readings or possible damage to the ohmmeter.

When making on-the-vehicle checks, the ohmmeter is rarely used. The ____________ method is generally used to detect excessive resistance.

A. current flow 23

B. current drop 23

C. voltage drop 24

2-22

23

No, you are incorrect. The voltage drop method is generally used when making on-the-vehicle checks. The ohmmeter is rarely used because of the problems of parallel paths and external power sources. The same results can be obtained by using a voltmeter.

Press A 24

2-23

24

OK. The voltage drop method is generally used to detect excessive resistance that might be occurring on the vehicle.

When electrical trouble is experienced in any circuit, the ________________ cannot be overlooked as a possible source of trouble.

A. cranking motor 25
B. generator or alternator and voltage regulator 25
C. battery 26

2-24

25

No, you are incorrect.

When electrical trouble is experienced in any circuit, the battery cannot be overlooked as a possible source of trouble. Since a visual inspection and a few quick electrical checks will reveal the condition of the battery, it is always advisable to start all circuit checks with the battery. Otherwise, a component part of some circuit, failing to function properly, may be unjustly condemned.

Press A 26

2-25

26

OK. The battery cannot be overlooked as a possible source of trouble when electrical trouble is experienced in a circuit.

There are two basic internal electrical circuits used on DC generators, the ________________.

A. split field and bucking field 27
B. shunt field and series field 27
C. "A" and "B" circuits 28

2-26

27

No, you are incorrect. The "A" circuit and the "B" circuit are the two basic internal electrical circuits used on DC generators. The "A" circuit is externally grounded at the voltage regulator, and the "B" circuit is internally grounded at the generator ground brush or field frame.

Press A 28

2-27

28

OK. "A" and "B" circuits are the two basic internal circuits used on DC generators.

Since the two systems ("A" and "B" circuits) require different procedures for checking and adjusting, it is important to know which circuit is being used.

On vehicles equipped with an "A" circuit generator, ________________ may be used.

A. either an "A" circuit or "B" circuit regulator 29
B. only an "A" circuit regulator 30
C. only a "B" circuit regulator 29

2-28

29

You are incorrect.

If an "A" circuit generator is used, ONLY an "A" circuit regulator may be used.

The field ground polarity of the generator and regulator must agree. "A" circuit components are NOT interchangeable with "B" circuit components, because of the difference between the two in the location of the field circuit ground.

Press A 30

2-29

30

OK. The regulator must be compatible with the generator, as the two types ("A" and "B" circuits) are not interchangeable.

Generator brushes should be replaced when they are ________________. (Recommended practice.)

A. one-half worn 32
B. three-quarters worn 31
C. one-quarter worn 31

2-30

5

31

No, you are incorrect. The accepted practice is to replace the generator brushes if they are one-half worn.

Press A 32

2-31

32

OK. If generator brushes are one-half worn, they should be replaced with new brushes.

Periodically, the commutator should be inspected. It may have developed a glazed, oxidized or dirty surface. In this case, the commutator must be cleaned with No. 00 sandpaper, or with a brush seating stone. In extremely bad cases, it may need ________.

A. to be turned down on a lathe 34

B. to be replaced 33

C. to be checked on an armature growler 33

2-32

33

No, you are incorrect. In extremely bad cases, the commutator bars may need to be turned down on a lathe. Also, high mica between the commutator bars will necessitate turning down on a lathe and undercutting to prevent arcing and rapid brush wear.

Undercutting is the process of cutting the mica from between the commutator bars to prevent the generator brushes from riding up over the mica and arcing as the contact between the brush and the commutator bar is broken.

Press A 34

2-33

34

OK. The commutator bars may need to be turned down on a lathe in extremely bad cases.

After disconnecting and reconnecting generator or regulator leads, or after installing new units in the charging system, the generator must ________ before the engine is started.

A. be checked for continuity 35

B. be polarized 36

X(C)-341

3-34

341

OK. If the commutator has developed a glazed, oxidized or dirty surface, it must be cleaned with No. 00 sandpaper or with a brush seating stone. In extremely bad cases, it may need to be turned down on a lathe.

Since you have missed one or more questions in this section, you should have an opportunity for a review. Take your time, read the questions carefully, and think before you make your selection.

Press A 16

2-34A

35

No, you are incorrect. After making repairs and tests, or after installing new units, the generator must be polarized before the engine is started. This will insure that it charges in the proper direction (polarity to match the system it is installed in).

Press A 36

3-35

36

OK. Polarizing is necessary when new units have been installed, or when generator or regulator leads have been disconnected and reconnected, to insure that the generator charges in the proper direction and not against the polarity of the battery.

If the generator is started with reversed polarity, its voltage and current will combine in series with that of the battery and may cause damage to the voltage regulator or other components in the circuit.

Press A 37

3-36

37

On "A" circuit generators, polarizing is done by momentarily connecting a jumper lead between the GEN and BAT terminals of the regulator. On "B" circuit generators, polarizing is accomplished by disconnecting the field lead from the regulator, and momentarily touching it to the BAT terminal of the regulator.

Failure to do this may result in damage to the regulator since "reverse polarity" causes fluttering, arcing, and burning of the cutout relay contact points.

Press A 38

3-37

38

Most DC generator regulators are of the three unit, vibrating contact type which consists of a cutout relay, voltage regulator and current regulator. The cutout relay is a ______________ operated switch that connects and disconnects the generator to the battery at the correct time.

A. battery 39
B. generator 39
C. magnetically 40
D. spring 39

3-38

39

No, that is not the correct answer.

The cutout relay is magnetically operated. It will normally be closed as a result of the magnetic effect of current flowing from the generator, and is opened by the magnetic effect of current flowing from the battery back to the generator, with some assistance from the cutout relay spring.

Press A 40

3-39

40

OK. The cutout relay is a magnetically operated switch. It is normally closed as a result of the magnetic force created by current flow from the generator to the battery and is opened by the reverse magnetic field from current flow from the battery, with some assistance from the cutout relay spring.

The voltage regulator unit limits the generator voltage to a safe value by regulating the ______________.

A. generator field current 42
B. armature winding current 41

3-40

41

No, you are incorrect. The voltage regulator limits the generator voltage to a safe value by regulating the generator field current. The voltage regulator is also a magnetically operated switch, connected in the generator field circuit. Its contacts are held closed by spring tension and opened by magnetic force.

Press A 42

3-41

42

OK. The voltage regulator unit limits the generator voltage by regulating the generator field current.

The current regulator unit limits the generator output or current to a safe value by regulating the ______________.

A. generator field current 44
B. current regulator spring tension 43
C. armature winding current 43
D. magnetic field in the current regulator circuit 43

3-42

43

No, you are incorrect. The current regulator unit, like the voltage regulator unit, limits the generator output and voltage by regulating the generator field current.

The windings around the current regulator core carry total generator output, and are current sensitive.

The windings around the voltage regulator core are shunt windings and are voltage sensitive. Shunt windings are many turns of relatively small wire. Series windings are a few turns of relatively heavy wire.

Press A 44

3-43

44

OK. The current regulator unit limits the generator output by regulating the generator field current.

The major difference between the current regulator and the voltage regulator is the windings around the core of each unit. The current regulator has series windings and is current sensitive, and the voltage regulator has shunt windings and is voltage sensitive. The voltage regulator unit may have a section of series windings, to accelerate opening and closing of the contact points.

Press A 45

3-44

45

Normally, periodic service of the regulator is not required. However, the contact points of a regulator will not operate indefinitely without some attention. It has been found that a majority of all regulator trouble can be eliminated by ______________.

A. leaving the regulator alone as long as it is working properly 46
B. periodic testing to determine its condition 46
C. a simple cleaning of the contact points 47

3-45

46

No, you are incorrect. A simple cleaning of the contact points can eliminate a majority of all regulator trouble. An oxidized condition of the regulator points may cause high resistance in the generator field circuit which will reduce the generator output. This in turn will cause an undercharged battery condition.

Press A 47

3-46

47

OK. A simple cleaning of the contact points can eliminate a majority of all regulator trouble.

In the testing procedure for oxidized contact points, the procedure used on both "A" and "B" circuits differs slightly.

Step 3 for "A" circuit states: disconnect field lead from regulator "F" terminal and ground the lead.

Step 3 for "B" circuit states: touch jumper lead between GEN terminal and "F" terminal of regulator.

Press A 48

3-47

48

Why are the two circuits ("A" and "B") tested for oxidized contact points in different manners?

A. The regulators are not interchangeable. 49

B. The fields are grounded at different places. 50

C. The manufacturer specifies the different procedures. 49

3-48

49

No, you are incorrect. The reason for the different procedures in checking for oxidized points is that the fields are grounded at different places. The "A" circuit is termed an "externally grounded" circuit and the "B" circuit is termed an "internally grounded" circuit.

Press A 50

3-49

50

OK. The fields are grounded at different places. That is the reason for the different procedures in checking for oxidized points in "A" and "B" circuit generator regulators.

The "A" circuit is grounded at the regulator and termed "externally grounded", and the "B" circuit is grounded in the generator at the grounded brush or field frame and is termed "internally grounded".

The CAUTION FOR DOUBLE CONTACT REGULATOR states: Never use a jumper lead to ground the generator or regulator field terminal when they are connected and operating. Press A 51

4-50

X(c)-50.1

50.1

OK. Checks for oxidized regulator contact points are different for "A" and "B" circuit regulators because the fields are grounded at different places.

Since you have made an error on a question or two in this section, you should have an opportunity for a review. Take your time, read carefully and think before answering.

Press A 34

3-50A

51

The generator or regulator field terminal of a double contact regulator should not be grounded when connected and operating because high current flow through the contacts might burn the contact points of the regulator.

52 38

Press A to advance t, the next frame, or press B if a review of the last section of material is desired.

4-51

52

Because of the different materials used in the manufacture of contact points, care must be exercised when cleaning them. The material used in some contacts is soft and can be easily damaged unless the proper cleaning methods are used. Other contact materials are hard and require a different method of cleaning.

For example, the contact points used in DOUBLE CONTACT REGULATORS and CUTOUT RELAYS are soft. They should be cleaned with a strip of ________.

A. fine sandpaper 53
B. emery cloth 53
C. No. 400 silicon carbide paper 54

4-52

53

No, you are incorrect. DOUBLE CONTACT REGULATORS and CUTOUT RELAYS should be cleaned with a strip of No. 400 silicon carbide paper, folded over and then drawn back and forth between the contacts. NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN THE CONTACT POINTS.

Press A 54

4-53

54

OK.
On STANDARD THREE UNIT VOLTAGE AND CURRENT REGULATORS, one contact is made of a soft material and the other of a hard material. Due to the difference in hardness, a different method must be used to clean each point. Contact points made of a hard material should be cleaned with ________________.

A. fine grinding stone 55

B. a spoon or riffler file 56

C. a strip of No. 400 silicon carbide paper 55

4-54

55

No, you are incorrect. The spoon or riffler file is used to clean the hard material contact points in the standard regulator. The opposite, or mating, contact point is made of a soft alloy and may be cleaned with a strip of No. 400 silicon carbide paper, folded over and then pulled back and forth between the contacts.

Press A 56

4-55

56

OK. A spoon or riffler file is used to clean the hard material contact in the STANDARD REGULATOR.

The wiring circuit is just as important to the charging system as the electrical units themselves. High resistance resulting from loose or corroded connections in the charging system between the generator and the regulator will result in ________________.

A. high voltage at the generator 57
B. voltage drop between the regulator and battery 57
C. an undercharged battery condition 57
D. all of the above 58

4-56

57

No, you are not entirely correct. High resistance in the charging circuit between the generator and the regulator will result in high voltage at the generator, a voltage drop between the regulator and the battery, and an undercharged battery condition.

Periodically, all terminals should be inspected for loose or corroded connections. Terminals should be cleaned and tightened if necessary.

Press A 58

4-57

58

OK. To troubleshoot the charging system and determine which unit within the system is at fault, a definite procedure is suggested. However, it should be noted that trouble in the system will usually be evidenced by ________________.

A. an undercharged or an overcharged battery condition 59

B. high resistance or voltage drop in the circuit 59

C Both of the above conditions 60

4-58

59

No, you are not entirely correct. As mentioned in the previous frame, trouble in the charging system is usually evidenced by an undercharged or overcharged battery condition, which may be caused by high resistance or voltage drop in the circuit.

Press A 60

4-59

60

OK. The desired voltage regulator setting is one which keeps the battery in a satisfactory state of charge without causing ________________.

A. excessive high voltage 61

B. the regulator to be overworked and frequently adjusted 61

C. excessive battery water usage 62

4-60

61

No, you are incorrect. The desired regulator setting is one which keeps the battery in a satisfactory state of charge without causing excessive battery water usage.

Press A 62

4-61

62

OK. Excessive battery water usage is the condition to be avoided when trying to obtain the desired regulator setting.

When the battery uses too much water and the regulated voltage is ___(1)___ the normal range, ___(2)___ the setting and check for an improved condition.

A. (1) below (2) raise 63
B. (1) above (2) lower 64
C. Neither A or B is correct 63

4-62

63

No, you are incorrect. If the regulated voltage is above the normal range and the battery uses too much water, lower the setting and check for improved condition over a reasonable service period.

Press A 64

4-63

64

OK. The normal range of voltage is specified at a given regulator ambient temperature. On most applications, the voltage regulator is designed automatically to change the voltage setting with a change in ambient temperature. The voltage setting is always higher when the regulator is ___(1)___ than when it is ___(2)___.

A. (1) cold (2) hot 66
B. (1) hot (2) cold 65
C. Changes of temperature have no effect on temperature compensated regulators. 65

4-64

65

No, you are incorrect. The voltage setting is always higher when the regulator is coid than when it is hot. The voltage setting is changed automatically on temperature compensated regulators and matches the charging requirements of the vehicle battery.

Press A 66

4-65

66

OK. When the battery is consistently undercharged and the regulated voltage is within the normal range, increase the setting ____________.

A. 2.0 to 3.0 volts 68
B. 0.2 to 0.3 volts 69

X (0)- 67

5-66

67

OK.
The voltage setting is always higher when the regulator is cold than when it is hot.

Since you have missed one or more questions in this section, it is suggested that you go back for a review. Read the information carefully and take your time in selecting an answer.

Press A 45

4-67

68

No, you are incorrect. When the battery is consistently undercharged and the regulated voltage is within the normal range, increase the setting 0.2 to 0.3 volt and check for improved condition over a reasonable service period. Note: Avoid regulated voltage above 14.8 volts at 125 F, as this may cause damage to lights and other voltage sensitive equipment.

Press A 69

5-68

10

69

OK. It rarely will be necessary to use voltage regulator settings outside the normal range in order to correct battery conditions. Batteries which do not respond to voltage regulator settings within the normal range usually will be found to be ____(1)____ or ____(2)____.

A. (1) in vehicles operated consistently at slow speeds
(2) batteries that have been improperly activated 71

B. (1) in vehicles that have been tampered with
(2) batteries that have been improperly installed 70

C. Neither of the above. 70

5-69

70

No, you are not entirely correct. Batteries which do not respond to voltage regulator settings within the normal range usually will be found to be (1) batteries used in vehicles that are operated consistently at low speeds, or (2) batteries that have been improperly activated.

Press A 71

5-70

71

OK. When a vehicle is operated consistently at low speed, the battery may remain undercharged even with a voltage regulator setting of 14.8 volts. Under these operating conditions, generator output and charging time may be insufficient to offset electrical loads on the battery. Periodic re-charging of the battery from an outside source, or replacement of the original generator with a special extra duty generator will be required.

Press A 72

5-71

72

Batteries suspected of having been improperly activated should be removed for a complete check. If the specific gravity at full charge is less than 1.230 in any cell, the battery has either been improperly activated or is worn out, and in either case will give poor performance.

However, when the specific gravity is above 1.310, the battery either has been filled with electrolyte that has too high a specific gravity, or electrolyte has been added in place of water. Either situation is harmful to the battery and will cause early failure.

Press A 73

5-72

73

ALTERNATOR CHARGING SYSTEM circuits are completely different from the direct current charging systems. Therefore, few, if any, of the trouble-shooting checks used for the direct current systems can be used for alternator systems. Before attempting to troubleshoot, it is wise to observe some definite precautions -- failure to do so can result in burned out ________ and vehicle wiring.

A. voltage regulator 74
B. alternator diodes 75
C. battery cables 74

5-73

74

No, you are incorrect. Usually the first thing to be damaged in an alternator charging system is the alternator diodes, especially with reversed battery or alternator connections. Battery and alternator polarities must agree.

Press A 75

5-74

75

OK. The diodes are usually the first things to be damaged in an alternator charging system if the battery and alternator polarities do not agree.

If booster batteries are used for any reason, they must be connected properly to prevent damage to the diodes. The negative (-) cable from the booster battery must be connected to the ____(1)____ terminal of the vehicle battery and the positive (+) booster cable to the ____(2)____ terminal.

A. (1) negative (2) positive 77
B. (1) positive (2) negative 76
C. It makes no difference. 76

5-75

76

No, you are incorrect. If booster batteries are used with an alternator charging system, they must be connected in parallel (positive to positive and negative to negative). If connected in series (positive to negative) the combined voltage of the two batteries would damage the diodes.

Press A 77

5-76

77

OK.
A fast charger should never be used as a booster for starting the vehicle. When a fast charger is used to charge the battery, the ______________.

A. alternator output terminal should be grounded 78
B. field terminal should be grounded 78
C. battery cables should be disconnected 79

5-77

78

No, you are incorrect. Battery cables should be disconnected when using a fast charger to charge batteries in a vehicle equipped with an alternator; especially if the battery is to be charged at a greater rate than the output of the alternator. Otherwise, the alternator diodes may be damaged by the excessive current flow to which they are subjected.

Never use the fast charger as a booster for starting the vehicle.

Press A 79

5-78

79

OK.
Another precaution to observe while working on alternators is: Never operate an alternator on an open circuit. Make absolutely certain all connections in the circuit are secure. Failure to observe this precaution may result in serious damage to the alternator or to the electrical equipment.

Press A 80

5-79

80

For greater detail regarding alternator repair and precautions to follow, you should refer to the Service Bulletin and specifications applicable to the equipment involved.

Press A 81 to advance to the next frame or press B 66 if a review of the last section of material is desired.

X(C) - 80.1

6-80

80.1

For more complete information regarding alternator service, refer to the appropriate Manufacturer's Service Bulletin and specifications.

You have made an error or two on the questions in this section, so you should have an opportunity to review. Think carefully before answering the questions. Press A 66

5-80A

81

The CRANKING SYSTEM consists of the cranking motor, battery, wiring and control switches. There are two basic types of cranking motor systems: the solenoid switch controlled cranking motor and the ______________ controlled motor.

A. Bendix drive 82
B. magnetic switch 83
C. overrunning clutch 82

6-81

82

No, you are incorrect. The two types of cranking motor systems are the solenoid switch controlled motor and the magnetic switch controlled motor. The two systems differ in their control switches and drive assemblies.

Press A 83

6-82

83

OK.
The SOLENOID SWITCH controls the cranking motor by two means. It mechanically pulls the motor's overrunning clutch pinion gear into mesh with the engine flywheel for cranking, and reverses the process after the engine is started and the control switch is de-energized. The solenoid also connects the ___(1)___ to the motor to start the cranking process and disconnects the ___(2)___ from the motor when cranking is completed.

A. (1) flywheel (2) pinion 84
B. (1) pinion (2) flywheel 84
C. (1) battery (2) battery 85

6-83

84

No, you are incorrect. The solenoid connects the battery to the motor to start the cranking process and disconnects the battery from the motor when cranking is completed.

Press A 85

6-84

85

OK. The battery is connected and disconnected by the solenoid.

The MAGNETIC SWITCH controls the cranking motor by only one means. It electrically connects the battery to the motor to start the cranking, and disconnects the battery from the motor when cranking is completed. The meshing and demeshing of the drive gear with the flywheel is entirely the function of the ________________.

A. drive assembly and motor 87
B. magnetic switch and Bendix drive 86
C. overrunning clutch 86

6-85

86

No, you are incorrect. The meshing and demeshing of the drive gear assembly with the flywheel is entirely the function of the drive assembly and motor, on the magnetic switch controlled cranking motor.

Press A 87

6-86

87

OK.
No periodic lubrication of the cranking motor, solenoid, or magnetic switch is required. The cranking motor and brushes cannot be inspected without disassembling the unit; therefore no servicing is required between engine overhaul periods, under normal operating conditions.

There is an exception to the above rule. Some companies have the cranking motor removed for servicing or repair after a certain number of engine hours, which may or may not coincide with the time of engine overhaul.

Press A 88

6-87

88

A visual inspection will often reveal much useful information relative to the condition of the cranking system. All wiring should be visually inspected periodically for frayed or damaged insulation. Faulty wiring should be replaced. All terminals should be checked for loose or corroded connections and should be cleaned and tightened, if necessary. If the cranking system does not perform properly, it is imperative that the ____________ be checked first.

A. cranking motor 89
B. solenoid 89
C. battery 89.1

6-88

89

No. you are incorrect. When analyzing trouble in any of the electrical systems, the battery should be checked first. The cranking system cannot be expected to perform properly without sufficient electrical power from the battery.

Press A 89.1

6-89

89.1

OK.
Cranking troubles will usually be evidenced by:

1. The motor cranking slowly or not at all, even though the solenoid or magnetic switch operates properly.
2. Failure of the solenoid to shift the pinion into mesh with the ring gear or failure of the magnetic switch to close.

Press A 90

6-89A

90.

If the cranking system does not perform properly, it is probably caused by the ________________, which is the most common cause of cranking troubles.

A. discharged battery 91
B. high resistance 92
C. solenoid or magnetic switch 91

6-90

91

No, you are incorrect. Aside from battery neglect, high resistance is the most common cause of cranking system troubles. Badly burned terminals or contact discs within the solenoid or magnetic switch are some causes of high resistance.

High resistance can also be caused by excessive paint or rust found between the cranking motor and engine, between the engine ground and chassis, between the chassis and battery ground strap, or between the ground strap cable and battery post.

Press A 92

6-91

92

OK.

If the battery, the wiring and the control units are in good condition, any poor cranking performance most likely is due to the cranking motor. In this case, the motor should be removed from the engine and checked in accordance with the Manufacturer's Test Specifications and applicable Service Bulletin.

Press A 93

6-92

93

Congratulations, you have successfully completed the film on INTRODUCTION TO BASIC AND GENERAL PROCEDURES FOR TROUBLESHOOTING ELECTRICAL SYSTEMS.

Press REWIND. X(C)-94

6-93

94

Since you have missed one or more questions in this section, you should have an opportunity for a review. Take your time; read the information over carefully before making your selection.

Press A 81

6-94

INSTRUCTOR'S GUIDE

AM 2-20
10/20/67

Title of Unit: TROUBLESHOOTING ELECTRICAL SYSTEMS

OBJECTIVES for this Unit:

1. To assist the student in troubleshooting procedures; to help him be able to isolate the cause of trouble in a specific part of a system.
2. To offer a guide to general and basic procedures. The test procedures are not intended to cover all aspects of troubleshooting.
3. To let the student become aware of the importance of using the Manufacturer's Specifications and Service Bulletins that pertain to the equipment involved.
4. This Unit will refer, as much as possible, to the basic instruments used in electrical equipment testing procedures. (The three most commonly used instruments are: the voltmeter, ammeter and the ohmmeter.)

LEARNING AIDS suggested:

Visual Aids: Delco-Remy Manual No. 5221; Periodic Maintenance and Circuit Checks.

Models: Any electrical components or assemblies that have been prepared in advance for classroom demonstration.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. Why is it good practice to use the manufacturer's specifications and service bulletins when servicing or repairing electrical units?
2. Why is it important to use a definite procedure when troubleshooting electrical equipment?
3. What are the three most commonly used instruments in electrical equipment testing?
4. What is the most common cause of excessively high resistance in a circuit?
5. What is the effect of excessive resistance in a circuit?
6. What precaution should be followed when using an ohmmeter in a circuit that may have a parallel path to a power source?
7. What method is generally used when making on-the-vehicle checks for excessive resistance or voltage drop?

8. Why is it advisable to start all circuit checks by checking the battery?

9. Name the four important points which can help to eliminate a large number of premature battery failures.

10. What are the two basic internal electrical circuits used on DC generators? Explain how they may be identified.

11. Explain why "A" circuit and "B" circuit generator regulators are not interchangeable.

12. Why is it necessary to undercut the mica between the commutator bars of a generator armature?

13. What are the three units in a DC generator regulator, and what are their functions?

14. Which service operation can eliminate a majority of all regulator trouble?

15. Why should CAUTION: NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN THE CONTACT POINTS be observed? (On generator regulators)

16. What will be the first evidence of trouble in the charging system? (Pertaining to failure, not to ammeter reading.)

17. What is meant by the term "TAILORING THE VOLTAGE REGULATOR SETTING?"

18. What is the best indication of a proper voltage regulator setting?

19. What effect does surrounding temperature have on voltage regulators?

20. What are temperature compensated voltage regulators?