SECTION 6D

ENGINE ELECTRICAL

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

Described below are the major engine electrical systems and components:

Charging System

(Figure 1)

The charging system includes the batteries (B), generator (4), battery discharge indicator circuit (2) and the connecting wiring.

Cranking Circuit

(Figure 1)

The cranking or starting circuit includes the batteries together with the engine control switch (1), sub starter switch (10), starter assembly (11) starter relay (12), transmission neutral safety switch (13), the glow plug circuit, and related wiring.

The glow plug circuit is tied into the starting circuit and contains the glow plugs (7), an indicator light (9), a timer (5), a temperature switch (6), a relay (8) and the related wiring.

The sub starter switch (10) is provided so that the engine may be cranked while the cab is tilted.

Engine Heaters

Heaters are available for the engine block and the oil pan to improve starting in very cold weather.

BATTERY

DESCRIPTION

The battery has three main functions. It provides a source of energy for cranking the engine, acts as a voltage stabilizer for the electrical system and, for a limited time, can provide energy when the electrical load exceeds the output of the generator.

The sealed battery as shown in figure 2 or 3 is standard for all vehicles for 1985. Refer to "Specifications" at the end of this section for specific application.

Water never needs to be added to the sealed battery so there are no filler caps on the cover. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. There are small vent holes in the cover to allow what little gas is produced inside the battery to escape. The special chemistry is also designed to greatly reduce the possibility of overcharge damage.

Since there are vent holes in the cover, the battery should always be kept in an upright position. A small amount of electrolyte may leak from the top of the battery if it is tipped at an angle of more than 45 degrees.

Do not tip the battery more than 45 degrees when carrying or installing it.

Evidence of electrolyte leakage does not necessarily mean that the battery is defective.

Ratings

A battery generally has two classifications of ratings:

1. A 20-hour reserve capacity rating at 27°C (80°F).
2. A cold rating at –18°C(0°F), which indicates the cranking load capacity.

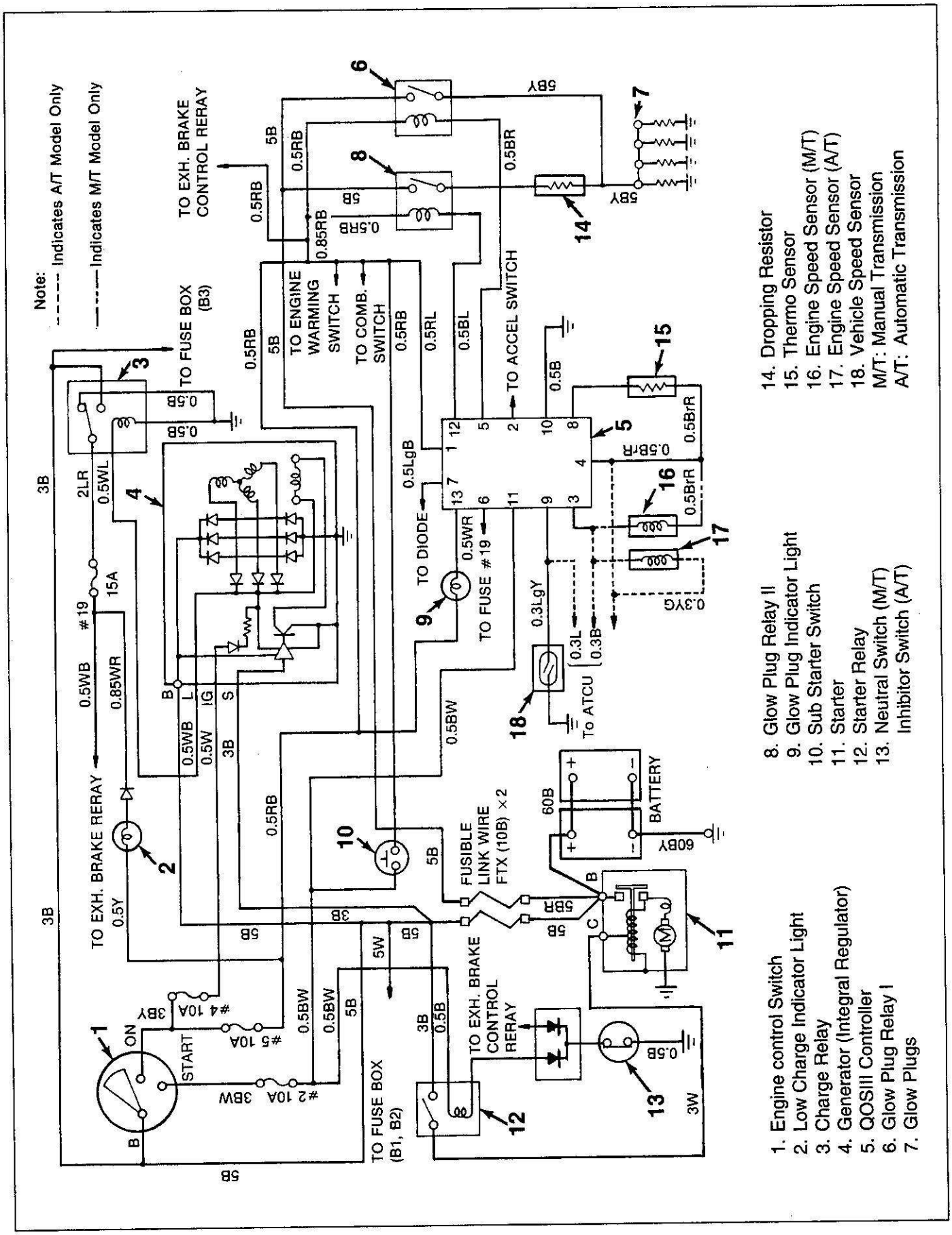
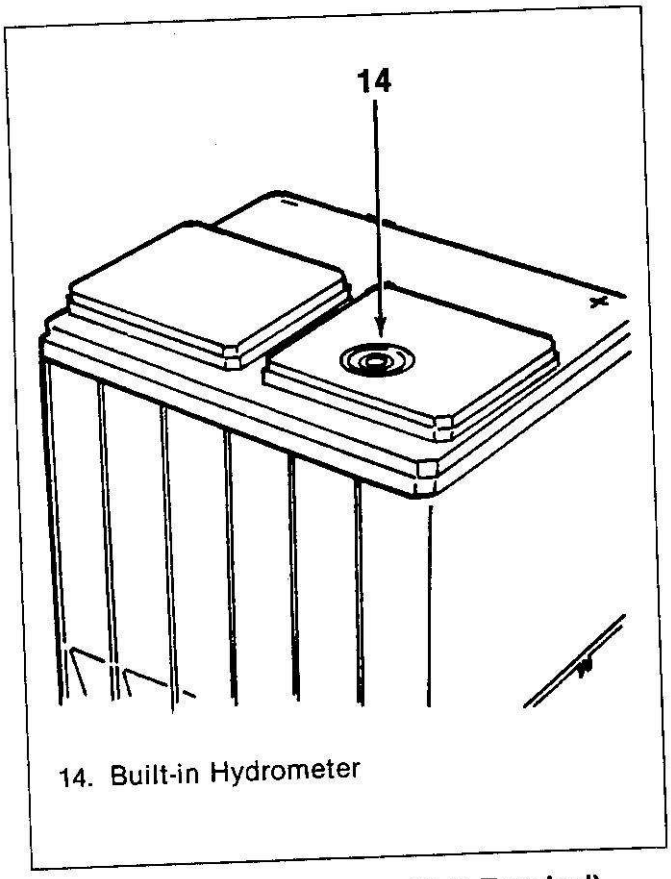
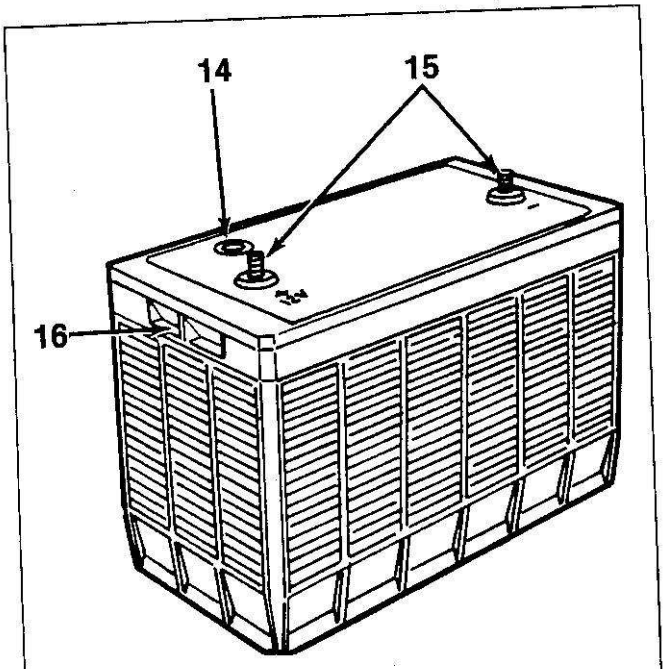


Figure 1. Charging, Starting and Preheating Systems Circuit Diagram



14. Built-in Hydrometer

Figure 2. Sealed Battery (Side Terminal)



14. Built-in Hydrometer
15. Terminals
16. Finger Grip Handles

Figure 3. Sealed Battery (Top Terminal)

Built-in Hydrometer

The sealed battery has a special temperature compensated hydrometer built into the cover to show the battery's state of charge.

The hydrometer has a green ball within a cage that is attached to a clear plastic rod. The green ball floats at a predetermined specific gravity of the electrolyte representing about a 65 percent state of charge. When the green ball floats, it rises within the cage and positions itself under the rod. A green dot then can be seen in the center of the hydrometer (figure 4). The built-in hydrometer provides a guide for battery testing and charging. In testing, a visible green dot means the battery is charged enough for testing. If the green dot is not visible, it means the battery must be charged before the test procedure is performed.

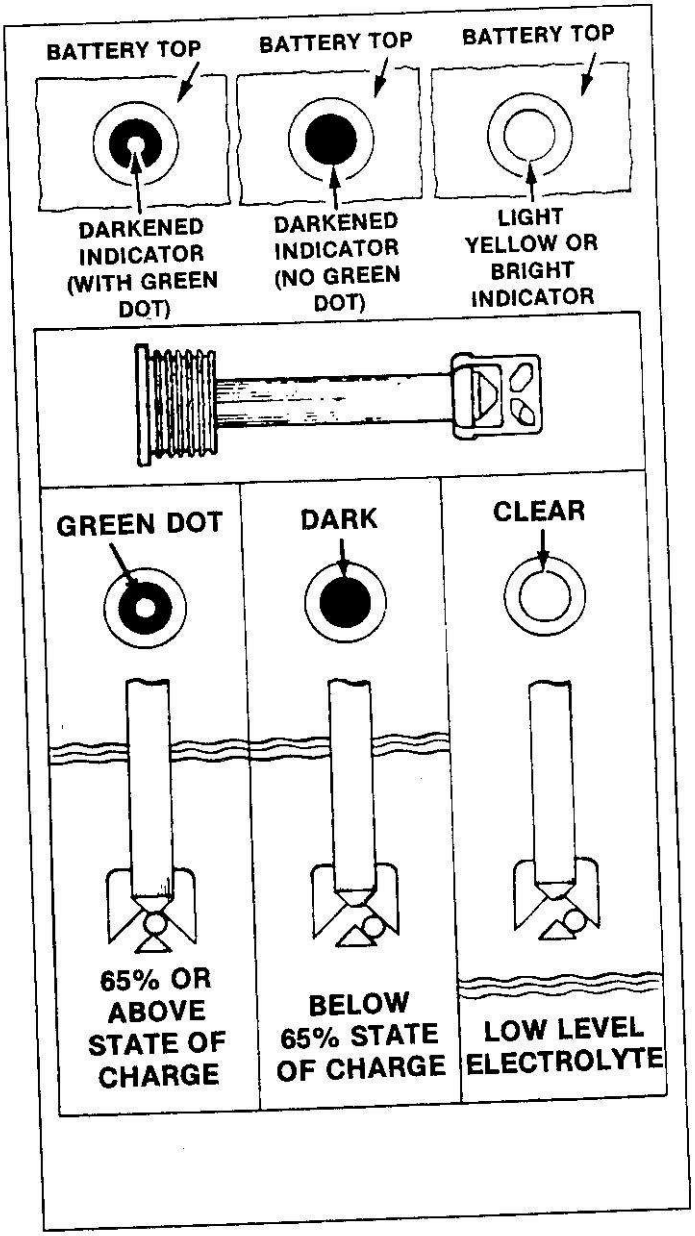


Figure 4. Built-In Hydrometer

In charging, the appearance of the green dot means that the battery is sufficiently charged. Charging can then be stopped to prevent overcharging.

The hydrometer on some batteries may be clear or light yellow (figure 4). This means the fluid level is below the bottom of the rod and attached cage. This may have been caused by excessive or prolonged charging, a broken case, excessive tipping or normal battery wearout. If a cranking complaint exists, and the hydrometer is clear or light yellow, replace the battery—do not charge, test or jump start the battery.

In order to properly observe the hydrometer, the top of the battery should be clean. A light may also be required when working in a poorly lit area.

Common Causes of Failure

If tests show that a battery is good, yet it does not perform well in service, one of the following conditions may be the problem:

1. Vehicle accessories left on for an extended period of time.
2. Problem in the charging system, such as a slipping fan belt, high wiring resistance, or a faulty generator or regulator.
3. A vehicle electrical load exceeding the generator capacity, with the addition of electrical devices such as radio equipment, air conditioning, window defoggers, or light systems.
4. Problems in the electrical system, such as shorted or pinched wires.
5. Extended slow-speed driving with many accessories turned on.
6. Loose or poor battery cable-to-post connections, previous improper charging or run-down battery, or loose hold-downs.
7. High-resistance connections or other problems in the cranking system.

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. Since freezing may ruin a battery, it should be protected against freezing by keeping it in a charged condition.

Carrier and Hold-Down

The battery carrier and hold-down should be clean and free from corrosion before installation.

The carrier should be in a sound mechanical condition so that it will support the battery securely and keep it level. Be certain there are no foreign objects in the carrier before installation.

To prevent the battery from shaking in its carrier, the hold-down bolts should be tight. However, the bolts should not be tightened to the point where the battery case or cover will be placed under a severe strain.

DIAGNOSIS OF BATTERY

Visual Inspection

Inspect

- Battery case or cover for cracks or breaks that could permit loss of electrolyte. Replace the battery if badly damaged, determine the cause of the damage, and correct as needed.

Hydrometer Check

Green Dot Visible (Figure 4)

If the hydrometer has a GREEN DOT visible, the battery is ready for testing. Proceed to "Load Test" later in this section.

Green Dot not Visible or Dark (Figure 4)

Charge the battery as outlined under the heading "Battery Charging Procedure" later in this section.

Light or Bright Indicator; Illustrated as "CLEAR" (Figure 4)

Do not charge, test or jump start the battery. Replace the battery.

Load Test

Top Terminal Batteries

If there is more than one battery in the vehicle, check each battery separately after disconnecting them from each other.

1. Remove battery cables from battery terminals and proceed as follows:
2. Attach terminal hex nuts, required for testing and charging as shown in figure 5.

Important

- The alligator clamps of the tester or charger should be placed between the terminal nuts and the lead pads of the terminal studs as shown in figure 5. If the tester clamps cannot be attached between nuts and lead pads of the terminals, the load value of "Load Test" should be 210 amperes.

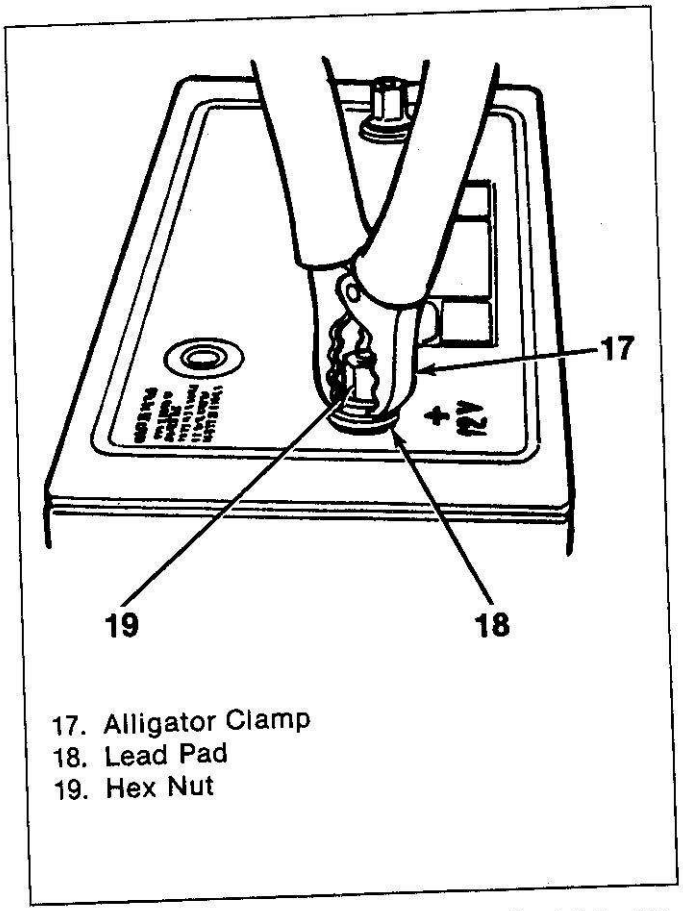
3. Connect a voltmeter and a battery load tester across the battery terminals.
4. Remove the surface charge from all batteries that have been on charge IF THE GREEN HYDROMETER DOT IS VISIBLE. This includes batteries in the vehicle having been charged by the vehicle generator.
   Do not remove surface charge from batteries that have been in storage. To remove surface

charge, apply a 300-ampere load across the terminals for 15 seconds. Then turn off load and wait for 15 seconds to allow the battery to recover.

Voltage and Temperature Chart

Degrees Temperature	Minimum Voltage
21°C (70°F) & Above	9.6
10°C (50°F)	9.4
–1°C (30°F)	9.1
–10°C (14°F)	8.8
–18°C (0°F)	8.5

5. If battery voltage does not drop below the minimum voltage as shown in the previous "Voltage and Temperature Chart," the battery is good and should be returned to service. (The battery temperature must be estimated by feel and by the temperature the battery has been exposed to for the preceding few hours.) If battery voltage drops below the minimum voltage listed, replace the battery.



17. Alligator Clamp
18. Lead Pad
19. Hex Nut

Figure 5. Testing and Charging Terminal Adapter (Top Terminal Battery)

ON-VEHICLE SERVICE: BATTERY

Battery Charging Procedure and Rules

The following basic rules apply to any sealed battery charging situation:

1. Do not charge a battery if the hydrometer is clear or light yellow—replace the battery.
2. Charge rates between three and fifty amperes are satisfactory as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 52°C (125°F)). If spewing occurs or temperature exceeds 52°C (125°F), the charging rate must be reduced or temporarily halted to permit cooling.
3. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.
4. Battery charging consists of a charge current in amperes for a period of time in hours. Thus a 25-ampere charging rate for two hours would be 50 ampere-hour charge to the battery. In most cases, batteries whose load test values are less than 200 amperes will have the green dot visible after least a 50 ampere-hour charge. Most batteries whose load test values are greater than 200 amperes will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, after this amount of charging, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.
5. The time required for a charge will vary because:
   a. Size of Battery—Example: A completely discharged large heavy-duty battery requires more than twice the recharging as a completely discharged small passenger car battery.
   b Temperature—Example: A longer time will be needed to charge any battery at –18°C (0°F) than at 27°C (80°F). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time the battery will accept a higher rate as it warms up.
   c. State of Charge—Example: A completely discharged battery requires more than twice as much as a half-charged battery. Because of a completely discharged battery the electrolyte is nearly pure water and a poor conductor, thus current flow accepted is very low at first. As the charging current causes the electrolyte acid content to increase, the charging current will likewise

increase.

d. Charger Capacity—Example: A charger that can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

Battery Cables

Excessive resistance caused by poor terminal connections and partial short circuits through defective cable insulation will result in abnormal voltage drop in the starter cable. Low voltage at the starter will cause hard starting.

CAUTION: To prevent the vehicle from moving and the engine from starting while performing these checks, engage the parking brake and place the transmission in "Neutral" position.

On diesel engines, disconnect the battery feed terminal connector at the fuel shutoff valve, or pull the "Engine Stop" knob out, as equipped.

Measure

1. Voltage drop between ground (–) battery terminal and vehicle frame.
   - Place one prod of test voltmeter on grounded battery post (not on cable clamp) and the other on frame. Operate starter and note the voltage reading.
2. Voltage drop between the positive (+) battery terminal and starter terminal stud with starter operating.
3. Voltage drop between starter housing and frame with starter operating.

   If the voltage drop in any of the above is more than 1.0 volt, there is excessive resistance in the circuit. To eliminate resistance, the cables should be disconnected and connections cleaned. If cables are frayed or the clamps excessively corroded, the cables should be replaced. When selecting new cables, be sure they are at least as large as the ones being replaced.

Jump Starting

If vehicle has a discharged battery, it can be started by using energy from another battery—a procedure called "jump starting."

CAUTION: The instructions below must be followed exactly or personal injury (particularly to eyes) or property damage may result from battery explosion, battery acid, or electrical (short circuit) burns.

The major safety precaution is to make the final connection to ground on the engine at some distance from the battery. This helps reduce the chance of an explosion due to sparks.

To lessen the chance of an explosion, never expose the battery to open flames or electric sparks. Also do not smoke near the battery. Batteries give off a gas that is flammable and explosive.

To lessen the risk of injury in case an explosion does occur, wear eye protection or shield your eyes when working near any battery. Do not lean over a battery.

Do not allow battery fluid to contact eyes, skin, fabrics, or painted surfaces because battery fluid is a corrosive acid. Flush any contacted area with water immediately and thoroughly. Also get medical help if eyes are affected.

To lessen the risk of a short circuit, remove rings, metal watch bands and other metal jewelry. Also do not allow metal tools to contact the positive battery terminal (or metal in contact with it) and any other metal on the vehicle.

Be certain when attaching the jumper cable clamps" to the positive terminals of the batteries that neither clamp contacts any other metal.

1. This vehicle has a 12-volt starting system and a negative ground electrical system. Be sure that the other vehicle also has a 12-volt starting system and negative ground. Its owner's manual may give you that information.

   IF YOU ARE UNSURE OF THE OTHER VEHICLE'S VOLTAGE (OR IF THE VOLTAGE AND GROUND ARE DIFFERENT FROM YOUR VEHICLE), DO NOT TRY TO JUMP START, AS PERSONAL INJURY OR SEVERE DAMAGE TO ELECTRICAL AND ELECTRONIC PARTS MAY RESULT.

   Because of the extra torque needed to start many diesel engines, diesel powered vehicles often have more than one battery. While it is possible to use the procedure described here to jump start a single-battery vehicle from a vehicle with more than one battery, the opposite may not be true. For example, at low temperature it may not be possible to start a diesel engine. Never connect "+" (red) to "–" (black), or "–" to "+" (figure 6).
2. Position the vehicle with the good (charged) battery so that the jump starting cables will reach. DO NOT ALLOW THE VEHICLES TO TOUCH.
3. Turn off all electrical motors and accessories in both vehicles. Turn off all lights except those needed to protect the vehicle or light up the work area. Turn off the ignition, apply the parking brake firmly. If the vehicle(s) have an

automatic transmission, shift to "PARK" (if no "PARK" position, shift to "NEUTRAL". If the vehicle(s) has a manual transmission, shift to "NEUTRAL". Do this in both vehicles. For vehicles with AC wheel lock control, refer to step 10.

4. If the discharged battery has filler caps, check the fluid level. DO NOT CHECK NEAR AN OPEN FLAME AND DO NOT SMOKE. Add clear drinking water to the proper level if low, and replace caps before jump starting.
5. Connect the first jumper cable from positive "+" (red) terminal on one battery to the "+" (red) terminal on the other battery. Never connect "+" (red) to "–" (black), or "–" to "+" (figure 6).
6. Connect one end of the second cable to the grounded negative "–" (black) terminal of the good (charged) battery (figure 6).
7. Connect the other end of the second jumper cable to a solid, stationary, metallic point on the engine of the vehicle with the discharged battery but at a point AWAY FROM THE BATTERY, 450 mm (18 in) or more from the battery if possible. Do not connect it to pulleys, fans, or other parts that will move when the engine is started.
   Do not touch hot manifolds as they can cause severe burns. If hot or moving parts can be avoided, the MOUNTING BRACKETS for the generator, or the air conditioning compressor, generally make a good point for this final ground attachment point. Take care that the jumper cable does not contact moving parts on or near the generator or compressor (figure 6).
8. Start the engine on the vehicle with the good (charged) battery and run the engine at a moderate speed.
9. Start the engine of the vehicle that has the discharged battery.
10. Jump Starting—AC Wheel Lock Controls—if it is necessary to jump start the vehicle from a booster battery, the circuit boards in the wheel lock control may be damaged. In order to avoid this condition, the following procedure should be used for jump starting vehicles equipped with wheel lock control:
    a. Connect the jumper cables between the booster battery and the discharged vehicle battery, per normal recommended procedures.
    b. Start the vehicle per normal procedures.
    c. Turn on major electrical accessories including lights and heater blower.
    d. Disconnect the jumper cables from the vehicle battery per normal procedures. The above procedure allows the transient energy to be dissipated through several circuits rather than having it all flow through the wheel lock control system.
11. Remove the battery cables by reversing the connecting sequence exactly. Begin by removing the last clamp first; that is, remove the jumper cable from the engine of the vehicle with the discharged battery as the first step.

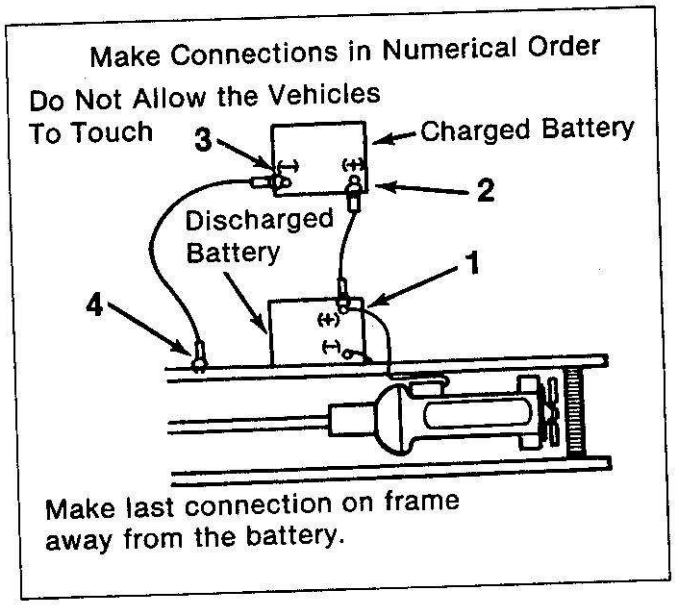


Figure 6. Jump Starting Connections

Battery Replacement

When handling a battery, the following safety precautions should be observed:

1. Hydrogen gas is produced by the battery. A flame or spark near the battery may cause the gas to ignite.
2. Battery fluid is highly acidic. Avoid spilling on clothing or other fabric. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately.

Remove or Disconnect

1. Negative cable from negative terminal.
2. Positive cable from positive terminal.
3. Battery hold-down clamp.
4. Battery.

Inspect

- Battery for physical damage, such as a cracked top or battery case, and correct.

Install or Connect

1. Battery.
   - Draw down the hold-down clamp, being careful not to distort or crack the case or cover.

- Check polarity to be sure the battery is not reversed with respect to the generator.

2. Positive cable to positive terminal.
3. Negative cable to negative terminal.

Tighten

- Battery cables to the battery: no more than 13 N·m (6 lb·ft) for side-mounted terminal batteries, or 20 N·m (14 lb·ft) for top mounted terminals.

CHARGING SYSTEM

DESCRIPTION

The main charging system components are the batteries, the generator and the battery discharge indicator light circuit. The generator is a 70-amp, selfrectifying type with a built-in regulator. The battery discharge indicator light is mounted in the instrument panel. For more details on this circuit refer to INDICATOR AND WARNING LIGHTS (SEC. 8C).

MAINTENANCE

The most common indication of charging system troubles is an undercharged or overcharged battery.
Since the battery itself may be defective, the first step should be to check its condition as described under "Diagnosis of Battery." In the case of an undercharged battery, check for battery drain caused by grounds or by accessories left turned on.

Keep the generator and all other electrical system terminals clean and tight. A loose or badly corroded terminal connection will create excessive resistance in the system and result in hard starting, dim lights etc.

Inspect the generator system at regular intervals and correct any potential causes of trouble before vehicle performance is affected.

DIAGNOSIS OF CHARGING SYSTEM

Trouble in the charging system will be evidenced as one or more of the following three conditions:

1. The battery discharge warning light will stay on.
2. An undercharged battery as evidenced by slow cranking.
3. An overcharge, or overvoltage, condition.

Uudercharged Battery

Inspect

1. Accessories to be sure none were left on for extended periods.
2. Drive belt for proper tension. Refer to "Generator Drive Belt" later in this section.
3. Battery. Refer to "Diagnosis of Battery" earlier in this section.
4. Wiring and connections for corrosion or looseness.

Overcharge (or Overvoltage) condition

A charging rate in excess of 15-volts for a prolonged period may cause early electrical system failure.
Blown fuses. light bulbs burned out, and even battery failure may result. If this condition exists, test the generator as described under "Generator Output Test" later in this section.

Noisy Generator

Inspect

1. Drive pulley for looseness.
2. Mounting bolts for looseness.
3. Bearings for dirt, damage, or wear.
   Generator noise may also be caused by worn or damaged diodes and/or starter.

Electrical Tests

Before performing the following generator electrical tests on the vehicle, be certain that the system wiring is not defective and generator belts are not slipping. Also, the battery must be fully charged for a valid test of the charging system.

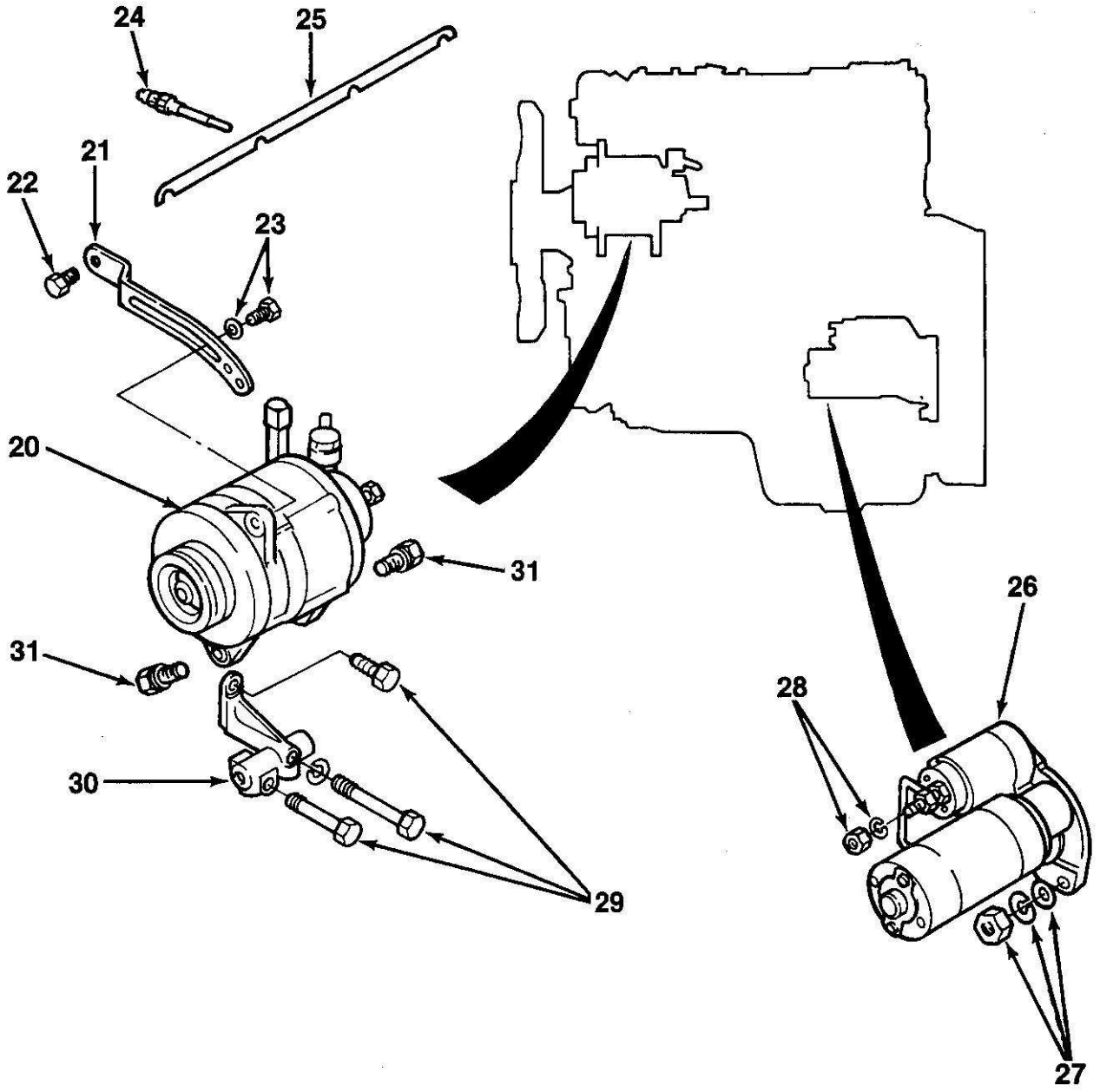
NOTICE: To avoid damage to the vehicle electrical system, always observe the following precautions:

- **Do not polarize the generator.**
- **Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.**
- **NEVER operate the generator with the output terminal open-circuited.**
- **Be sure the generator and battery have the same ground polarity.**
- **When connecting a charger or booster battery to the vehicle battery, connect negative to negative and positive to positive.**

1. With the engine control switch "ON" and engine

not running, connect a voltmeter from terminal "E" to ground. The voltmeter should read zero volts.

2. With the engine control switch "ON," and engine not running, connect a voltmeter from terminal "B" to ground. The voltmeter should read at least 12 volts.
3. With the engine control switch "ON" and the engine not running, connect a voltmeter from white wire side of the connector to ground. The voltmeter should show 12 volts.
4. With the engine control switch "ON" and the engine not running, the "charge" light should be on. This shows that the other circuit in the connection is working.
5. With the engine running and the headlight high beams turned on, read the voltage at the "B" post on the generator. The voltage should be at least 13.5 volts.
6. If steps 1 through 4 are not OK, check connectors in the harness for looseness or corrosion and retest.
7. If step 5 voltage is low, substitute a known good regulator and test again. If the voltage is still low, bench test the generator.



20. Generator
21. Generator Adjusting Bracket
22. Bracket Mounting Bolt
23. Generator Adjusting Bolt
24. Glow Plug
25. Glow Plug Connector
26. Starter Assembly
27. Starter Mounting Nut and Washers
28. Battery Cable Nut and Washer
29. Generator Bracket Mounting Bolt
30. Generator Bracket
31. Generator Mounting Bolt

Figure 7. Engine Electrical Components

GENERATOR REPLACEMENT

Remove or Disconnect (Figure 7)

1. Electrical wiring at the generator.
2. Vacuum and oil hoses attached to the rear of the vacuum pump.
3. Loosen the lower mounting bolts (31).
4. Loosen the adjusting bolt (23).
5. Adjusting bolt and washer (23).
6. Drive belts.
7. Lower mounting bolts (31).
8. Generator (20).

Inspect

- Mount brackets for damage.
- Drive belts for wear or damage.

Install or Connect (Figure 7)

1. Generator (20).
2. Lower mounting bolts (31).
3. Adjusting bolt and washer (23).
   - Align adjusting bolt into the bracket slot.
4. Drive belts.
5. Vacuum and oil hoses at the vacuum pump.
6. Electrical wiring at the generator.

Tighten

1. New drive belts to 530–620 N (120–140 lb) and used drive belts to 440–530 N (100–120 lb).
2. Upper mount nut to 70 N·m (51 lb·ft).
3. Lower mount bolt to 100 N·m (74 lb·ft).

STARTING SYSTEM

DESCRIPTION

Starter and Glow Plug Relays

(Figure 8)

The starter is a 3 kilowatt, reduction drive model. The gear housing and armature end bearing housings are aluminum. The brush assembly has replaceable brushes. The commutator bars are mica insulated and are undercut.

The starter circuit starts at the batteries. The battery cable goes to the large terminal on the starter.

From that terminal wires lead to the engine control switch and the starter relay.

From the engine control switch the starter circuit goes through Fuse #2 and the transmission neutral switch to the starter relay. When the engine control switch is turned to start and the transmission neutral switch is closed, the starter relay closes to complete the circuit from the batteries to the starter solenoid. The starter circuit is also connected to the QOS III controller. The QOS III controller operates when the engine control switch is turned to the "ON" position.

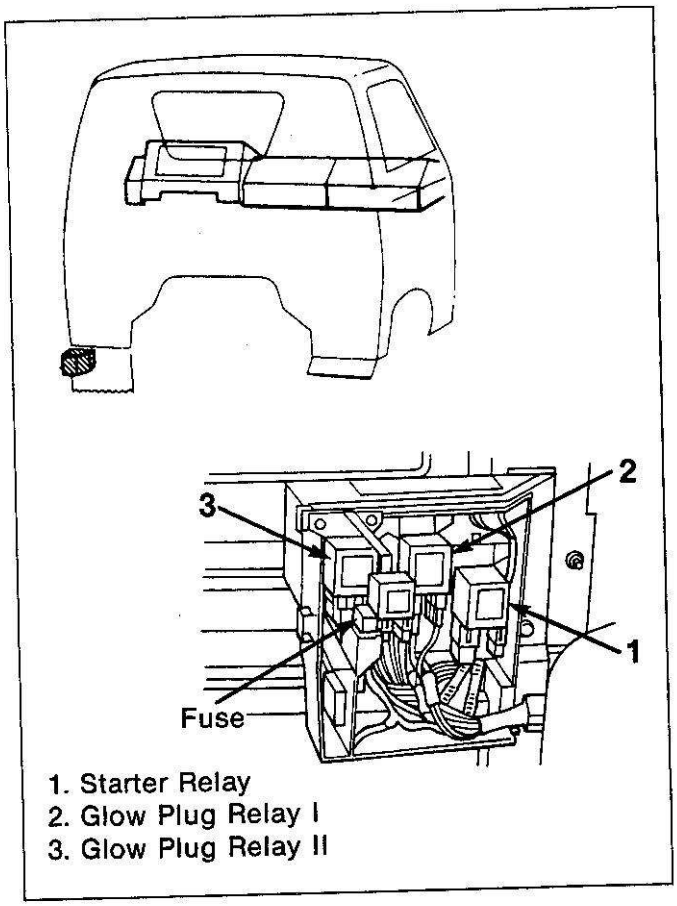
A sub starter switch circuit allows the engine to be started when the cab is raised.

The starter and glow plug relays are located on the frame at the left rear side of the cab (figure 8).

MAINTENANCE

Keep the starter's exterior clean. Remove corrosion from the terminals, leads, and connectors.

Tighten the starter to engine mounting bolts and the electrical cable retaining nuts.



1. Starter Relay
2. Glow Plug Relay I
3. Glow Plug Relay II

Figure 8. Starter and Glow Plug Relay

DIAGNOSIS OF STARTING SYSTEM

No Cranking, No Sound

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for the cause of the discharged batteries.
- Sulfated battery terminals. Turn on the headlights. The headlights will be bright. Attempt to start the engine. The headlights will be very dim or go out. Clean all the battery terminals and cable ends.
- A starter that draws too much current.
- Starter relay won't work. Attempt to start and listen for a "click" at the starter relay. If there is no "click," check the starter relay control terminals with a test light. If the test light shows that power is getting to the starter relay, check the ground circuit with the test light. If the ground circuit is OK, replace the starter relay.
- Engine control switch start circuit won't close. With the engine control switch turned to start, check the starter relay with a test light. If the test light doesn't come on, check the starter circuit at the engine control switch with the test light. If the test light comes on, check the harness for an open and repair. If the test light does not come on, replace the engine control switch.
- Starter relay power circuit isn't closing. Attempt to start. The starter relay "clicks." Check the secondary terminals with a test light. If the test light lights on the battery side only, replace the starter relay. If the test light lights on both terminals, check for an open at the starter.
- Starter clicks when start is attempted. Check all power connections for corrosion. Clean connections if corrosion is present. Terminal on starter should have at least 9 volts on it when cranking the engine. If voltage is OK, replace the starter.

Slow Cranking, Solenoid Clicks or Chatters

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for cause of discharged batteries.
- Corrosion on the battery terminals. Check for corrosion. Hint: Test for warm terminals. Clean all the battery terminals and connectors.
- Loose or dirty connections. Measure the cranking voltage at the battery terminals. If the voltage is less than 9.6 volts, load test the battery. If the battery is bad, replace the battery. If the battery is good, repair the starter.

If the voltage is 9.6 volts or more, measure the voltage from the battery NEGATIVE terminal to the engine block. If the voltage is 0.5 volt or more, repair the ground cable and connections.

If the voltage is less than 0.5 volt, measure the voltage at the battery cable terminal on the starter. If the voltage is 9 volts or more, repair the starter. If the voltage is less than 9 volts, clean and tighten the positive cable connections. If the voltage is still less than 9 volts, replace the positive cable.

ON-VEHICLE SERVICE: STARTER SYSTEM

Maintenance

Keep starter terminals and all other terminals in the electrical system clean and tight. A loose or corroded connection or terminal will cause excessive resistance in the system that will result in hard starting.

At regular intervals, inspect the starting system to locate and correct potential causes of trouble before the system performance is affected.

Starting motors do not require lubrication except during overhaul.

Starter Replacement

Remove or Disconnect (Figure 7)

1. Battery negative cable from the battery.
2. Cables and electrical leads from the starter.
3. Three mounting nuts and washers (27, 28).
4. Starter (26).

Install or Connect

1. Starter (26).
2. Three mounting washers and nuts (27, 28).

Tighten

- Mounting nuts to 70 N·m (51 lb·ft).

3. Cables and electrical leads to the starter.
4. Battery negative cable to the battery.

GENERATOR UNIT REPAIR

DESCRIPTION OF GENERATOR

The generator (1) is a 12 volt, 3 kw, model with a solid state regulator mounted to the brush holder (2). The generator must be disassembled to remove the regulator or brush holder assembly. The generator rotor bearings (4) contain enough grease to eliminate periodic lubrication. Two brushes carry current through two slip rings to the field coil.

The stator windings are assembled on the inside of a laminated core that forms part of the generator frame. A rectifier bridge connected to the stator windings contains six diodes that change the stator AC voltages to a DC voltage (figures 9 and 10).

The vacuum pump (3) is attached to the rear of the generator.

GENERATOR OUTPUT TESTS

To check the generator in a test stand, proceed as follows:

Important

- Use a fully charged battery when performing these tests.

1. Connect an ammeter (5) from the positive (+) battery side to the generator output wire (6). This is 8 mm (0.032 in) (black) wire. Leave the carbon pile disconnected.
2. Slowly increase the generator speed and observe the voltage meter (8). If voltage is uncontrolled with speed and increases above 15.5 volts on a 12-volt system, replace the regulator and check the rotor winding. If the voltage is below 15.5 volts, connect the carbon pile (7) across the battery.
3. Run the generator at 4,000 RPM and adjust the carbon pile to obtain maximum current output, which should be 55 to 70 amperes at 13.5 volts.
4. If the output is not within 10 amperes of the rated output, check the rotor winding, rectifier bridge, and stator as described later under "Inspection and Repair" and "Electrical Bench Tests."

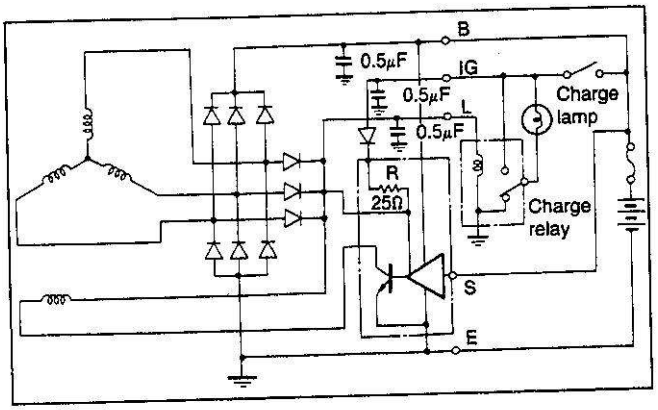
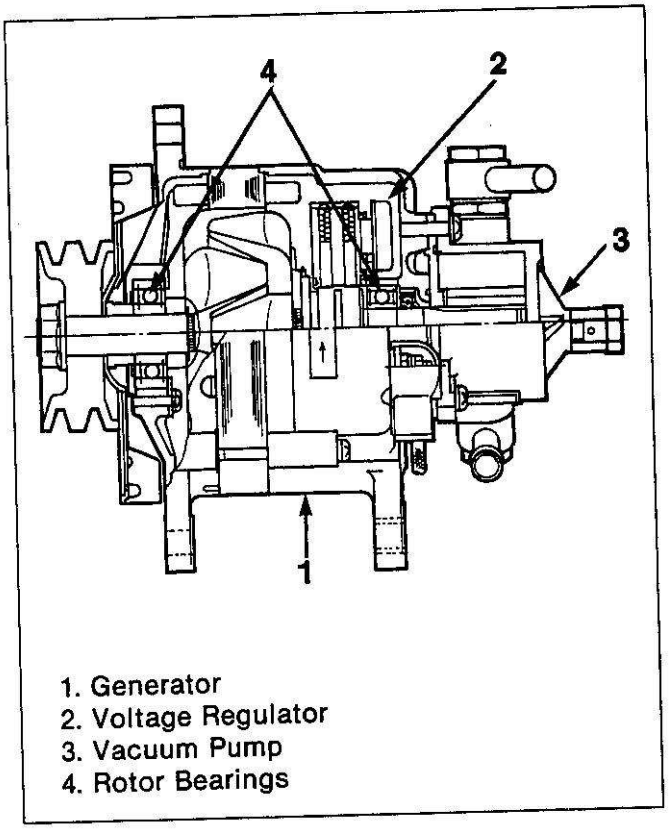


Figure 9. Generator Schematic



1. Generator
2. Voltage Regulator
3. Vacuum Pump
4. Rotor Bearings

Figure 10. Generator

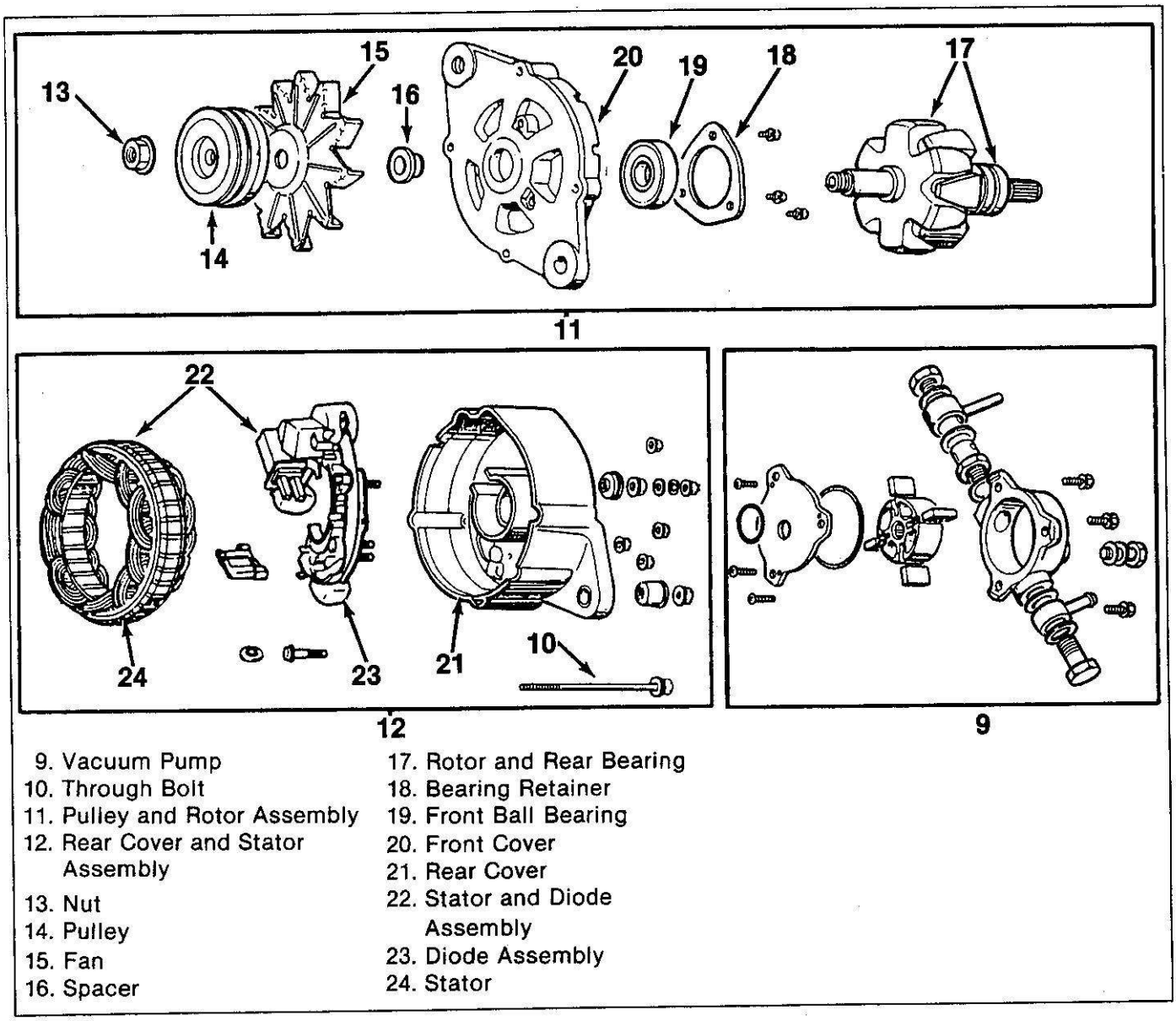
Inspect

- Before performing the generator output test, all charging system components, wires and terminals for wear or damage. Repair or replace any parts found defective.

DISASSEMBLY OF GENERATOR

Disassemble (Figure 16)

1. Vacuum pump assembly (9).
   - Remove the vacuum pump screws attached to the back of the generator. Hold the center plate to prevent the rotor and vanes from dropping out, then remove the vacuum pump in the direction in line with the rotor shaft. Remove the center plate fixing screws and the center plate, then remove the rotor and vanes.
2. Through bolts (10).
   - Separate the front cover assembly from the rear cover assembly.
     When separating the front and rear cover assemblies, be sure the stator assembly stays seated in the rear cover.
3. Pulley and rotor assembly (11).
   - Be sure not to damage the oil seal when removing the pulley and rotor assembly from the rear cover assembly.
   - Tape the rotor shaft splines to prevent accidental damage.
4. Rear cover and stator assembly (12).
5. Pulley nut (13).
   - Clamp the rotor assembly in a vise to remove the pulley nut.
6. Pulley (14).
7. Fan (15).
8. Spacer (16).
9. Rotor and rear bearing (17).
10. Bearing retainer (18).
11. Front ball bearing (19).
12. Front cover (20).
13. Rear cover (21).
    - Remove nuts at the rear cover battery terminal and diode holder assembly.



9. Vacuum Pump
10. Through Bolt
11. Pulley and Rotor Assembly
12. Rear Cover and Stator Assembly
13. Nut
14. Pulley
15. Fan
16. Spacer
17. Rotor and Rear Bearing
18. Bearing Retainer
19. Front Ball Bearing
20. Front Cover
21. Rear Cover
22. Stator and Diode Assembly
23. Diode Assembly
24. Stator

Figure 16. Generator Assembly

Important

- Separate the stator and rear cover. Be sure you identify the proper position of the insulated washers to prevent improper installation.

14. Stator and diode assembly (22).
15. Diode assembly (23).
    - Separate the diodes from the stator by melting the solder on the stator coils, diodes and N terminal leads. When melting solder, hold the lead wire with long-nose pliers to prevent heat from being transferred to the diodes.
16. Stator (24).

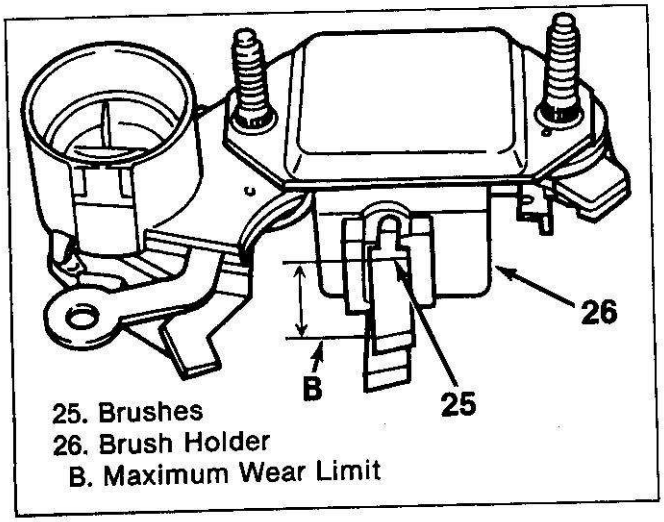
INSPECTION AND REPAIR

Clean

- All metal parts except the voltage rectifier bridge, stator, rotor and bearing assemblies in a suitable solvent.
- Wipe or blow the components dry.

Inspect

- Brush holder and brushes. The brushes have a line that indicates their limit. If the brushes are shorter than 6 mm (0.24 in) replace the brushes (figure 17).
- Voltage regulator for damage or corrosion.
- Bearings and spacer. Rotate the bearing and check for roughness or excessive drag. If in doubt about the bearing, replace it.



25. Brushes
26. Brush Holder
B. Maximum Wear Limit

Figure 17. Brush Holder and Brushes

- Rotor and stator windings for burned insulation or broken terminal connectors, wires, etc.
  Burned insulation may appear as very dark or blackened wiring, and sometimes charred paint or a combination of the two. Replace the rotor or stator if the windings are burned.
- Generator frames. Check for distortion, cracks or damage. Replace as necessary.
- Rotor slip rings. If the rings are dirty, clean them with 500–600 grain or finer polishing cloth.
  Clean the slip rings with rubbing alcohol if the rings are contaminated. Spin the rotor and hold the polishing cloth against the rings until they are clean. Slip rings which are rough, scored, or out-of-round, must be machined in a lathe to 34 mm (1.339 in). Finish the slip rings with 500–600 grain or finer polishing cloth and blow away all dust particles after the machining process.
- All vacuum pump components for wear, damage or other abnormal conditions.
- Check valve. Apply a light pressure onto the check valve with a screwdriver and check the valve to be sure it's operating smoothly (figure 18).
- Oil seal (O-ring). Check the inner face of the rear cover for traces of oil leakage. Be sure the inner face of the oil seal is not worn or damaged.
  If worn or damaged, use a screwdriver to remove the oil seal (O-ring) from the rear cover.
  Install a new oil seal (O-ring) using an oil seal installer or equivalent.

Measure (Figures 19 and 20)

- The length of the vanes. The length must be 14.0–15.0 mm (0.551–0.591 in) (figure 9).
  Replace vanes if not within these specifications.
- The inside diameter of the vacuum pump housing.
  The diameter must be 60.0–60.1 mm (2.362–2.366 in) (figure 20).
  Replace the housing if not within these specifications.

ELECTRICAL BENCH TESTS (GENERATOR)

Inspect

- For an open circuit by connecting a self-powered test light or ohmmeter to each slip ring. If the test light does not come on or if the ohmmeter reading is high (infinite), the winding is open.
- For a grounded winding by connecting a self-powered test light or ohmmeter from one slip ring to the armature shaft. if the light lights or continuity exists, the armature is grounded.
- Shorted winding or high resistance by connecting a 12-volt battery and 0-10 amp ammeter in series with the two slip rings.
  The ammeter should read about 4.1 amps at 12 volts. The specified resistance is 2.9 ohms. An ammeter reading above the specified value

indicates shorted windings. An ammeter reading below the specified value indicates excessive resistance. If readings are not to specifications replace the rotor.

- Stator for continuity across the stator leads. If no continuity exists, replace the stator.

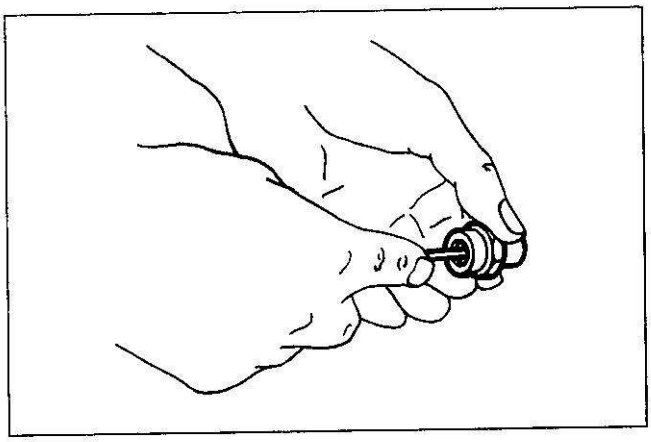


Figure 18. Checking Check Valve Operation

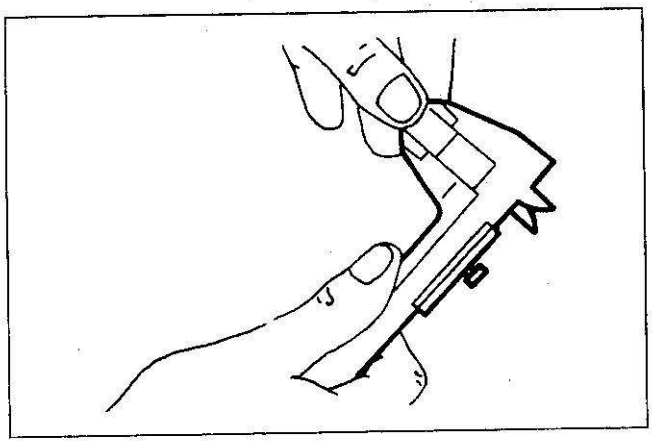


Figure 19. Measuring Length of Vane

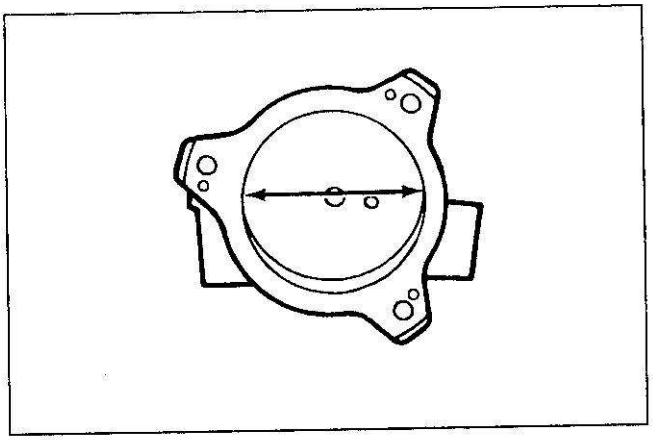


Figure 20. Inside Diameter of Vacuum Pump

- Stator for grounds by first unsoldering the rectifier bridge from the stator. Be sure to mark where the leads go. Then connect a self-powered test light or ohmmeter from each stator lead to the frame. If the test light lights or the ohmmeter indicates continuity, the stator is grounded and must be replaced.
- Check the diodes for continuity with an ohmmeter across the positive (+) side diodes and negative (–) side diodes. If continuity exists, the diode is in satisfactory condition. If no continuity exists, the diode is faulty. Reverse the ohmmeter test leads and check continuity. If no continuity exists, the diode is in satisfactory condition. If continuity exists at any point, the diode is defective and must be replaced.
  Resolder the rectifier bridge leads to the diodes. Then resolder the rectifier bridge to the stator terminals.
- IC voltage regulator. Measure the voltage across the E and F terminals. Voltage must be between 14.4–15.0 volts at 20°C (68°F). The meter should show a varying resistance gradually from zero using a rheostat. The voltage should increase abruptly about 2 volts. If the voltage if interrupted, replace the regulator (figure 21).
- Measure the voltage across the L, S, and E terminals. Voltage must be 14.4–15.0 volts at 20°C (68°F). The meter should show a varying resistance gradually from zero using a rheostat. The voltage should increase abruptly 2–6 volts. If the voltage is interrupted, replace the regulator (figure 21).
- Measure the voltage across the B, L and E terminals. Voltage must be 14.9–16.5 volts at 20°C (68°F).
  The meter should show a varying resistance gradually from zero using a rheostat.
  The voltage should increase abruptly. If the voltage is interrupted, replace the regulator (figure 21).

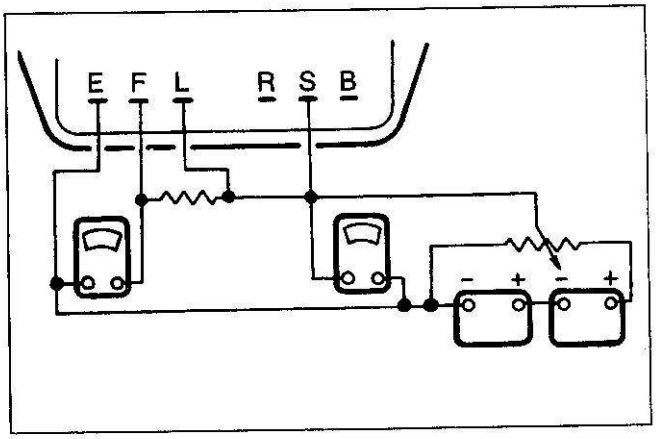


Figure 21. Measuring Voltage at Voltage Regulator

ASSEMBLY OF GENERATOR

Assemble (Figure 16)

Important

- When connecting the stator coil leads and diode leads using solder, use long-nose pliers and work as quickly as possible to prevent the heat from transferring to the diodes.

1. Stator (24).
2. Diode assembly (23).
3. Stator and diode assembly (22).
4. Rear cover (21).
5. Front cover (20).
6. Front ball bearing (19).
7. Bearing retainer (18).
8. Rear bearing (17).
9. Spacer (16).
10. Fan (15).
11. Pulley (14).
12. Pulley nut (13).

Tighten

- Pulley nut to 98 N·m (72 lb·ft).

13. Rear cover and stator assembly (12).
    - Position the projected portion of the ring on the bearing so that the projection becomes minimal.
14. Pulley and rotor assembly (11).
    - Install the pulley and rotor assembly holding the brushes pushed in with a paper clip. Remove the tape on the rotor shaft splines and insert the pulley and rotor assembly into the rear cover assembly.
15. Through bolts (10).
    - Place a guide bar through the holes in the front cover and rear cover flange for proper alignment. Install the through bolts.

Tighten

- Through bolts to 4 N·m (35 lb·in).

16. Vacuum pump assembly (9).
    - Position the rotor (27), with the serrated boss (28) turned up, on the center plate and housing (figures 22).
    - Align the holes in the center plate and rotor.
    - Install vanes (29) into the slits in rotor (27). The vanes must be installed with the round side turned outward (figure 22).
    - After installation of seal (O-ring), install the center plate (figure 23).
    - Install the vacuum pump assembly to the back of the generator with 3 screws.

Tighten

- Vacuum pump screws to 6 N·m (52 lb·in).

- Install 5 cc (0.016 oz) engine oil in the filler port, then check that the generator pulley can be turned smoothly by hand.

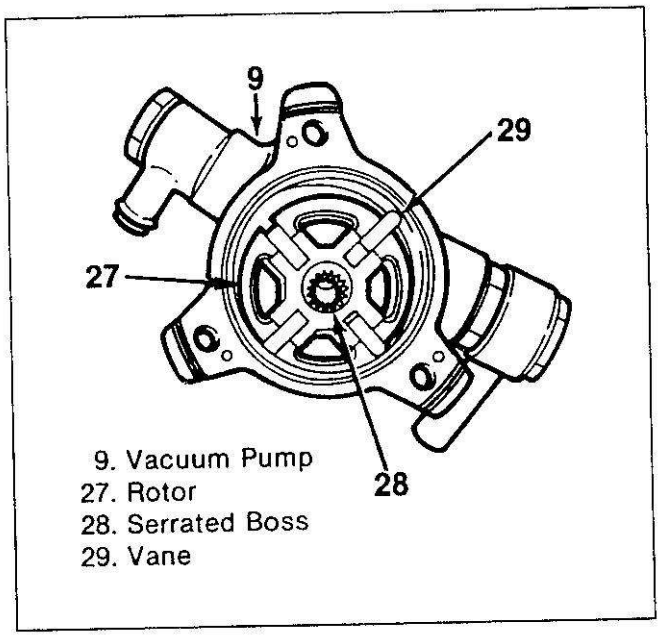


Figure 22. Installing Vanes Into Rotor

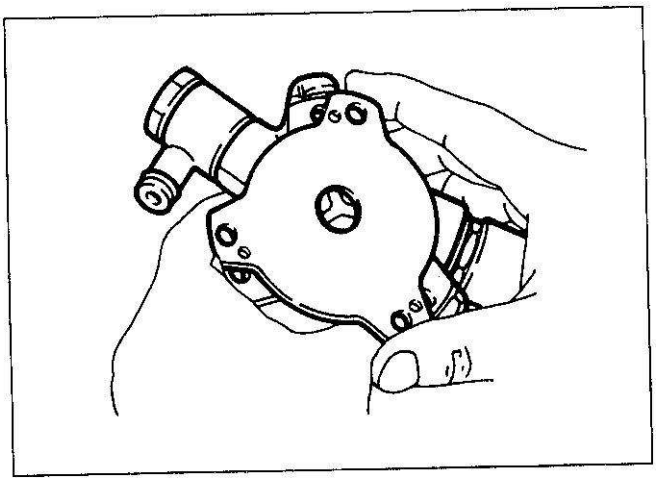
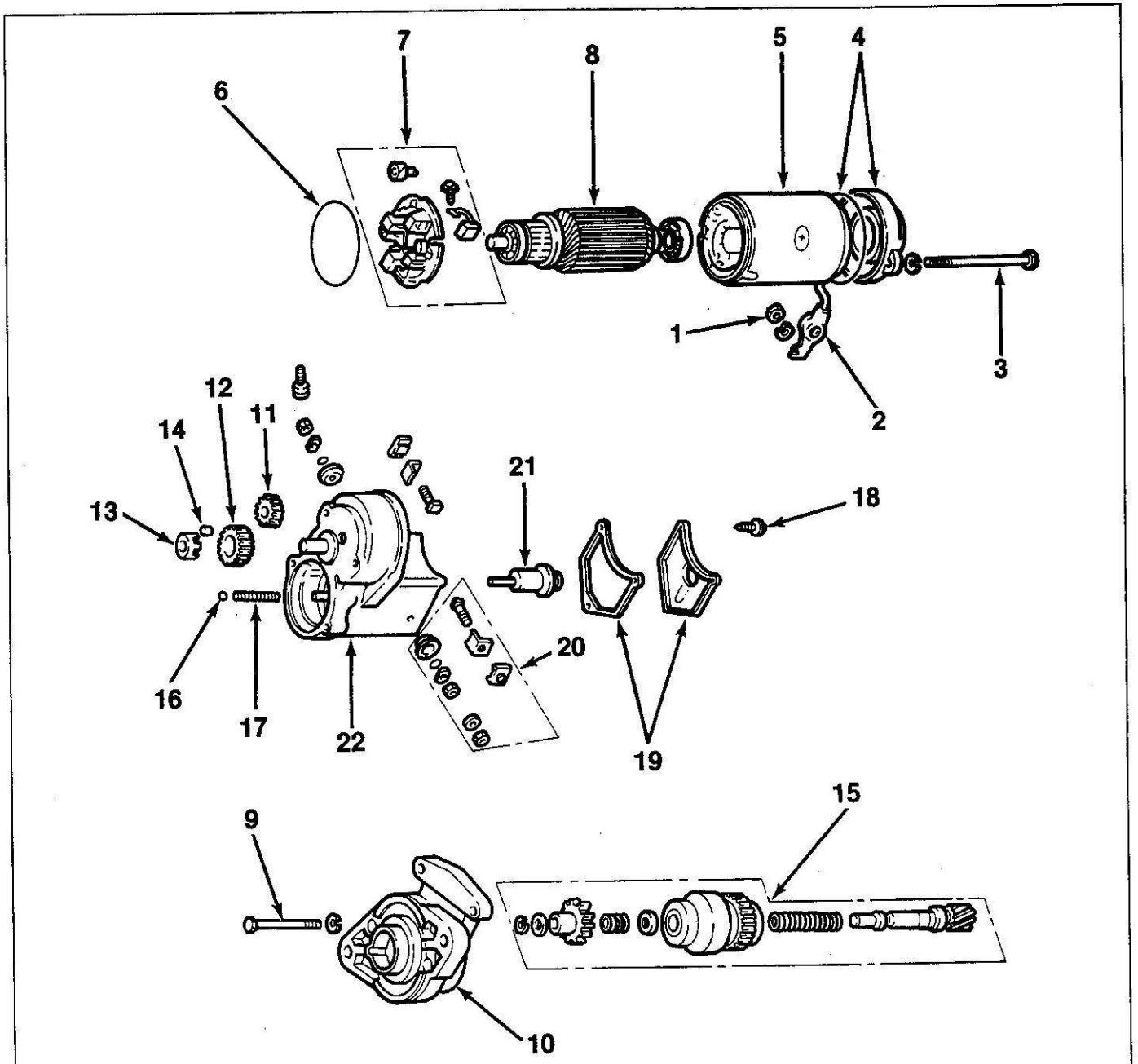


Figure 23. Installing Vacuum Pump Center Plate

STARTER MOTOR UNIT REPAIR



1. Nut
2. Lead Wire
3. Through Bolt
4. End Frame
5. Field Frame
6. Seal
7. Brush and Brush Holder
8. Armature
9. Screw
10. Drive Housing
11. Pinion
12. Pinion
13. Retainer
14. Roller
15. Clutch Assembly
16. Steel Ball
17. Ball Spring
18. Screw
19. Cover and Gasket
20. Terminal
21. Plunger
22. Solenoid Housing Assembly

Figure 24. Starter Motor Assembly

DESCRIPTION OF STARTER MOTOR

The 3 kw starter motor is a gear-reduction type with a direct-acting solenoid working through the gear clutch (figure 24).

The ball bearings on the clutch assembly are serviced as part of the whole clutch assembly. The starter is constructed of three main assemblies. The starter housing (10), starter field frame assembly(5), and starter end frame (4). The starter housing encloses the starter clutch assembly (15). The starter field frame contains the starter armature (8) and field coils, and the starter end frame encloses the rear of the starter field frame that has two through bolts (3) attaching to the starter housing (10).

DIAGNOSIS PRIOR TO DISASSEMBLY

Before disassembling the starter motor for repair, the following test should be made.

NOTICE: Never operate the starter motor more than 30 seconds at a time. Allow it to cool at least two minutes before operating again. Overheating, caused by too much cranking will damage the starter motor.

Starter Motor Tests

(Figure 25)

With the starter motor removed from the engine, the pinion gear should be checked for freedom of operation by turning it on the spline shaft. The armature should be checked for freedom of rotation by turning the pinion gear with a screwdriver. Keep in mind that there is more drag with a gear reduction starter motor. Tight bearings, a bent armature shaft, thick grease or a loose pole shoe will cause a high level of drag. If the drag is low with no sounds of grinding or jamming, the motor should be given a no-load test before disassembly.

Before giving the starter a no-load test, test the solenoid operation as follows:

1. Connect a 12V battery source (23), shunt (24) and ammeter (25) between the solenoid start terminal (26) and the housing (10).
2. The solenoid should pull in as indicated by the pinion gear moving to the end of the shaft.
3. If the solenoid does not operate properly, repair the solenoid before giving the starter a no-load test. Refer to "Disassembly of Starter Motor," later in this section.

No-Load Test

(Figure 25)

1. Secure the starter in a vice. Do not clamp around field frame.
2. Connect the starter motor (10) and ammeter (25) in series, being sure the battery is fully charged (12 volts). Observe the operation of the starter after the pinion clutch gear engages.

   The starter should draw 11.0 volts and 220 amps or less. The armature speed should be 4,200 RPM or more as indicated on the tachometer (27).

   - It is not necessary to obtain the exact voltage specified as a good reading can be made by understanding that if the voltage is slightly higher, the RPM will be slightly higher, with current remaining basically unchanged. However, if the exact voltage is desired, a carbon pile (29) connected across the battery can be used to reduce the voltage to the specified value.

     If more than one 12-volt battery is used in series, connect the carbon pile across only one of the 12-volt batteries.

No-Load Test Results

1. Rated current draw and no-load speed indicates normal condition of the starter motor.
2. Low free speed and high current draw indicates:
   - Too much friction. Tight, dirty or worn bearings, bent armature shaft or loose pole shoes allowing the armature to drag.
   - Shorted armature. This can be furthers checked on a growler after disassembly.
   - Grounded armature or fields. Check further after disassembly.
3. Starter motor is not turning. Ammeter shows high current draw. This indicates:
   - A direct ground in the terminal or fields.
   - "Frozen" bearings. This should have been noted by turning the armature manually.
4. Starter motor is not turning. Ammeter shows no current draw. This indicates:
   - Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing the circuit with a test light.
   - Open armature coils. Inspect the commutator for badly burned bars after disassembly.
   - Broken brush springs, worn brushes, high insulation between the commutator bars or other causes that would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicates a high internal resistance due to:
   - Poor connections.
   - Faulty leads.
   - Dirty commutator.
   - Causes listed under number 4.

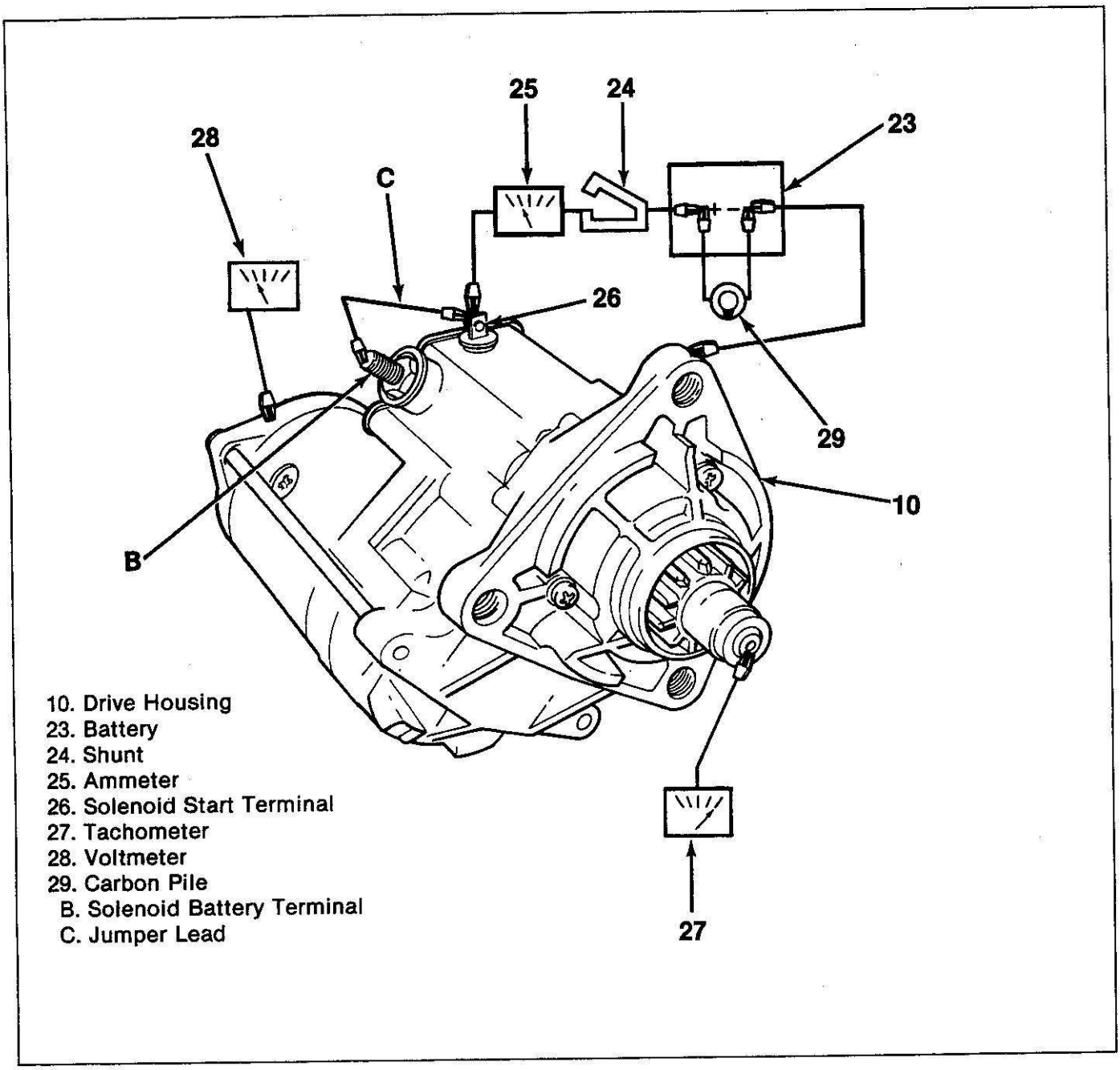


Figure 25. Starter No-Load Test

6. High free speed and high current draw indicate shorted fields.
   If shorted fields are suspected, replace the field coil assembly and check for improved performance.

DISASSEMBLY OF STARTER MOTOR

Remove or Disconnect (Figure 24)

- Clean the outside of the starter motor and scribe alignment marks across the drive housing and field frame.

1. Nut and lead wire (1, 2).
   Disconnect the nut and lead wire from the solenoid.
2. Through bolts and end frame (3, 4).
   Remove two through bolts and end frame from the field frame.
3. Field frame (5).
   Separate the field frame from the solenoid.
4. Field frame seal (O-ring) (6).
5. Brush and brush holder (7).
   Using long-nose pliers, remove the brushes and pull out the brush holder from the armature.
6. Armature (8).
   Using a plastic hammer, tap on the field frame end to separate the armature from the field frame.

7. Screws (9).
   Remove three screws from the drive housing and separate the drive housing from the magnetic switch.
8. Drive housing (10).
9. Pinions(11, 12).
   Remove two pinions and remove the overrunning clutch and retainer.
10. Retainer (13).
11. Roller (14).
12. Pinion clutch assembly (15).
13. Steel ball (16).
    Remove the steel ball from the clutch assembly.
14. Ball spring (17).
    Remove the steel ball from the clutch assembly.
15. Screw (18).
16. Cover and gasket (19).
17. Terminal (20).
18. Plunger (21).
19. Solenoid housing assembly (22).

CLEANING, INSPECTION AND REPAIR

Clean

- All disassembled parts.
- Be careful not to let solvent get into the clutch assembly or the sealed bearing. Don't wash the armature bearings in solvent.
- Use electrical parts cleaner on the solenoid coil, brushes, armatures, and field coils.

Inspect (Figure 26)

1. Starter housing.
   - Housing for cracks or damage.
   - Clutch bearing bore for signs of bearing spin.
   - Flange surface for flatness.
   - Replace the housing if worn or damaged.
2. Clutch assembly.
   - Pinion gear for badly worn or chipped teeth, or for wobble on the shaft (figure 26).
   - Bearings for wobble, roughness or damage.
   - Clutch for roughness or slipping.
   - Drive gear for badly worn or chipped teeth. Replace the clutch assembly if its condition is doubtful.
3. Pinion gears.
   - Teeth for wear or damage.
   - Inner surface for wear or damage.
4. Roller bearing for wear. Assemble the gear and bearing on the solenoid housing stub shaft and check for wobble.
5. Solenoid housing for cracks or other damage.
6. Solenoid for damage.
7. Armature.
   - Commutator to runout and replace the armature if runout is less than 0.2 mm (0.0079 in) (figure 27).
   - Commutator segments for wear or damage. The depth of each segment must not be less than 0.2 mm (0.0079 in) (figure 28).
   - Commutator outer diameter. The diameter must not be less than 42 mm (1.654 in) (figure 29).
   - Armature bearings for wear and damage. If the bearings are noisy while turning them by hand, they must be replaced.
8. Brush and brush holder.
   - Replace the brushes if the brush length is less than 13 mm (0.51 in) (figure 30).
   - Brush springs for wear, damage or other abnormal conditions.
     Replace the brush springs if the spring tension is less than 3.3 kg (7.3 lb) (figure 31).
   - The movement of the brush in the brush holder. If the brush movement within the brush holder is sluggish, check the brush holder for distortion and sliding faces or contamination. Clean or repair as necessary.
   - Touch one probe of the ohmmeter or self-powered test light across the insulated brush holder positive (+) side and the other probe to the grounded brush holder negative (–) side. If the light lights or continuity is indicated at the ohmmeter, the brush holder is grounded and must be replaced (figure 32).

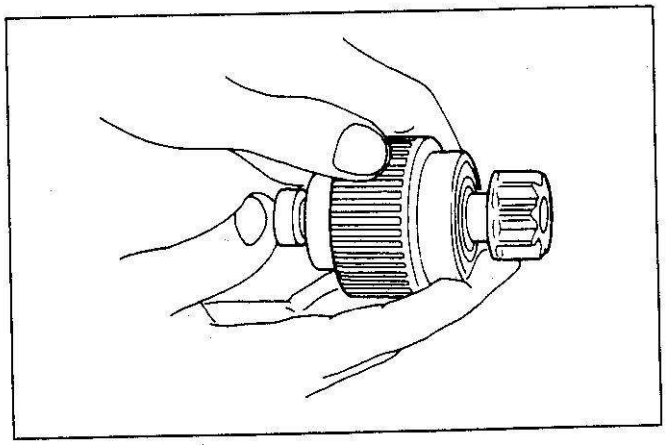


Figure 26. Inspecting Pinion Gear

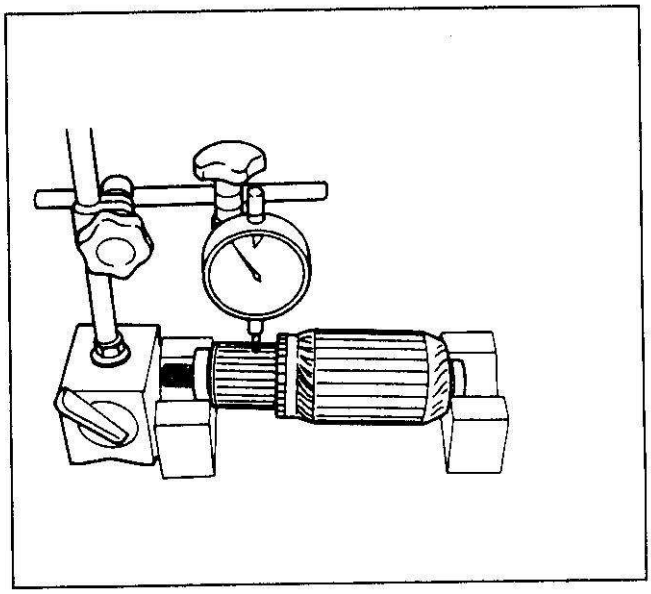
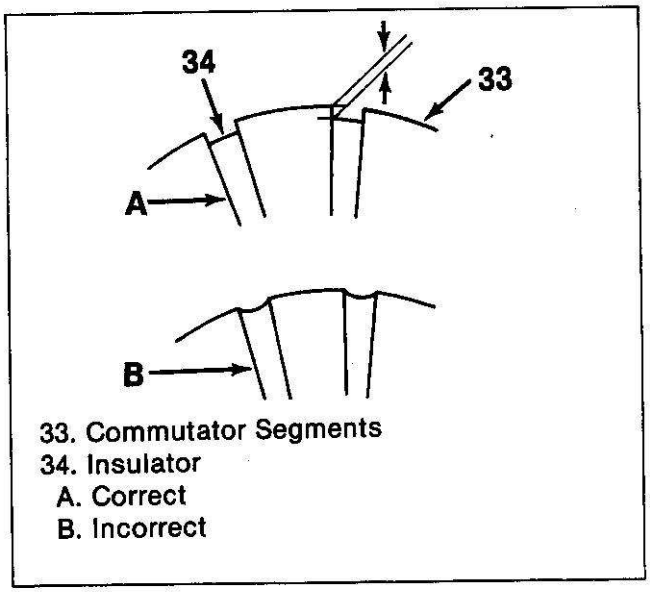


Figure 27. Checking Armatuer Runort



33. Commutator Segments
34. Insulator
A. Correct
B. Incorrect

Figure 28. Checking Commutator Segments

ELECTRICAL BENCH TESTS (STARTER)

Inspect (Figures 33-37)

1. Armature for short circuit.
   Short circuits are detected by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature parallel to the shaft. The steel strip will vibrate on the area of the short circuit. Shorts between the bars are sometimes caused by brush dust (figure 33).
2. Armature for grounds.
   Grounds in the armature can be detected by the use of a self-powered test light or ohmmeter. Touch one probe of the ohmmeter or test light to the commutator segment and the other probe to the armature core. If the light lights or continuity is indicated at the ohmmeter the armature is grounded and must be replaced (figure 34).
3. Armature for opens.
   Touch one probe of the ohmmeter or self-powered test light across two segments of the commutator. There must be continuity at any locations on the commutator (figure 35).
4. Field ground test.
   Touch one probe of the ohmmeter or self-powered test light to the field winding end or brush and other probe to outside surface of the field frame body. Replace the field frame assembly if continuity exists (figure 36).
5. Field winding open test.
   Touch one probe of the ohmmeter or self-powered test light to the starter lead wire terminal and the other probe to brush. Replace the field frame assembly if no continuity exists (figure 37).

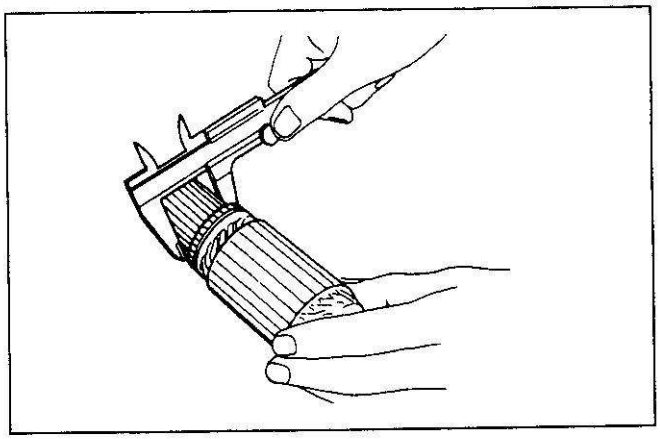


Figure 29. Measuring Commutator Outside Diameter

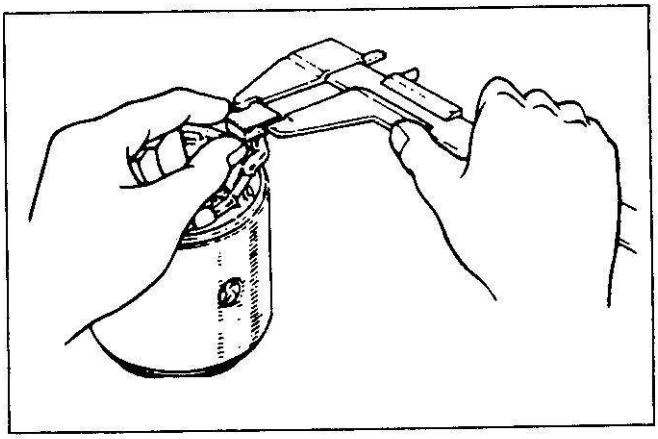


Figure 30. Measuring Brush Length

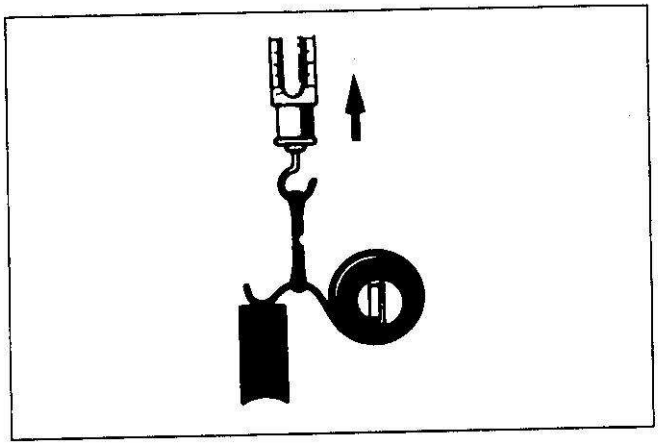


Figure 31. Measuring Brush Spring Tension

6. Solenoid assembly.
   - The solenoid should be tested with starter assembled.
   - Disconnect the field frame lead wire.
   - Each test should be completed in a short time (3–5 seconds) to prevent the coils from burning.

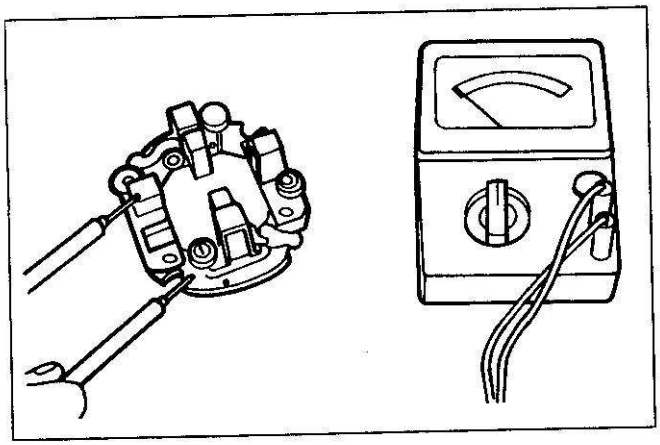


Figure 32. Checking Brush Holder for Grounds

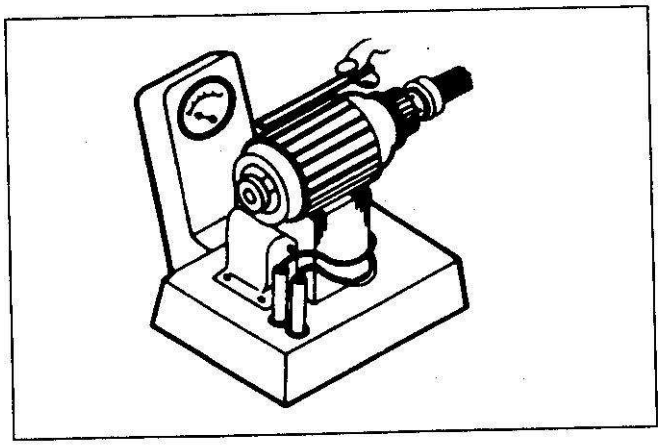


Figure 33. Checking Armature for Shorts

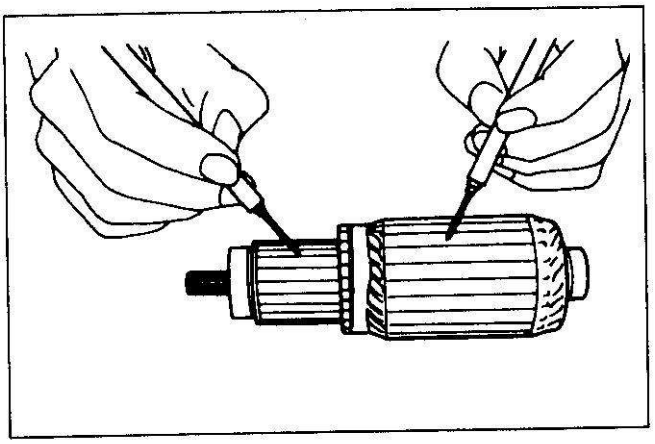


Figure 34. Checking Armature for Grounds

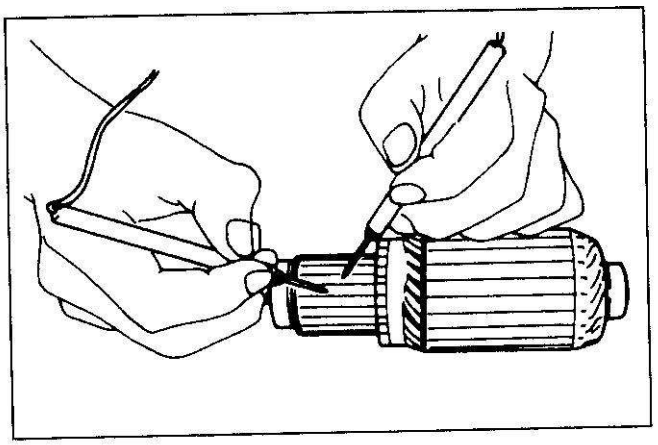


Figure 35. Checking Armature for Opens

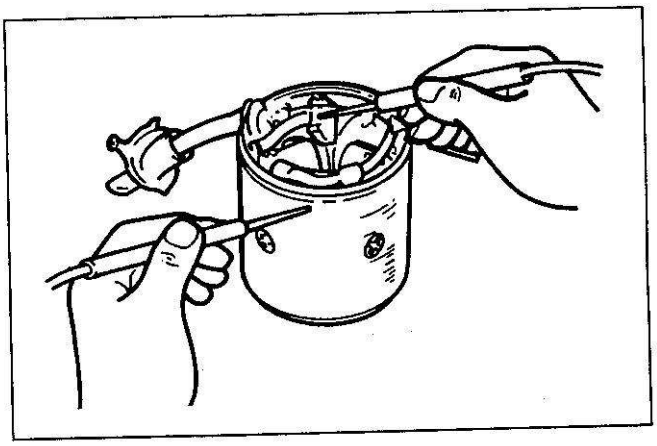


Figure 36. Field Ground Test

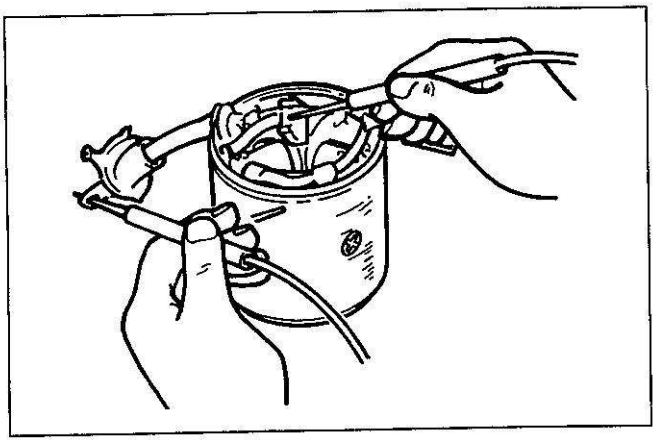
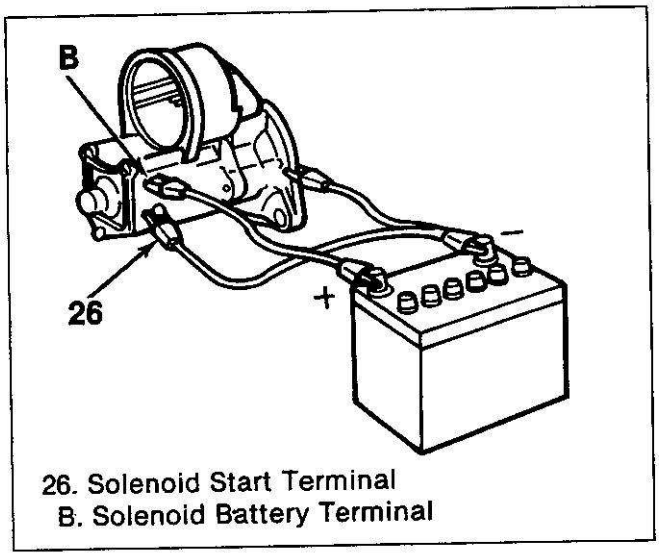


Figure 37. Field Winding Open Test



26. Solenoid Start Terminal
B. Solenoid Battery Terminal

Figure 38. Solenoid Pull-out Test

Solenoid Pull-Out Test

(Figure 38)

- Connect a jumper wire from the battery negative (–) side to the starter housing and solenoid start terminal.
- Connect a jumper wire from the battery positive (+) side to the solenoid battery terminal.

Solenoid Hold-In Test

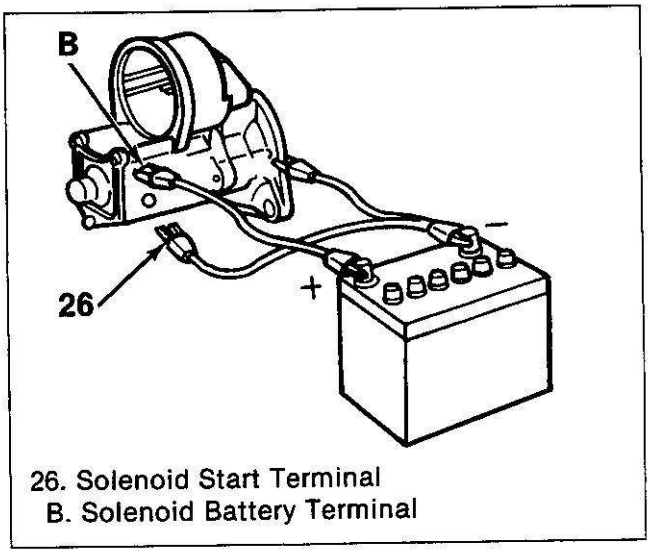
(Figure 39)

- This test is performed the same way as the pull-out test except the jumper wire is disconnected from the solenoid start terminal.
- The pinion gear must be held in the pulled-out position. Replace the solenoid if the pinion gear doesn't stay in the hold position.

Solenoid Return Test

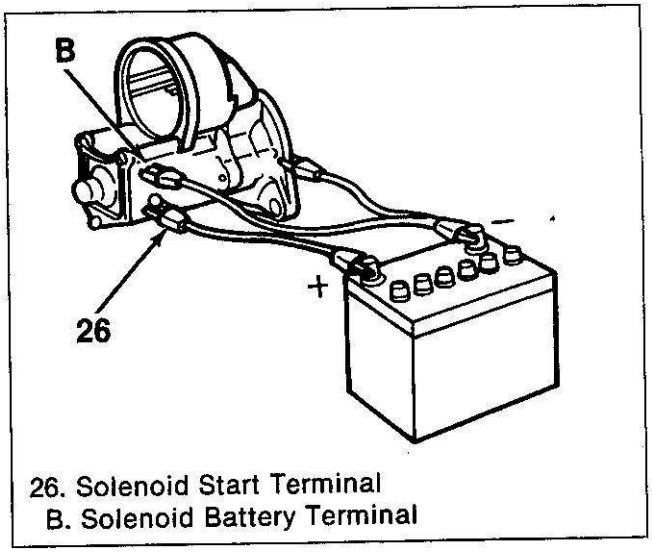
(Figure 40)

- Connect a jumper wire from the battery (–) side to the solenoid battery terminal.
- Connect a jumper wire from the battery positive (+) side to the solenoid terminal.
- The pinion gear must return to its proper position. Replace the solenoid if the pinion gear doesn't return to the proper position.



26. Solenoid Start Terminal
B. Solenoid Battery Terminal

Figure 39. Solenoid Hold-in Test



26. Solenoid Start Terminal
B. Solenoid Battery Terminal

Figure 40. Solenoid Return Test

ASSEMBLY OF STARTER MOTOR

Install or Connect (Figure 24)

1. Solenoid housing assembly (22).
2. Plunger (21).
3. Terminal (20).
4. Cover and gasket (19).
5. Cover screw (18).
6. Ball spring (17).
7. Steel ball (16).
8. Pinion clutch assembly (15).

9. Roller (14).
10. Retainer (13).
11. Pinions(12, 11).
12. Pinion drive housing (10).
13. Screws (9).

Tighten

- Pinion drive housing screws to 9 N·m (78 lb·in).

14. Armature (8).
15. Brush and brush holder (7).
16. Field frame seal (O-ring) (6).
17. Field frame (5).
18. End frame and through bolts (3, 4).

Tighten

- End plate through bolts to 13 N·m (113 lb·in).

19. Lead wire and nut (2, 1).

Tighten

- Lead wire nut to 24 N·m (17 lb·ft).

ENGINE HEATERS

ENGINE BLOCK HEATER

The engine block heater is a 600-watt unit. It is located between the two rear tappet covers on the left side of the engine.

ENGINE LUBE OIL HEATER

The lube oil heater is a 300 watt unit. It is located on the lower right side of the oil pan.

The electrical leads from each heater go forward to the front cross frame where each lead plugs into a receptacle. A single lead then goes from the receptacle to the front of the truck and terminates in a plug.

SPECIFICATIONS

STARTER MOTOR

Rated Voltage	12 V
Rated Output	3 kw
Terminal Voltage (No Load)	11 V
Maximum Current (No Load)	220 amp
Minimum RPM (No Load)	4,200 RPM
Maximum Voltage (Load)	7 V
Maximum Current (Load)	890 amp
Minimum RPM (Load)	940 RPM
Maximum Solenoid Voltage	3 V
Maximum Solenoid Current	1,800 amp
Maximum Cranking Time	30 second
Number of Pinion Gear Teeth	11
Pinion Gear Rotation (View From Pinion Side)	Clockwise
Brush Length	
Standard	20.5 mm (0.81 in)
Limit	13 mm (0.51 in)
Commutator Diameter	
Standard	43 mm (1.693 in)
Limit	42 mm (1.654 in)
Mica Segment Undercut	
Standard	0.5–0.8 mm (0.020–0.031 in)
Limit	0.2 mm (0.0079 in)
Brush Spring Tension	
Limit	3.3 kg (7.3 lb)
Starter Motor Weight	10.5 kg (23 lb)

SPECIFICATIONS (CONT.)

GENERATOR

Rated Voltage	12 V
Rated Output	70 amp
Rated Output at 5000 RPM	67 amp
Regulated Voltage	13.5 V
Brush Length	
Standard	20 mm (0.787 in)
Limit	6 mm (0.236 in)
Slip Ring Diameter	
Standard	34.6 mm (1.362 in)
Limit	33.6 mm (1.323 in)
Generator Pulley Direction (Viewed From Pulley Side)	Clockwise
Pulley Diameter	82 mm (3.23 in)
Generator Weight	7.7 kg (17.0 lb)
Maximum Vacuum Pump Output	–680 mm Hg (–13.15 psi)
Vacuum Pump Vane	
Standard Length	14.0–15.0 mm (0.551–0.591 in)
Vacuum Pump Housing Inside Diameter	
Standard	60.0–60.1 mm (2.362–2.366 in)
Vacuum Pump Weight	1.2 kg (2.65 lb)

BATTERY

Type	Delco 31-751
Cold Crank Capacity	750 amp
Reserve Capacity (25 Amperes)	160 Minutes

FASTENER TORQUES

Starter Motor	
Mount Nuts	70 N·m (51 lb·ft)
Pinion Drive Housing Screws	9 N·m (78 lb·in)
End Plate Through Bolts	13 N·m (113 lb·in)
Starter Lead Wire Nut	24 N·m (17 lb·ft)
Generator	
Upper Mount Nut	70 N·m (51 lb·ft)
Lower Mount Bolt	100 N·m (74 lb·ft)
Pulley Nut	98 N·m (72 lb·ft)
Rear Cover Through Bolts	4 N·m (35 lb·in)
Vacuum Pump Screws	6 N·m (52 lb·in)