Servicing GM Charging and Starting Systems
Part II

Courtesy General Motors Corp.

Charging System Testing

Battery Testing

Note: All testing procedures used in this article are designed for use with a charging/starting system tester containing a variable load test (carbon pile) and a hand held volt-ohmmeter. Follow the instructions supplied by the manufacturer of the particular test equipment being used when performing the tests outlined here.

Tests that should be performed to determine the condition of the battery are the Capacity Test (load test), the Hydrometer Test (state of charge) and the Open Circuit Voltage Test (state of charge). Perform these tests as outlined to aid in battery diagnosis.

Note: Perform the Hydrometer Test only when checking a battery with removable cell caps. If testing shows the battery to be in good condition but discharged, check for the following:

1. A vehicle accessory that stays on with the vehicle shut off.
2. There was extended slow-speed driving with many accessories turned on.
3. The vehicle electrical load is more than the alternator output, particularly with the addition of aftermarket equipment.
4. An alternator with an output rating lower than what was originally installed on the vehicle.

Charge Indicator (Delco Eye)

Delco batteries use an indicator eye to monitor the battery's state of charge (Figure 1-18).

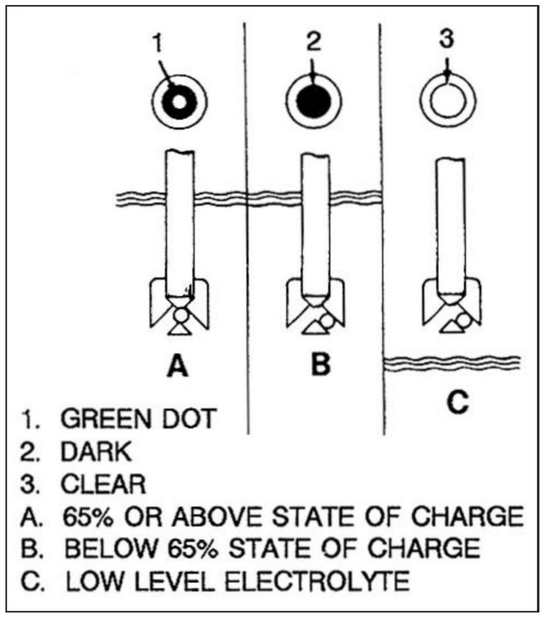

Figure 1-18—Charge Indicator

Refer to the following steps to determine battery condition by looking at the charge indicator eye:

1. GREEN DOT VISIBLE: The state of charge is 65 percent or more of the full charge. Under this condition the battery may be load tested.
2. DARK; GREEN DOT NOT VISIBLE: The state of charge is below 65 percent. Charge the battery until the green dot appears. (To make the green dot appear after charging, shake the battery slightly or tap the eye to remove any bubbles.)
3. CLEAR OR LIGHT YELLOW: The fluid level has dropped below the bottom of the hydrometer. This can be caused by a broken case, tipping of the battery, extended use or overcharging because of a problem in the electrical system. Check the charging system and replace the battery.

Caution: When the dot has returned to green, stop the charge. Allow battery to cool, and proceed with the load test as outlined under "Battery Testing" here. If electrolyte seeps from the vent(s), stop the charge and allow the battery to cool before proceeding.

Hydrometer (State of Charge) Test

Use a hydrometer to check the specific gravity of all battery cells (Figure 1-19). In order to get an accurate interpretation of hydrometer readings, cell temperatures have to be considered. For each 6 degrees C (10 degrees F) below 26 degrees C (78 degrees F), subtract 4 points (.004) from the actual hydrometer reading. For each 6 degrees C (10 degrees F) above 26 degrees C (78 degrees F), add 4 points (.004) to the actual hydrometer reading (Figure 1-20).

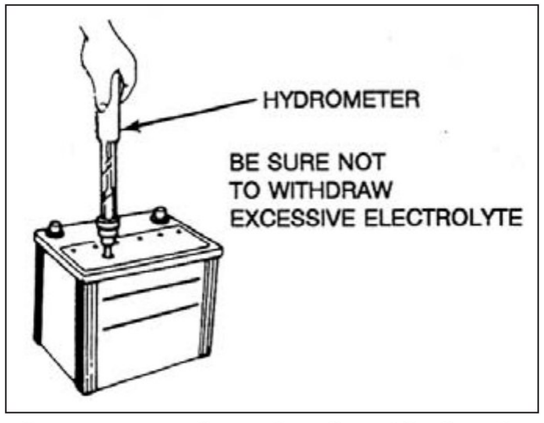

Figure 1-19—Checking Specific Gravity

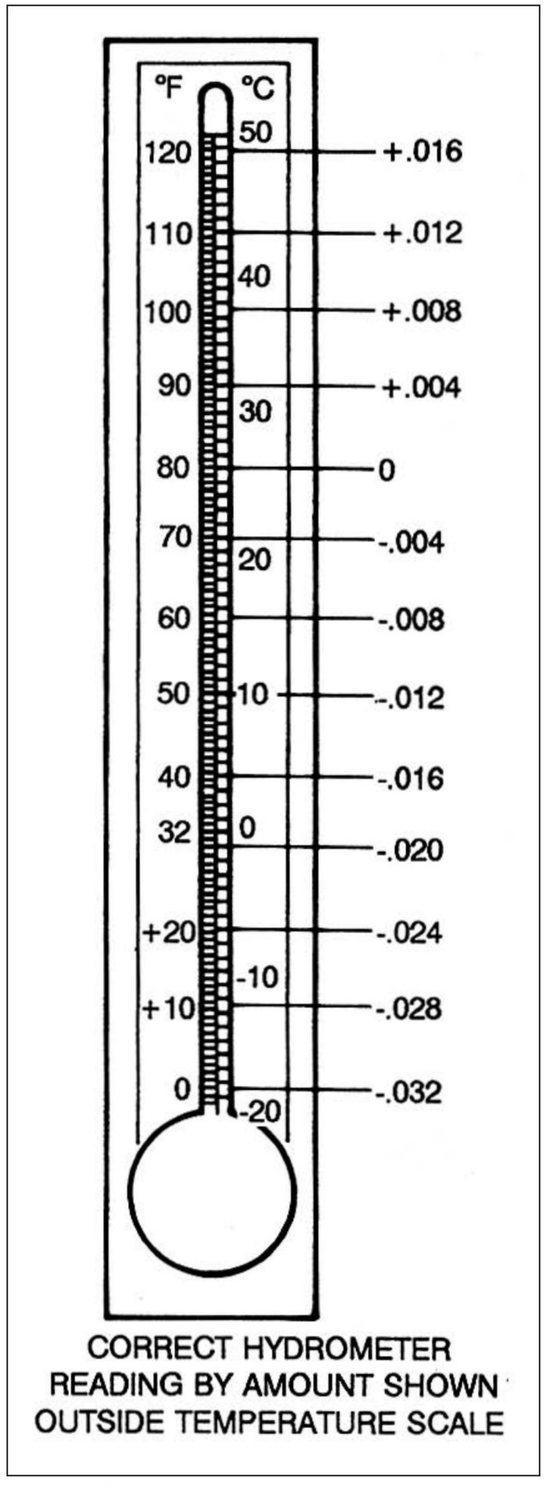

Figure 1-20—Hydrometer Termperature Correction Chart

If the difference between any two cells is 50 points (.050) or more, the battery should be replaced.

If any cell reads below 1.230, the battery must be charged for 20 minutes at 35 amperes and tested again.

Note: Ensure that the electrolyte level is correct.

Refer to the Figure 1-21 to determine the battery state of charge after checking the specific gravity.

Specific Gravity	State of Charge	Open Circuit Volts
1.280	100%	12.6 or more
1.225	75%	12.4
1.190	50%	12.2
1.155	25%	12.0
1.120	Discharged	11.7 volts or less

Figure 1-21—Battery Specific Gravity vs. State of Charge

Open Circuit Voltage (State of Charge) Test

The voltage reading taken in this test will indicate the battery state of charge, but will not indicate cranking capacity.

1. Place a 10-amp load on the battery for 10 seconds. Then let the battery "soak" for about two minutes with no loads applied.
2. Disconnect the negative battery cable.
3. Connect a voltmeter across the battery terminals. If the battery reads less than 12.40 volts and has passed the Capacity (Load) Test, it must be charged before any other tests are performed. Refer to Figure 1-22 to determine the state of charge.

OPEN CIRCUIT VOLTAGE	
Open Circuit Volts	State of Charge
11.7 volts or less	Discharged
12.0	25%
12.2	50%
12.4	75%
12.6 or more	100%

Figure 1-22—Open Circuit Voltage vs. State of Charge

Capacity (Load) Test

Batteries are rated in cold cranking amps (CCAs). The requirements of the vehicle determine the battery rating to be installed. To properly perform the Load Test, it is necessary to know the CCA rating. For the recommended CCA rating, refer to the AC Delco Battery Catalog (Number 7A-100).

The following test determines if the battery has the capacity required to meet the electrical demands placed on it when cranking the engine with the starter.

1. Connect a volt/amp tester with a rheostat (carbon pile) across the battery terminals (Figure 1-23). Note: On some batteries, the use of battery side terminal adapters may be required to ensure good connections.
2. If the battery has just been charged or used in a vehicle, apply a 300 ampere load for 15 seconds to remove the surface charge from the battery.
3. Wait 15 seconds to let the battery recover and then apply a load equal to one-half the CCA rating. After 15 seconds, read the voltage, then remove the load.
4. If the voltage does not drop below the minimum listed in the following chart, the battery is good and can be used. (Estimate the battery temperature by the temperature the battery has been exposed to for the preceding few hours.)
5. If the voltage is less than the minimum listed in the chart, replace the battery.

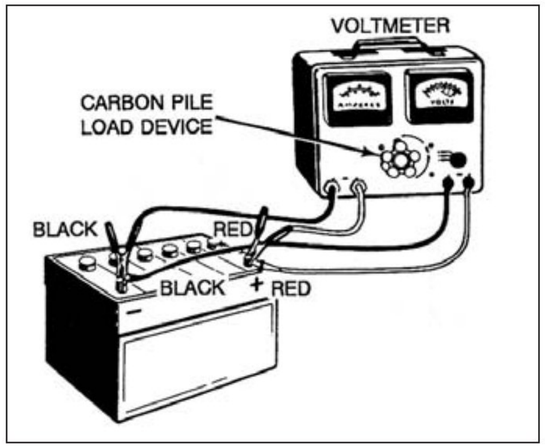

Figure 1-23—Charging/Starting System Tester - Typical

Refer to Figure 1-24 for minimum voltage specifications for different temperatures.

Parasitic Draw Test

Parasitic Draw refers to a battery drain that occurs over an extended time period after the vehicle is shut off. This may include the obvious causes such as a luggage compartment or glove compartment lamp with a defective switch or a hidden, lower current drain caused by an electronics problem.

Estimated Temperature	Minimum Voltage
70°F (21°C)	9.6
50°F (10°C)	9.4
30°F (0°C)	9.1
15°F (-10°C)	8.8
0°F (-18°C)	8.5
0°F (Below -18°C)	8.0

Figure 1-24—Battery Temperature vs. Minimum Voltage

Note: It is necessary to use a high capacity ammeter for other first portion of this test. If a clamp-on type ammeter is used, all battery cables must fit in the clamp with the clamp closed to ensure all current is being measured. The battery must be either fully charged or substituted with a known good one before beginning this test. (Figure 1-25)

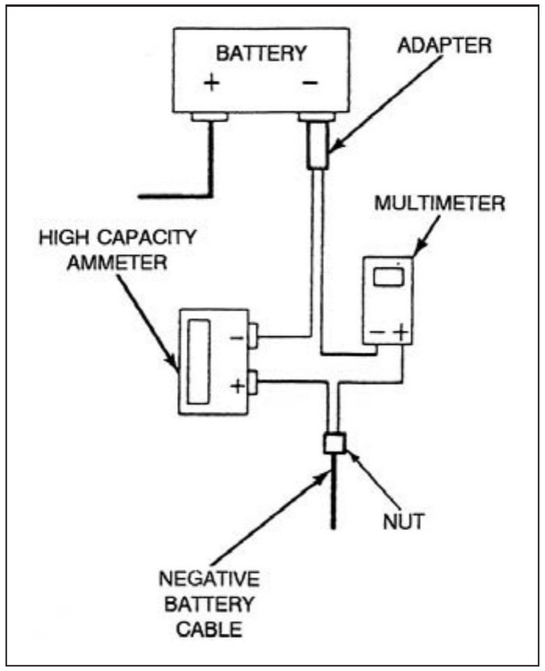

Figure 1-25—Checking for Parasitic Draw

1. Disconnect negative battery cable.
2. If necessary, install a battery side terminal adapter to the negative terminal of the battery. Install a clean nut on the negative cable retaining screw to ensure a good contact with the surface of the cable connector.
3. Connect a high capacity ammeter between the disconnected negative battery cable and the battery negative terminal or adapter. Caution: A high capacity (10 amp minimum) ammeter must be connected first to determine if any constant rate high current draw exists. This could damage a low current ammeter or blow the ammeter fuse.
4. If after one minute, the high capacity ammeter shows a draw of more than one amp on the system, check the vehicle for any automatically switched lamps (glove compartment, luggage compartment, dome, courtesy, etc.), or other accessory that does not shut off properly. Repair as required.
5. If draw is less than one amp, connect a digital multimeter set to the 2 DCA scale between the negative battery terminal and the negative battery cable in parallel with the high current ammeter.
6. Disconnect the high current ammeter and take a reading with the digital multimeter after waiting one minute. The time delay is required for vehicles with accessories such as automatic ride height or other similar self-monitoring systems. A current draw of 50mA or less indicates parasitic draw is not excessive.

Circuit Testing

Warning Circuit – Voltmeter

1. Turn the ignition switch to the ON position. The voltmeter should indicate battery voltage.
2. Turn on the headlamps. The voltmeter should show a slight decrease in battery voltage.
3. Start the engine. The voltmeter should indicate approximately 13.5 volts.
4. If the voltmeter does not operate as indicated, refer to the vehicle manufacturer's published information for proper diagnosis.

Warning Circuit – Indicator Lamp

Note: If the charging indicator lamp does not operate as described and the charging system is operating properly, the problem lies outside the charging system. Refer to the vehicle manufacturer's published information for proper diagnosis.

1. Turn the ignition switch to the ON position. The charge indicator lamp should glow.
2. Start the engine. The charge indicator lamp should go out.
3. Turn the ignition to the OFF position. The charge lamp should stay off. Note: The lamp may flicker momentarily as the engine stops.

Charging System Voltage Drops

Alternator performance can be reduced by excessive resistance or a voltage drop in the alternator circuit on both the alternator output and alternator ground circuits. Circuit resistance is checked using a digital voltmeter connected from the battery positive terminal to the alternator battery terminal and from the alternator case to the battery negative terminal. Note: Any damaged, loose or corroded wires or connectors must be cleaned or replaced before any tests are made.

1. Connect positive lead of voltmeter to alternator output stud. Connect negative lead to positive battery cable at battery.
2. Start engine and run engine at 1,300 to 1,500 rpm.
3. Using a carbon pile tester, apply a load to the battery to obtain an alternator output of 20 amps.
4. If voltage drop is higher than .2 volt, inspect and test all wires and connections to pinpoint problem area.
5. Stop engine. Connect positive lead of voltmeter to alternator case. Connect negative lead to negative battery cable at battery. Repeat Steps 2 and 3.

Alternator Output Testing

Note: Upon completion of the alternator output test, refer to the Alternator Output Specifications reference manual to determine the manufacturer's specification for specific alternator output. Actual maximum output of the alternator should be within 10 percent of its maximum rated output.

Load Test

The load test determines whether or not the alternator is capable of delivering its rated current output.

To determine the under-load alternator output:

1. Connect a carbon pile type electrical system tester. Follow the manufacturer's directions for correct hookup. Note: On some batteries, the use of battery side terminal adapters may be required to ensure good connections.
2. Start the engine and increase speed to 2,000 rpm.
3. Use the carbon pile rheostat on the tester to obtain maximum alternator output of the charging system. Maintain voltage at 13 volts or more. Release the load. Caution: Do not allow the voltage to go above 16 volts.
4. Let the engine return to an idle, then turn it off. Compare output results with specifications.
5. Refer to the Alternator Output Specifications reference manual to determine the manufacturer's specification for maximum alternator output. If the output is within 10 percent of the rating, the alternator is operating normally. If the output is not within 10 percent and the alternator is equipped with an internal voltage regulator, the alternator must be replaced. If it is equipped with an external voltage regulator, proceed with Voltage Regulator Testing to determine whether the alternator or the volt-

age regulator should be replaced.

Voltage Regulator Testing

Note: Alternator testing must be performed prior to testing the voltage regulator to ensure that alternator output is present. The battery must be fully charged for the regulator test to be accurate.

Imported Vehicles Equipped with Bosch Remote Voltage Regulators

NOTE: Perform alternator output tests before testing the voltage regulator.

1. Connect a suitable volt/amp tester to the charging circuit. Follow the manufacturer's directions for the correct hookup.
2. Start the engine.
3. Apply a 10-amp load to the charging circuit with the engine running at approximately 2,500 rpm.
4. The voltage reading must be between 13.7 to 14.9 volts. If the reading is out of specifications, replace the voltage regulator.

Chrysler Vehicles Equipped with Remote Voltage Regulators (Figure 1-26)

NOTE: Perform alternator output tests before testing the voltage regulator.

1. Connect the positive lead of the voltmeter to the blue/black wire at the voltage regulator. Connect the negative lead to ground.
2. Start the engine and run it at approximately 1,250 rpm with all accessories turned off. The voltmeter should read between 13.6 and 15.8 volts. Note: Ensure that the regulator is properly grounded.
3. Turn the engine off. Disconnect the regulator and check for battery voltage at both connector terminals. Turn the ignition switch to the ON position.
4. If battery voltage is present at both terminals, but readings in Step 2

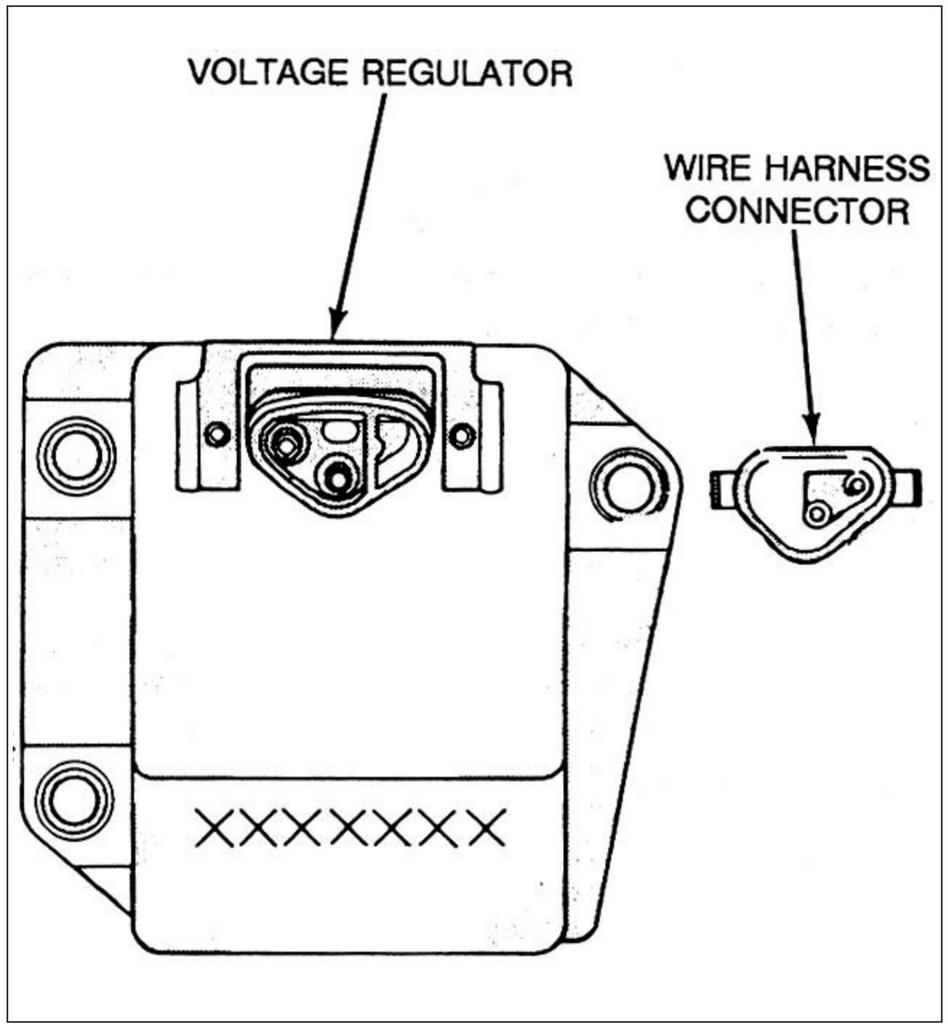

Figure 1-26—Chrysler Electronic Remote Voltage

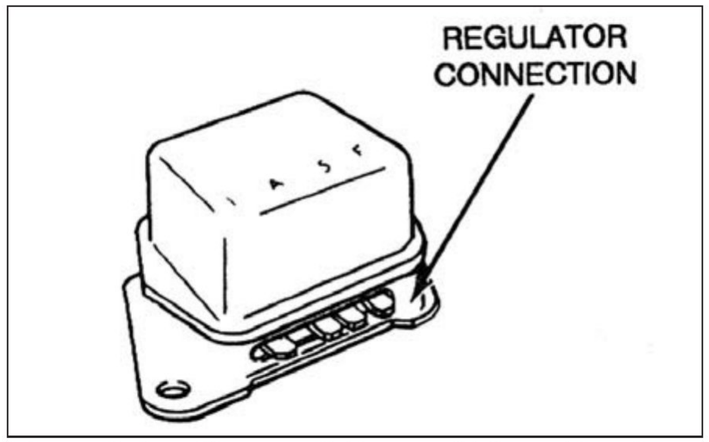

Figure 1-27—Motorcraft Remote Voltage Regulator

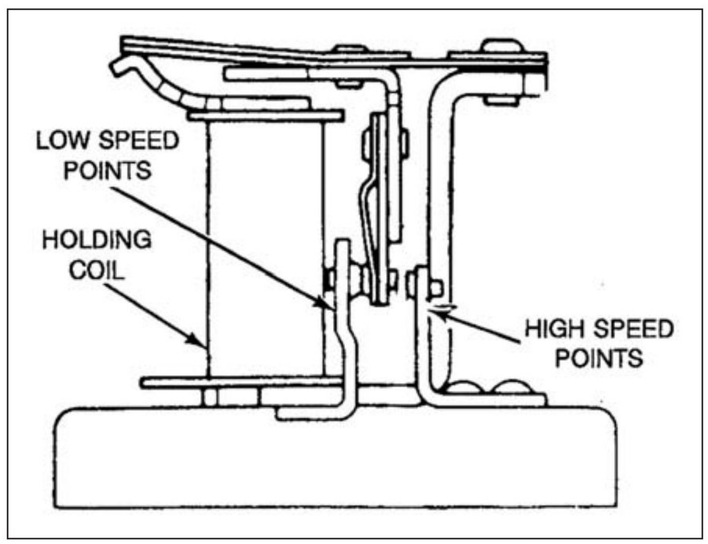

Figure 1-28—Hitachi Remote Voltage Regulator

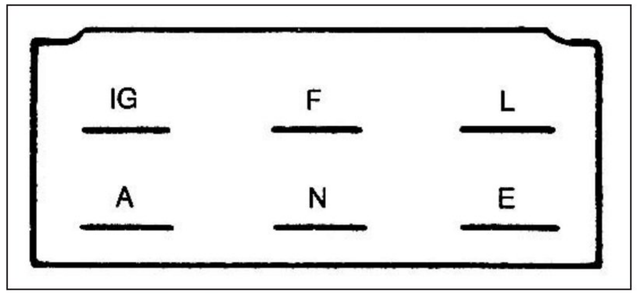

Figure 1-29—Mitsubishi Remote Voltage Regulator Connector

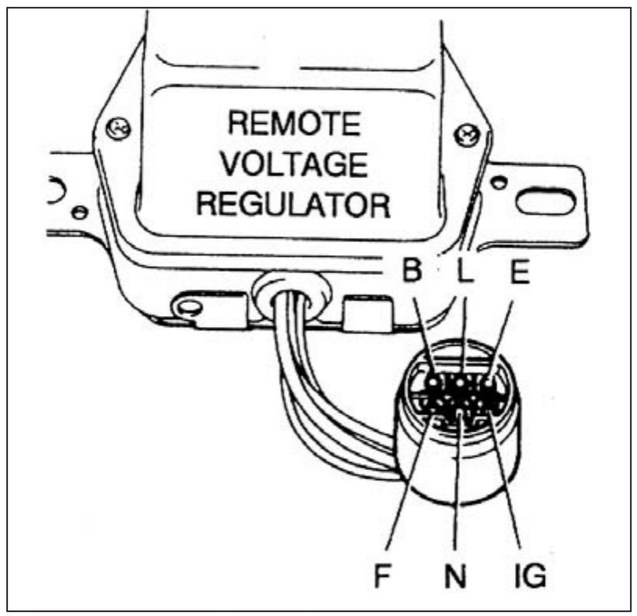

Figure 1-30—Nippondenso Remote Voltage Regulator

are not within specifications, replace the voltage regulator.

Ford and AMC Vehicles Equipped with Motorcraft Remote Voltage Regulators (Figure 1-27)

NOTE: Perform alternator output tests before testing the voltage regulator.

1. Connect a voltmeter to the battery.
2. Disconnect the electrical connector from the voltage regulator.
3. Start the engine, and let it idle.
4. Using a jumper wire, momentarily connect terminals "A" and "F" at the regulator connector.
5. Watch the volt/amp tester. If the alternator output test results were not within specification and now the voltage reads between 13.5 and 15.9 volts, replace the voltage regulator.

Caution: This is a "full field" test. Testing time should be kept to an absolute minimum to avoid damage to any charging system components.

Imported Vehicles Equipped with Hitachi Remote Voltage Regulators (Figure 1-28)

Note: Perform alternator output tests before testing the voltage regulator.

1. Remove the voltage regulator cover.
2. Using an ohmmeter, check the resistor and the holding coil resistance values. The resistor should have approximately 10.5 ohms resistance. The holding coil should have approximately 24 ohms resistance.
3. While the ignition is off, check that the low speed contact points are closed.
4. Start the engine and check to see if the high speed contact points are closed with the engine idling.
5. Using a carbon pile tester, apply an approximately 20 amp load to the system and increase the engine speed to 2,500 rpm. The high speed contact points should now be open.
6. If the voltage regulator does not operate as described, replace it.

Imported Vehicles Equipped with Mitsubishi Remote Voltage Regulators (Figure 1-29)

NOTE: Perform alternator output tests before testing the voltage regulator.

1. Connect a voltmeter between terminals "A" and "E" of the voltage regulator connector. Leave the electrical connector connected to the regulator.
2. Start the engine and allow to idle.
3. Disconnect one battery terminal while the engine is idling.
4. Increase the engine speed to approximately 2,000 rpm.
5. The voltmeter should read between 14.0 and 15.8 volts. If the reading is not within specifications, replace the voltage regulator.

Imported Vehicles Equipped with Nippondenso Remote Voltage Regulators (Figure 1-30)

1. Remove the voltage regulator cover and inspect the condition of the point sets. If burned or pitted, replace the voltage regulator.
2. Disconnect the harness connector. Make the following resistance checks using a digital ohmmeter. If any reading is out of specification, replace the voltage regulator.
3. Check resistance between terminals "IG" and "F." Readings should be zero ohms at rest and approximately 11 ohms when pulled in.
4. Measure resistance between terminals "L" and "E." Readings should be zero ohms at rest and approximately 100 ohms when pulled in.
5. Measure resistance between terminals "B" and "E." Reading should be infinity at rest and approximately 100 ohms when pulled in.
6. Measure resistance between terminals "B" and "L." Readings should be infinity at rest and zero ohms when pulled in.
7. Measure resistance between terminals "N" and "E." Reading should be approximately 24 ohms.

Starting System Testing

Starter and Circuit Testing

Perform the following tests to determine if there is an excessive current draw on the system (due to poor connections) or faulty components.

Draw Test

The draw test refers to the amount of current the starter uses to crank the engine.

Note: Perform the draw test if the starter cranks slowly and compare results with specifications. The battery must be fully charged or substituted with a known good one before beginning this test.

1. Connect a clamp-on type ammeter to the positive cable leading to the starter. Note: This cable does not always come directly from the battery. It may come from a starter relay.
2. Disable the ignition system to prevent the engine from starting. On fuel injected vehicles, disable the fuel system also.
3. Crank the engine for approximately 15 seconds and read the current draw while the engine is cranking.
4. Rule of thumb specifications for starter motor draw are:
   - 4 cylinder engine = 135 to 150 amps
   - 6 cylinder engine = 150 to 185 amps
   - 8 cylinder engine = 185 to 200 amps.
5. For exact figures, refer to the vehicle manufacturer's specifications.
6. If the current draw exceeds specifications by 10 percent or more, conduct all starter circuit tests before replacing the starter.

Neutral Switch

On a vehicle equipped with an automatic transmission or transaxle, the neutral switch (sometimes referred to as the neutral start or neutral safety switch) prevents the starter from operating while the gear selector lever is in a forward or reverse drive range. When working

properly, the switch allows the starter to operate only when the gear selector lever is placed in park or neutral. Some vehicles with an interlock system also require the brake pedal to be depressed.

1. Set the parking brake.
2. Apply the service brakes.
3. Place the gear selector lever in the Park position.
4. Turn the ignition to the start position. The starter should operate.
5. Release the key.
6. Place the gear selector lever in the Reverse position.
7. Turn the ignition switch to the start position. The starter should not operate.
8. Repeat these steps for the remaining gear selector positions.

If the engine cranks in any gear selector position other than Park or Neutral, the neutral switch is faulty. Refer to the vehicle manufacturer's published information for servicing the neutral switch.

Clutch Pedal Switch

Vehicles equipped with manual transmissions may have a clutch pedal operated starter lock-out switch. On these vehicles, the clutch pedal must be applied in order for the starter to operate. To service this type of switch, refer to the manufacturer's published information.

Starter System Voltage Drops

Starter performance can be reduced by excessive resistance or a voltage drop in the starter high current circuit. Circuit resistance is checked using a digital voltmeter while the starter is operated (Figures 1-31 and 1-32).

NOTE: The engine must not start during the cranking system test. To avoid engine starting, use a remote starter switch to operate the starter (Figures 1-31 and 1-32). Use a digital voltmeter capable of displaying readings less than 1 volt.

1. Connect the voltmeter between the starter housing and the battery ground (Figure 1-31).
2. Crank the engine and record the voltmeter reading.
3. Connect the voltmeter between the battery positive terminal and the starter high current terminal (Figure 1-32).
4. Crank the engine and record the voltmeter reading.

Voltage readings should not exceed .3 volt. If an excessive voltage drop is found, disconnect, clean and service all of the connections in that circuit including the ground connections at the vehicle frame and engine block. When finished, retest the circuit.

Failure Analysis

Alternators

Many times the cause of an alterna-

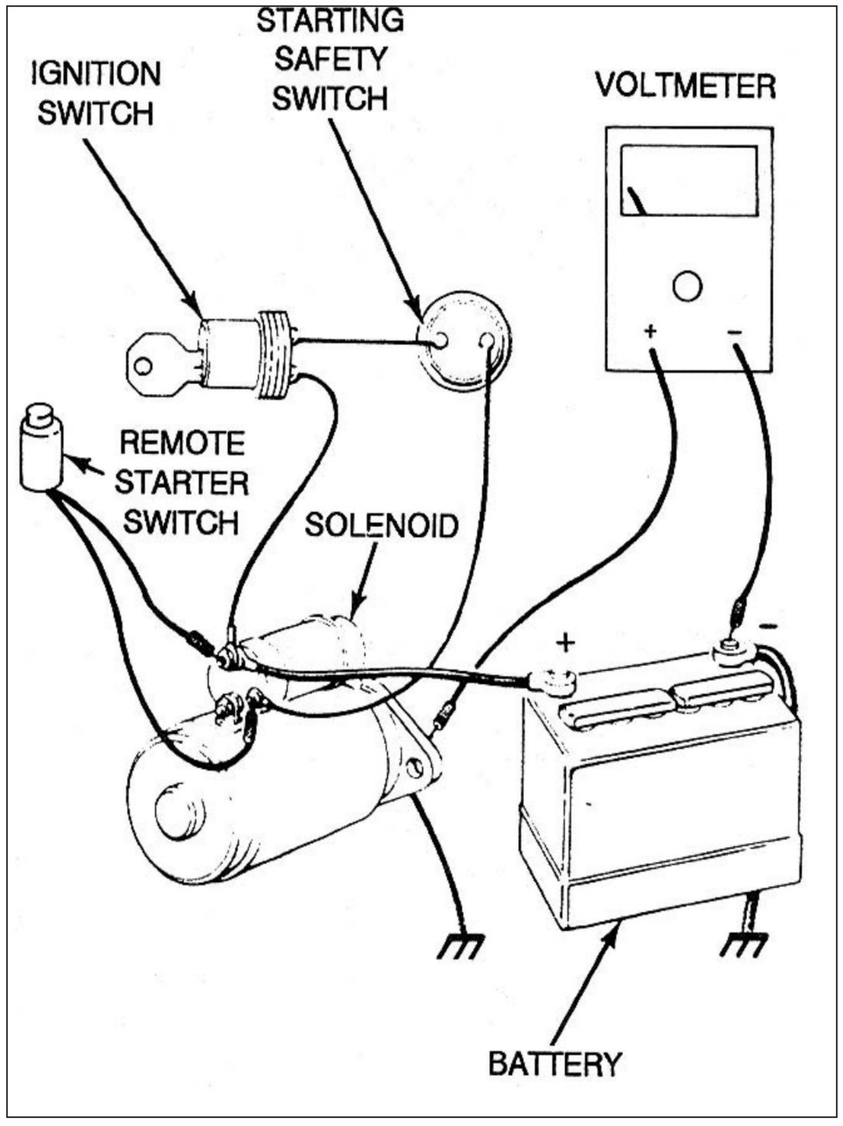

Figure 1-31—Checking Ground Circuit

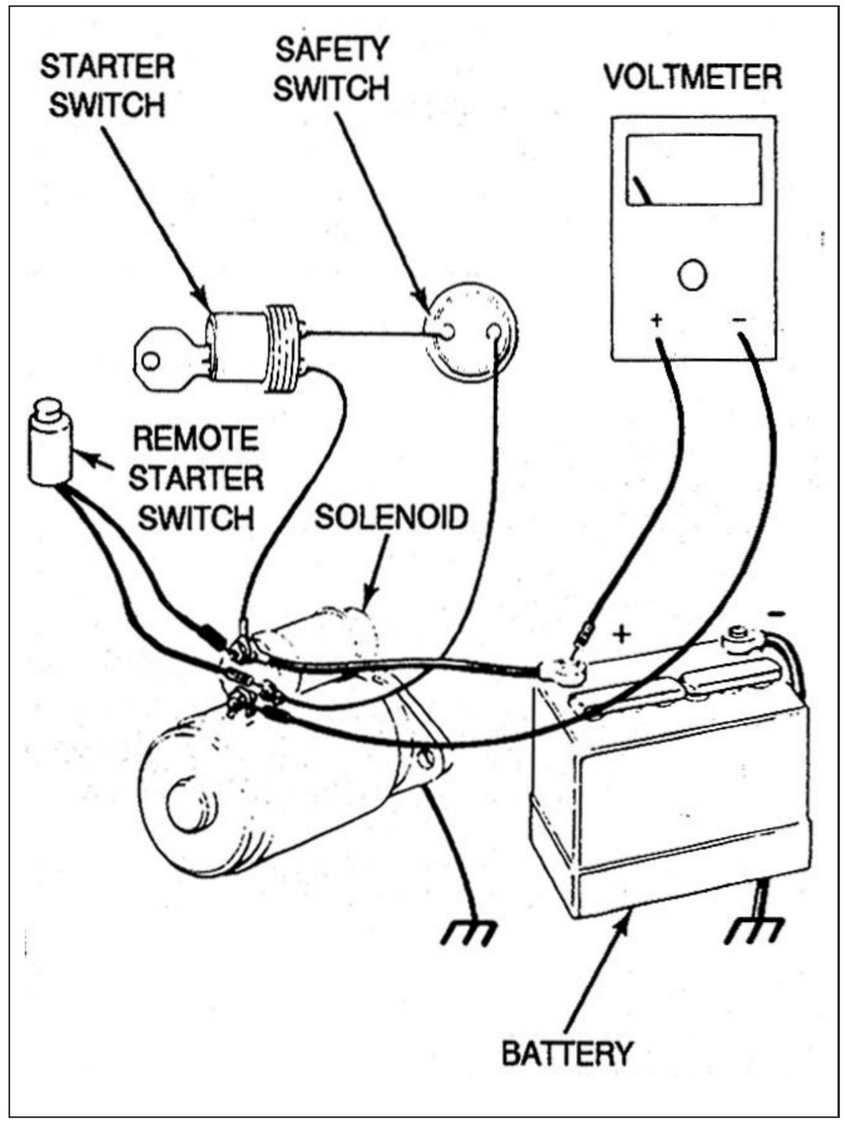

Figure 1-32—Checking Insulated Circuit

tor failure can be traced to sources other than electrical problems in the alternator, regulator or related circuits. A visual inspection, as outlined earlier in this section, should also include looking over the mounting hardware for proper fit, alignment and retaining bolts and nuts. Components such as the pulley, belts, brackets and bearings should be inspected whenever an alternator is tested.

Starters

Most starter damage is limited to the clutch assembly and the pinion drive gear, and starter replacement is necessary. However, whenever starter pinion damage is found, the flywheel should be carefully inspected. The most common types of damage are "milling," intermittent wear and excessive (inner or outer) wear.

"Milling" occurs in concentrated areas on the flywheel and refers to the pinion and/or flywheel teeth actually appearing to be machined down. The starter pinion is usually shortened evenly all the way around. This is caused by the starter spinning before it is fully engaged. Milling of the flywheel can occur in an evenly spaced pattern due to the tendency of the engine to stop on a compression stroke when it is shut off. This also results in the number of worn spots being the same as the number of cylinders in the engine.

To correct this condition, it is necessary to replace the starter and the flywheel. For proper flywheel service, refer to the manufacturer's published service manual information.

Intermittent wear appears as shiny spots or areas of excessive wear between areas of little or no wear, usually on the flywheel. This condition may be caused by flywheel runout. To correct this condition, it is necessary to service the flywheel. For proper flywheel service, refer to the manufacturer's published service manual information.

Excessive wear refers to unusual wear patterns on the flywheel and/or drive pinion. It may be caused by too little or too much starter pinion-to-flywheel clearance. On some vehicles, shims are used to set the proper pinion-to-flywheel clearance. Excessive wear can also be caused by improper installation or an incorrect starter or flywheel. If incorrect components are suspected, refer to the manufacturer's published service manual information. Excessive wear is usually accompanied by starter noise during engine cranking.

See Part III in the December Issue.