ELECTRICAL

GROUP INDEX

BATTERY/STARTING/CHARGING SYSTEMS DIAGNOSTICS

CONTENTS

GENERAL INFORMATION

The battery, starting, and charging systems operate with one another; therefore, they must be tested as a complete system. In order for the vehicle to start and charge properly, all of the components involved in these systems must perform within specifications.

Group 8A covers battery, starting (Fig. 1) and charging (Fig. 2) system diagnostic procedures. These procedures include the most basic conventional diagnostic methods, to On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Use of an induction milliamp ammeter, volt/ohmmeter, battery charger, carbon pile rheostat (load tester), and 12-volt test lamp will be required.

All OBD-sensed systems are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for any failure it detects. See Using On-Board Diagnostic System in this group for more information.

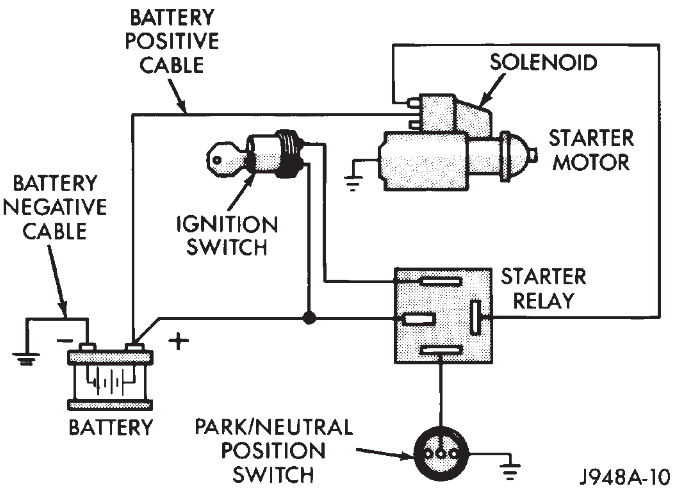


Fig. 1 Starting System Components (Typical)

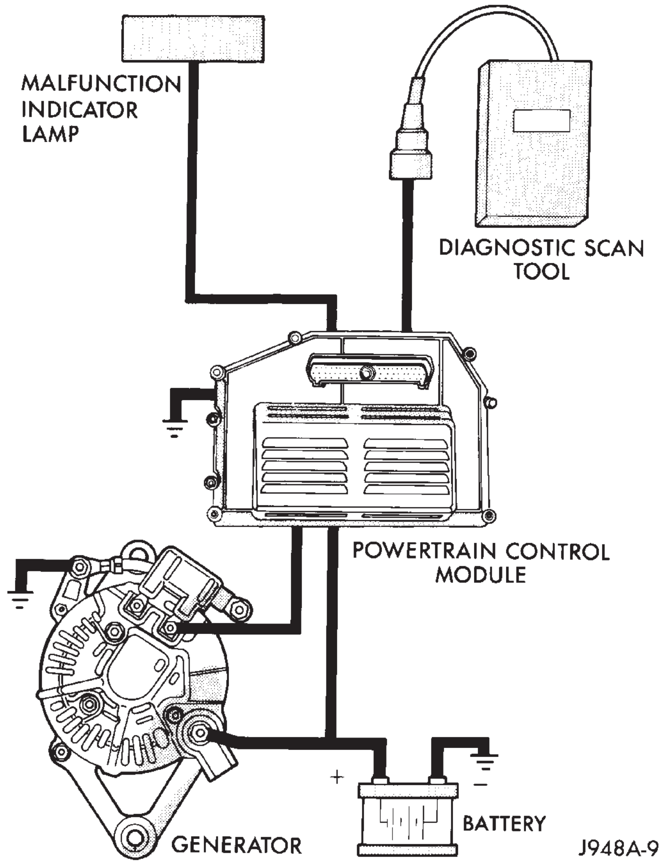


Fig. 2 Charging System Components (Typical)

BATTERY

GENERAL INFORMATION

The storage battery is a device used to store electrical energy potential in a chemical form. When an electrical load is applied to the battery terminals, an electrochemical reaction occurs within the battery. This reaction causes the battery to discharge electrical current.

The battery is made up of 6 individual cells that are connected in series. Each cell contains positively charged plate groups made of lead oxide, and negatively charged plate groups made of sponge lead. These dissimilar metal plates are submerged in a sulfuric acid and water solution called electrolyte.

As the battery discharges, a gradual chemical change takes place within each cell. The sulfuric acid in the electrolyte combines with the plate materials, causing both plates to change to lead sulfate. At the same time, oxygen from the positive plate material combines with hydrogen from the sulfuric acid, causing the electrolyte to become mainly water.

The chemical changes within the battery are caused by movement of excess or free electrons between the positive and negative plate groups. This movement of electrons produces a flow of electrical current through the load device attached to the battery terminals.

As the plate materials become more similar chemically, and the electrolyte becomes less acid, the voltage potential of each cell is reduced. However, by charging the battery with a voltage higher than that of the battery, the process is reversed.

Charging the battery gradually changes the sulfated lead plates back into sponge lead and lead oxide, and the water back into sulfuric acid. This action restores the difference in electron charges deposited on the plates, and the voltage potential of the battery cells.

For a battery to remain useful, it must be able to produce high-amperage current over an extended period. A battery must also be able to accept a charge, so that its voltage potential may be restored.

In addition to producing and storing electrical energy, the battery serves as a capacitor or voltage stabilizer for the vehicle electrical system. It absorbs abnormal or transient voltages caused by switching of any of the vehicle's electrical components.

The battery is vented to release excess gas that is created when the battery is being charged or discharged. However, even with these vents, hydrogen gas can collect in or around the battery. If hydrogen gas is exposed to flame or sparks, it can ignite.

If the electrolyte level is low, the battery could arc internally and explode. If the battery is equipped with removable cell caps, add distilled water whenever the electrolyte level is below the top of the plates. If the battery cell caps cannot be removed, the battery must be replaced when the electrolyte level is low.

WARNING: DO NOT ATTEMPT TO ASSIST BOOST, CHARGE, OR TEST BATTERY WHEN ELECTROLYTE LEVEL IS BELOW THE TOP OF THE PLATES. PERSONAL INJURY MAY OCCUR.

BATTERY RATINGS

Currently, there are 2 commonly accepted methods for rating and comparing battery performance. These ratings are called Cold Cranking Amperage (CCA), and Reserve Capacity (RC). Be certain that a replacement battery has CCA and RC ratings that equal or exceed the original equipment specification for the vehicle being serviced. See Battery Classifications and Ratings charts in Specifications at the back of this group.

COLD CRANKING AMPERAGE

The Cold Cranking Amperage (CCA) rating specifies how much current (in amperes) the battery can deliver for 30 seconds at -17.7°C (0°F). Terminal voltage must not fall below 7.2 volts during or after the 30 second discharge. The CCA required is generally higher as engine displacement increases, depending also upon the starter current draw requirements.

RESERVE CAPACITY

The Reserve Capacity (RC) rating specifies the time (in minutes) it takes for battery terminal voltage to fall below 10.2 volts at a discharge rate of 25 amps. RC is determined with the battery fully-charged at 26.7°C (80°F). This rating estimates how long the battery might last after a charging system failure, under minimum electrical load.

DIAGNOSIS

The battery must be completely charged and the top, posts, and terminal clamps should be properly cleaned before diagnostic procedures are performed. Refer to Group 8B - Battery/Starter/Generator Service for more information.

The condition of a battery is determined by two criteria:

(1) **State-Of-Charge** This can be determined by viewing the built-in test indicator, by checking specific gravity of the electrolyte (hydrometer test), or by checking battery voltage (open circuit voltage test).

(2) **Cranking Capacity** This can be determined by performing a battery load test, which measures the ability of the battery to supply high-amperage current.

If the battery has a built-in test indicator, use this test first. If it has no test indicator, but has removable cell caps, perform the hydrometer test first. If cell caps are not removable, or a hydrometer is not available, perform the open circuit voltage test first.

The battery must be charged before proceeding with a load test if:

- the built-in test indicator has a black or dark color visible
- the temperature corrected specific gravity is less than 1.235
- the open circuit voltage is less than 12.4 volts.

A battery that will not accept a charge is faulty and further testing is not required. A battery that is fully-charged, but does not pass the load test is faulty and must be replaced.

Completely discharged batteries may take several hours to accept a charge. See Charging Completely Discharged Battery.

A battery is fully-charged when:

- all cells are gassing freely during charging
- a green color is visible in the sight glass of the built-in test indicator
- three corrected specific gravity tests, taken at 1-hour intervals, indicate no increase in specific gravity
- open circuit voltage is 12.4 volts or greater.

ABNORMAL BATTERY DISCHARGING

Any of the following conditions can result in abnormal battery discharging:

(1) Corroded battery posts and terminals.

(2) Loose or worn generator drive belt.

(3) Electrical loads that exceed the output of the charging system, possibly due to equipment installed after manufacture or repeated short trip use.

(4) Slow driving speeds (heavy traffic conditions) or prolonged idling with high-amperage draw systems in use.

(5) Faulty circuit or component causing excessive ignition-off draw. See Ignition-Off Draw in this group for diagnosis.

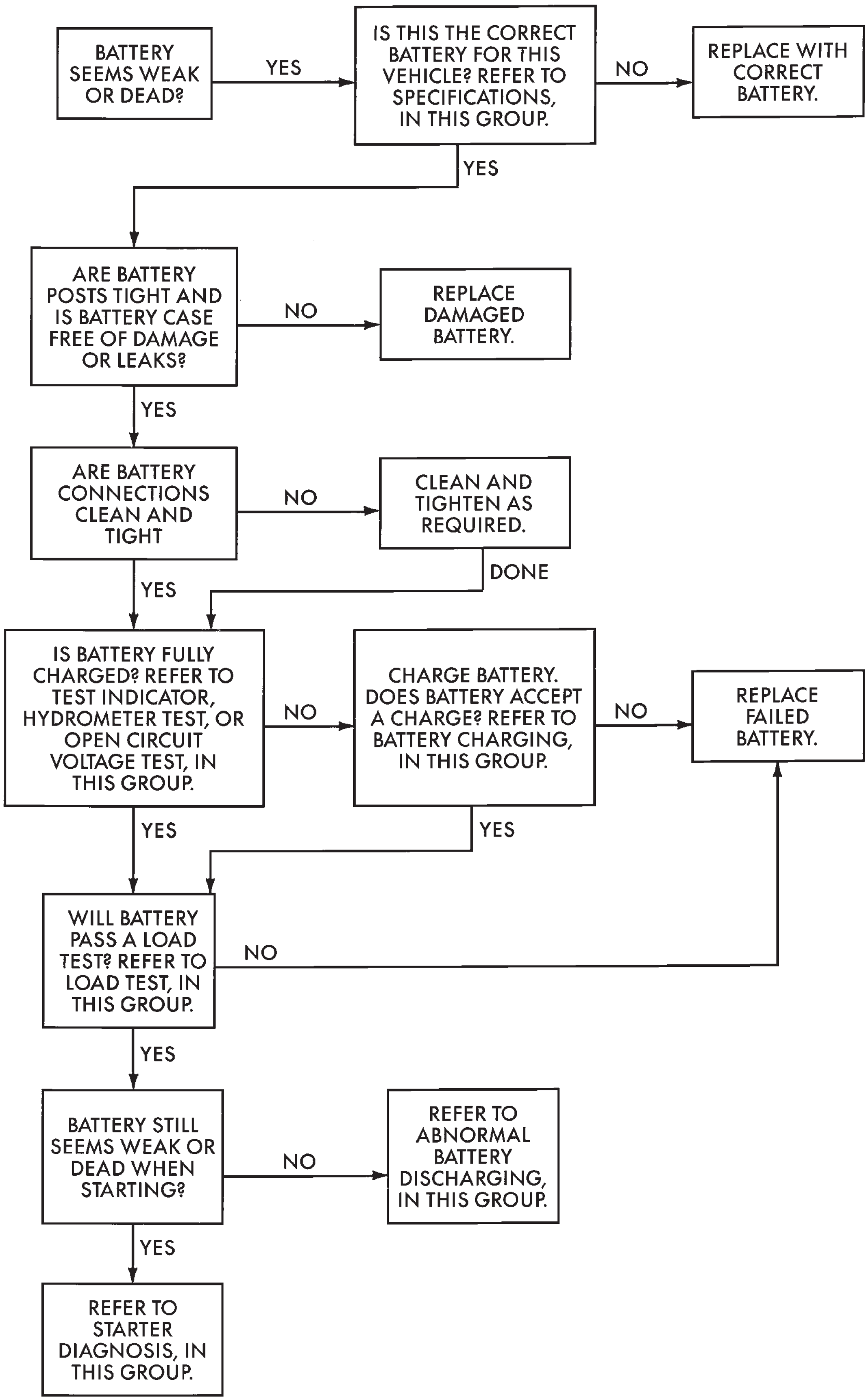
(6) Faulty charging system.

(7) Faulty or incorrect battery.

BUILT-IN TEST INDICATOR

A test indicator (hydrometer) built into the top of the battery case, provides visual information for battery testing (Fig. 1). It is important when using the test indicator that the battery be level and have a clean sight glass to see correct indications. Additional light may be required to view indicator.

BATTERY DIAGNOSIS



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WARNING: DO NOT USE OPEN FLAME AS A SOURCE OF ADDITIONAL LIGHT FOR VIEWING TEST INDICATOR. EXPLOSIVE HYDROGEN GAS MAY BE PRESENT IN THE AREA SURROUNDING BATTERY.

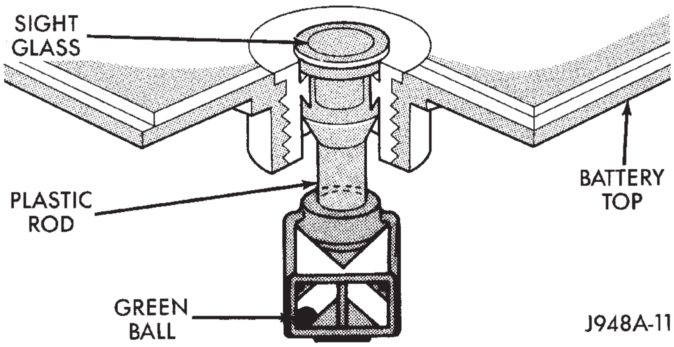

Fig. 1 Built-In Test Indicator

Like a hydrometer, the built-in test indicator measures the specific gravity of the electrolyte. Specific gravity will indicate battery state-of-charge. However, the test indicator will not indicate cranking capacity of the battery. See Load Test in this group for more information.

Look into the sight glass and note the color of the indicator (Fig. 2). Refer to the following description, as the color indicates:

GREEN—indicates 75% to 100% state-of-charge.

The battery is adequately charged for further testing or return to use. If the vehicle will not crank for a minimum of 15 seconds with a fully-charged battery, perform Load Test.

BLACK OR DARK—indicates 0% to 75% state-of-charge.

The battery is inadequately charged and must be charged until green indicator (Fig. 2) is visible in sight glass (12.4 volts or more) before the battery is tested further or returned to use. See Abnormal Battery Discharging in this group to diagnose cause of discharged condition.

YELLOW OR BRIGHT—indicates low electrolyte level.

The electrolyte level in the battery is below test indicator (Fig. 2). A maintenance-free battery with non-removable cell caps must be replaced if electrolyte level is low. Water can be added to a low-maintenance battery with removable cell caps. A low electrolyte level may be caused by an over-charging condition. See Charging System in this group to diagnose an over-charging condition.

WARNING: DO NOT ATTEMPT TO CHARGE, TEST, OR ASSIST BOOST BATTERY WHEN YELLOW OR BRIGHT COLOR IS VISIBLE IN SIGHT GLASS OF TEST INDICATOR. LOW ELECTROLYTE LEVEL CAN ALLOW BATTERY TO ARC INTERNALLY AND EXPLODE. PERSONAL INJURY MAY OCCUR.

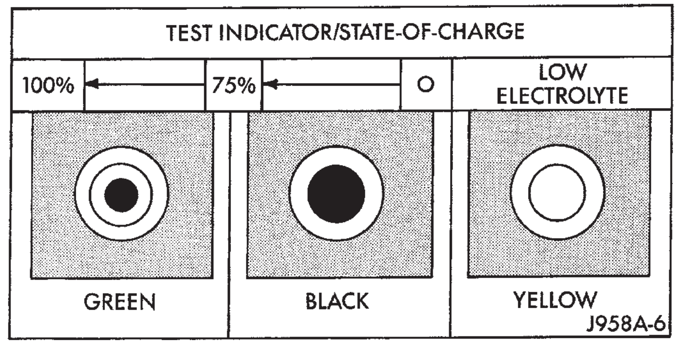

Fig. 2 Built-In Test Indicator Sight Glass

HYDROMETER TEST

The hydrometer test reveals the battery state-of-charge by measuring the specific gravity of the electrolyte. This test cannot be performed on batteries with non-removable cell caps. If battery has non-removable cell caps, see Built-In Test Indicator or Open Circuit Voltage Test.

Specific gravity is a comparison of the density of the electrolyte to the density of pure water. Pure water has a specific gravity of 1.000, and sulfuric acid has a specific gravity of 1.835. Sulfuric acid makes up approximately 35% of the electrolyte by weight, or 24% by volume.

In a fully-charged battery the electrolyte will have a temperature corrected specific gravity of 1.260 to 1.290. However, a specific gravity of 1.235 or above is satisfactory for battery load testing and/or return to service.

Before testing, visually inspect battery for any damage (cracked case or cover, loose posts, etc.) that would cause the battery to be faulty. Then remove cell caps and check electrolyte level. Add distilled water if electrolyte level is below the top of the battery plates.

To use the hydrometer correctly, hold it with the top surface of the electrolyte at eye level. Refer to the hydrometer manufacturer's instructions for correct use of hydrometer. Remove only enough electrolyte from the battery so the float is off the bottom of the hydrometer barrel with pressure on the bulb released.

Exercise care when inserting the tip of the hydrometer into a cell to avoid damaging the plate separators. Damaged plate separators can cause premature battery failure.

Hydrometer floats are generally calibrated to indicate the specific gravity correctly only at 26.7°C (80°F). When testing the specific gravity at any other temperature, a correction factor is required.

The correction factor is approximately a specific gravity value of 0.004, referred to as 4 points of specific gravity. For each 5.5°C above 26.7°C (10°F above 80°F), add 4 points. For each 5.5°C below 26.7°C (10°F below 80°F), subtract 4 points. Always correct the specific gravity for temperature variation. Test the specific gravity of the electrolyte in each battery cell.

Example: A battery is tested at -12.2°C (10°F) and has a specific gravity of 1.240. Determine the actual specific gravity as follows:

(1) Determine the number of degrees above or below 26.7°C (80°F):

26.6°C - -12.2°C = 38.8°C (80°F - 10°F = 70°F)

(2) Divide the result from step 1 by 5.5 (10):

38.8°C/5.5 = 7 (70°F/10 = 7)

(3) Multiply the result from step 2 by the temperature correction factor (0.004):

7 x 0.004 = 0.028

(4) The temperature at testing was below 26.7°C (80°F); therefore, the temperature correction is subtracted:

1.240 - 0.028 = 1.212

The corrected specific gravity of the battery in this example is 1.212.

If the specific gravity of all cells is above 1.235, but variation between cells is more than 50 points (0.050), the battery should be replaced.

If the specific gravity of one or more cells is less than 1.235, charge the battery at a rate of approximately 5 amperes. Continue charging until 3 consecutive specific gravity tests, taken at 1-hour intervals, are constant. If the cell specific gravity variation is more than 50 points (0.050) at the end of the charge period, replace the battery.

When the specific gravity of all cells is above 1.235, and cell variation is less than 50 points (0.050), the battery may be load tested.

OPEN CIRCUIT VOLTAGE TEST

A battery open circuit voltage (no load) test will show state-of-charge of a battery. This test can be used in place of the hydrometer test if a hydrometer is not available, or for maintenance-free batteries with non-removable cell caps.

Before proceeding with this test or load test, completely charge battery as described in Battery Charging in this group.

Test battery open circuit voltage as follows:

(1) Before measuring open circuit voltage the surface charge must be removed from the battery. Turn headlamps on for 15 seconds, then allow up to 5 minutes for voltage to stabilize.

(2) Remove both battery cables, negative first.

(3) Using a voltmeter connected to the battery posts (refer to instructions provided with voltmeter) measure open circuit voltage (Fig. 3).

See Open Circuit Voltage chart. This voltage reading will indicate state-of-charge, but will not reveal cranking capacity. If a battery has an open circuit voltage reading of 12.4 volts or greater, it may be load tested. A battery that will not endure a load test is faulty and must be replaced.

OPEN CIRCUIT VOLTAGE

Open Circuit Volts	Percent Charge
11.7 volts or less	0%
12.0	25%
12.2	50%
12.4	75%
12.6 or more	100%

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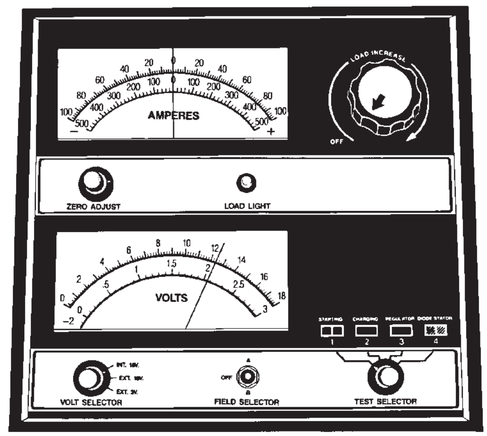

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Fig. 3 Testing Open Circuit Voltage

LOAD TEST

A battery load test will verify battery cranking capacity. The test is based on the Cold Cranking Amperage (CCA) rating of the battery. See Battery Classifications and Ratings chart in Specifications, at the back of this group.

WARNING: IF BATTERY SHOWS SIGNS OF FREEZING, LEAKING, LOOSE POSTS, OR LOW ELECTROLYTE LEVEL, DO NOT LOAD TEST. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

Before performing load test, the battery must be FULLY-CHARGED.

(1) Remove both battery cables, negative first. Battery top and posts should be clean.

(2) Connect a suitable volt-ammeter-load tester (Fig. 4) to the battery posts (Fig. 5). Refer to operating instructions provided with the tester being used. Check the open circuit voltage (no load) of the battery. Open circuit voltage must be 12.4 volts or greater.

(3) Rotate the load control knob (carbon pile rheostat) to apply a 300 amp load for 15 seconds, then return the control knob to OFF (Fig. 6). This will remove the surface charge from the battery.

(4) Allow the battery to stabilize to open circuit voltage. It may take up to 5 minutes for voltage to stabilize.

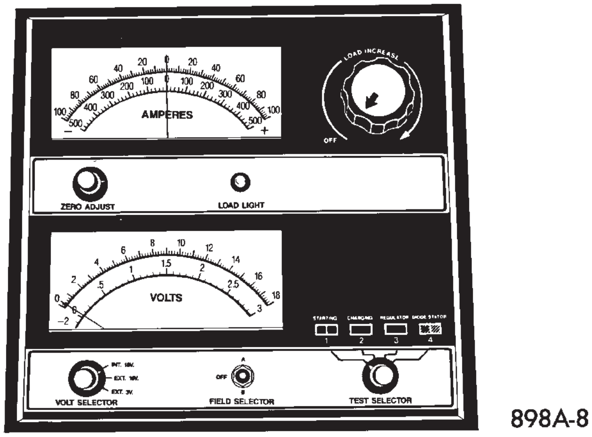

Fig. 4 Volt-Amps-Load Tester (Typical)

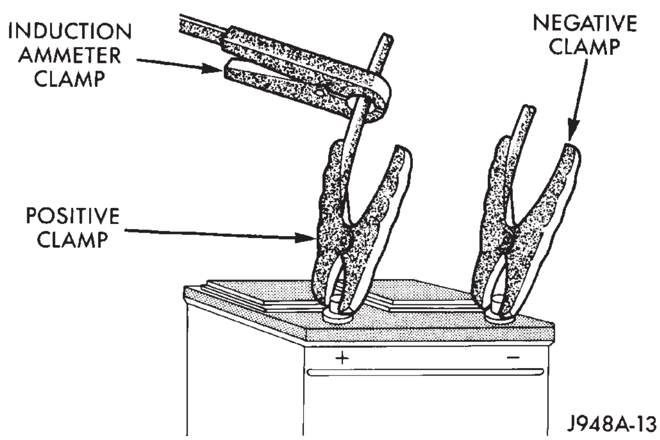

Fig. 5 Volt-Ammeter-Load Tester Connections

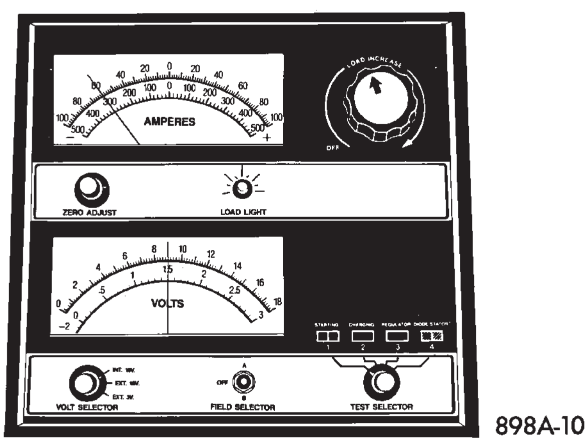

Fig. 6 Remove Surface Charge from Battery

(5) Rotate the load control knob to maintain a load equal to 50% of CCA rating (Fig. 7). After 15 seconds, record the loaded voltage reading, then return the load control knob to OFF.

(6) Voltage drop will vary with battery temperature at the time of the load test. Battery temperature can be estimated by the ambient temperature over the past several hours. If the battery has been charged, boosted, or loaded a few minutes prior to

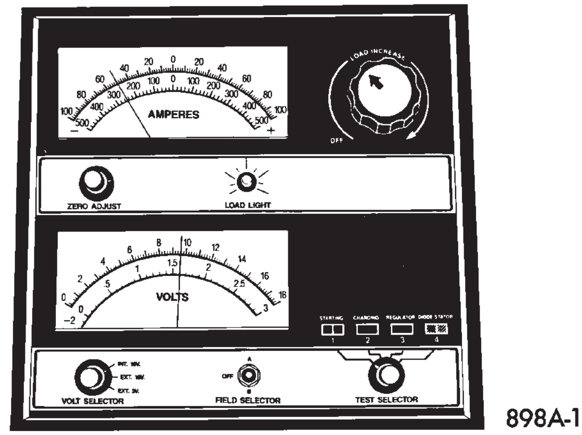

Fig. 7 Load 50% CCA Rating - Note Voltage

test, the battery will be somewhat warmer. See Load Test Temperature chart for proper loaded voltage reading.

(7) If the voltmeter reading falls below 9.6 volts, at a minimum battery temperature of 21°C (70°F), replace the battery.

LOAD TEST TEMPERATURE

Minimum Voltage	Temperature	
	F°	C°
9.6	70 and above	21 and above
9.5	60	16
9.4	50	10
9.3	40	4
9.1	30	-1
8.9	20	-7
8.7	10	-12
8.5	0	-18

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BATTERY CHARGING

A battery is fully-charged when:

- all cells are gassing freely during charging
- a green color is visible in sight glass of built-in test indicator
- three corrected specific gravity tests, taken at 1-hour intervals, indicate no increase in specific gravity
- open circuit voltage is 12.4 volts or above.

WARNING: DO NOT ASSIST BOOST OR CHARGE A BATTERY THAT HAS LOW ELECTROLYTE LEVEL OR IS FROZEN. BATTERY MAY ARC INTERNALLY AND EXPLODE.

WARNING: EXPLOSIVE HYDROGEN GAS FORMS IN AND AROUND BATTERY. DO NOT SMOKE, USE FLAME, OR CREATE SPARKS NEAR BATTERY.

WARNING: POISONOUS AND CAUSTIC. BATTERY CONTAINS SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES, OR CLOTHING. IN EVENT OF CONTACT, FLUSH WITH WATER AND CALL PHYSICIAN IMMEDIATELY. KEEP OUT OF REACH OF CHILDREN.

CAUTION: Always disconnect the battery negative cable before charging battery to avoid damage to electrical system components. Do not exceed 16.0 volts while charging battery.

Battery electrolyte will bubble inside battery case during normal battery charging. If the electrolyte boils, or is discharged from the vent holes while charging, immediately reduce charging rate or turn OFF charger and evaluate battery condition.

Battery should not be hot to the touch. If the battery feels hot to the touch, turn OFF charger and let battery cool before continuing charging operation.

Some battery chargers are equipped with polarity sensing circuitry. This circuitry protects the charger and/or battery from being damaged if improperly connected.

If the battery state-of-charge is too low for the polarity sensing circuitry to detect, the charger will not operate. This makes it appear that the battery will not accept charging current. Refer to instructions provided with the battery charger being used to bypass the polarity sensing circuitry.

BATTERY CHARGING TIME TABLE

Charging Amperage	5 Amps	10 Amps	20 Amps
Open Circuit Voltage	Hours Charging at 21°C		
12.25 to 12.39	6 Hrs.	3 Hrs.	1.5 Hr.
12.00 to 12.24	8 Hrs.	4 Hrs.	2 Hrs.
11.95 to 12.09	12 Hrs.	6 Hrs.	3 Hrs.
10.00 to 11.95	14 Hrs.	7 Hrs.	3.5 Hrs.
10.00 to 0	See Charging Completely Discharged Battery		

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After the battery has been charged to 12.4 volts or greater, perform a load test to determine cranking capacity. If the battery will endure a load test, return the battery to use. If the battery will not endure a load test, it must be replaced.

Clean and inspect battery holddowns, tray, terminals, posts, and top before completing service. Refer to Group 8B - Battery/Starter/Generator Service for more information.

CHARGING TIME REQUIRED

The time required to charge a battery will vary, depending upon the following factors:

(1) **Battery Capacity**—A completely discharged heavy-duty battery requires twice the recharging time of a small capacity battery.

WARNING: NEVER EXCEED 20 AMPS WHEN CHARGING A COLD (-1°C/30°F) BATTERY. PERSONAL INJURY MAY RESULT.

(2) **Temperature**—A longer time will be needed to charge a battery at -18°C (0°F) than at 27°C (80°F). When a fast charger is connected to a cold battery, current accepted by the battery will be very low at first. As the battery warms, it will accept a higher charging current rate.

(3) **Charger Capacity**—A charger that supplies only 5 amperes will require a longer charging time. A charger that supplies 20 amperes or more requires a shorter charging time.

(4) **State-Of-Charge**—A completely discharged battery requires more charging time than a partially discharged battery. Electrolyte is nearly pure water in a completely discharged battery. At first, the charging current (amperage) will be low. As the battery charges, the specific gravity of the electrolyte will gradually rise.

CHARGING COMPLETELY DISCHARGED BATTERY

The following procedure should be used to recharge a completely discharged battery. Unless this procedure is properly followed, a good battery may be needlessly replaced.

(1) Measure voltage at battery posts with a voltmeter, accurate to 1/10 (0.10) volt (Fig. 8). If the reading is below 10 volts, the charge current will be low. It could take some time before the battery accepts a current greater than a few milliamperes. Such low current may not be detectable on ammeters built into many chargers.

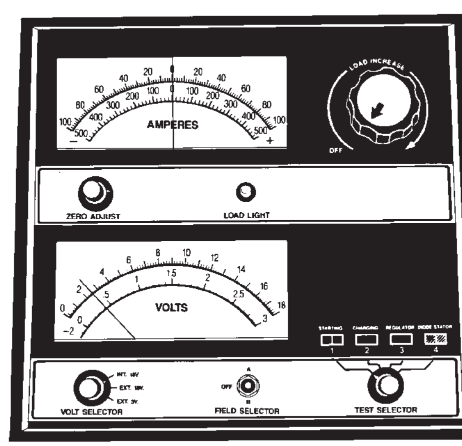

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Fig. 8 Voltmeter Accurate to 1/10 Volt Connected

(2) Disconnect battery negative cable. Connect charger leads. Some battery chargers are equipped

with polarity sensing circuitry. This circuitry protects the charger and/or battery from being damaged if improperly connected. If the battery state-of-charge is too low for the polarity sensing circuitry to detect, the charger will not operate. This makes it appear that the battery will not accept charging current. Refer to the instructions provided with the battery charger to bypass the polarity sensing circuitry.

(3) Battery chargers vary in the amount of voltage and current they provide. The amount of time required for a battery to accept measurable charger current at various voltages is shown in Charge Rate chart. If charge current is still not measurable at end of charging times, the battery should be replaced. If charge current is measurable during charging time, the battery may be good and charging should be completed in the normal manner.

CHARGE RATE

Voltage	Hours
16.0 volts maximum	up to 4 hrs.
14.0 to 15.9 volts	up to 8 hrs.
13.9 volts or less	up to 16 hrs.

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IGNITION-OFF DRAW

GENERAL INFORMATION

Ignition-Off Draw (IOD) refers to power being drained from the battery with the ignition switch turned OFF. A normal vehicle electrical system will draw from 5 to 20 milliamps (0.005 - 0.020 amps). This is with the ignition switch in the OFF position, and all non-ignition controlled circuits in proper working order. The 20 milliamps are needed to supply PCM memory, digital clock memory, and electronically-tuned radio memory.

A vehicle that has not been operated for approximately 20 days, may discharge the battery to an inadequate level. When a vehicle will not be used for 20 days or more (stored), remove the IOD fuse in the Power Distribution Center (PDC). This will reduce battery discharging.

Excessive battery drain can be caused by:

- electrical items left on
- faulty or improperly adjusted switches
- internally shorted generator
- intermittent shorts in the wiring.

If the IOD is over 20 milliamps, the problem must be found and corrected before replacing a battery. In most cases, the battery can be charged and returned to service.

DIAGNOSIS

Testing for high-amperage IOD must be performed first to prevent damage to most milliamp meters.

(1) Verify that all electrical accessories are off. Turn off all lamps, remove ignition key, and close all doors. If the vehicle is equipped with illuminated entry or electronically-tuned radio, allow the systems to automatically shut off (time out). This may take up to 3 minutes.

(2) Determine that the underhood lamp is operating properly, then disconnect or remove bulb.

(3) Disconnect negative cable from battery.

(4) Connect a typical 12-volt test lamp (low-wattage bulb) between the negative cable clamp and the battery negative terminal. Make sure that the doors remain closed so that illuminated entry is not activated.

The test lamp may light brightly for up to 3 minutes, or may not light at all, depending upon the vehicle's electrical equipment. The term brightly, as used throughout the following tests, implies the brightness of the test lamp will be the same as if it were connected across the battery.

The test lamp must be securely clamped to the negative cable clamp and battery negative terminal. If the test lamp becomes disconnected during any part of the IOD test, the electronic timer function will be activated and all tests must be repeated.

(5) After 3 minutes the test lamp should turn off or be dimly lit, depending upon the vehicle's electrical equipment. If the test lamp remains brightly lit, do not disconnect it. Remove each fuse or circuit breaker (refer to Group 8W - Wiring Diagrams) until test lamp is either off or dimly lit. This will isolate each circuit and identify the source of the high-amperage draw.

If the test lamp is still brightly lit after disconnecting each fuse and circuit breaker, disconnect the wiring harness from the generator. If test lamp now turns off or is dimly lit, see Charging System in this group to diagnose faulty generator. Do not disconnect the test lamp.

After high-amperage IOD has been corrected, low-amperage IOD may be checked. It is now safe to install a milliamp meter to check for low- amperage IOD.

(6) With test lamp still connected securely, clamp a milliamp meter between battery negative terminal and negative cable clamp.

Do not open any doors or turn on any electrical accessories with the test lamp disconnected or the milliamp meter may be damaged.

(7) Disconnect test lamp. Observe milliamp meter. The current draw should not exceed 0.020 amp. If draw exceeds 20 milliamps, isolate each circuit by removing circuit breakers and fuses. The milliamp meter reading will drop when the source of the draw is disconnected. Repair this circuit as necessary, whether a wiring short, incorrect switch adjustment or a component failure is found.

STARTING SYSTEM

GENERAL INFORMATION

The starting system (Fig. 1) consists of:
- ignition switch
- starter relay
- park/neutral position switch (automatic transmission)
- wiring harness and connections
- battery
- starter with an integral solenoid.

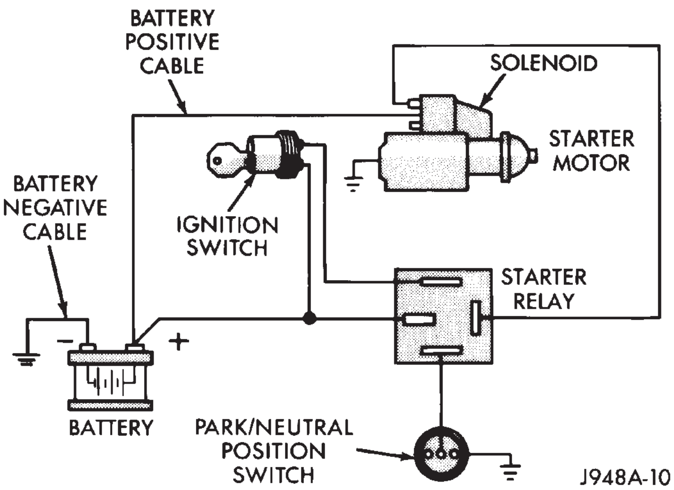

Fig. 1 Starting System Components (Typical)

Following is a general description of the major starting system components. Refer to Group 8W - Wiring Diagrams for complete circuit descriptions and diagrams.

These components form 2 separate circuits. A high-amperage feed circuit that feeds the starter up to 300+ amps, and a low-amperage control circuit that operates on less than 20 amps.

Battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the START position.

If the vehicle is equipped with an automatic transmission, the park/neutral position switch provides a ground path to the starter relay coil ground terminal. This switch provides ground only with the transmission in NEUTRAL or PARK. If the vehicle is equipped with a manual transmission, the starter relay coil ground terminal is always grounded.

With the starter relay coil now energized, the normally open relay contacts close. The relay contacts connect the relay common feed terminal to the relay normally open terminal. The closed relay contacts energize the starter solenoid coil windings.

The energized solenoid coils pull-in and hold-in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter. This engages the starter overrunning clutch and pinion gear with the flywheel/drive plate ring gear.

As the solenoid plunger reaches the end of its travel, the solenoid contact disc completes the high-amperage starter feed circuit. Current now flows between the solenoid battery terminal and the starter motor, energizing the starter.

Once the engine starts, the overrunning clutch protects the starter from damage by allowing the starter pinion gear to spin faster than the pinion shaft. When the driver releases the ignition switch to the ON position the starter relay coil is de-energized. This causes the relay contacts to open. When the relay contacts open, the starter solenoid coil is de-energized.

When the solenoid coil is de-energized, the solenoid plunger return spring returns the plunger to its relaxed position. This causes the contact disc to open the starter feed circuit, and the shift lever to disengage the overrunning clutch and pinion gear from the ring gear.

The starter motor and solenoid are serviced only as a complete assembly. If either component fails, the entire assembly must be replaced.

DIAGNOSIS

Before removing any unit from the starting system for repair, perform the following inspections:

INSPECTION

BATTERY INSPECTION

To determine condition of the battery, see Battery in this group.

WIRING INSPECTION

Inspect wiring for damage. Inspect all connections at:
- starter solenoid
- park/neutral position switch (automatic transmission)
- ignition switch
- starter relay
- battery (including all ground connections).

Clean, tighten and repair all connections as required.

SOLENOID, RELAY AND SWITCH INSPECTIONS

Inspect the solenoid, relay and ignition switch to determine their condition. Also, if equipped with automatic transmission, inspect condition of the park/neutral position switch. Testing information can be found in the following pages.

STARTING SYSTEM DIAGNOSIS

CONDITION	POSSIBLE CAUSES	CORRECTION
STARTER FAILS TO ENGAGE	1. Battery discharged or faulty.	1. See Battery, in this group. Charge or replace battery, if required.
	2. Starting circuit wiring faulty.	2. See Cold Cranking Test, in this group. Test and repair feed and/or control circuits, if required.
	3. Starter relay faulty.	3. See Relay Test, in this group. Replace relay, if required.
	4. Ignition switch faulty.	4. Refer to Group 8D - Ignition Systems, for testing and service information. Replace or adjust switch, if required.
	5. Park/Neutral position switch (auto trans) faulty or misadjusted.	5. Refer to Group 21 - Transmission and Transfer Case, for testing and service information. Replace switch, if required.
	6. Starter solenoid faulty.	6. See Solenoid Test, in this group. Replace starter assembly, if required.
	7. Starter assembly faulty.	7. Refer to Group 8B - Battery/Starter/ Generator Service, for starter service procedures. Replace starter assembly, if required.
STARTER ENGAGES, FAILS TO TURN ENGINE	1. Battery discharged or faulty.	1. See Battery, in this group. Charge or replace battery, if required.
	2. Starting circuit wiring faulty.	2. See Cold Cranking Test, in this group. Test and repair feed and/or control circuits, if required.
	3. Starter assembly faulty.	3. Refer to Group 8B - Battery/Starter/ Generator Service, for starter service procedures. Replace starter assembly, if required.
	4. Engine seized.	4. Refer to Group 9 - Engine, for diagnostic and service procedures.
STARTER ENGAGES, SPINS OUT BEFORE ENGINE STARTS	1. Broken teeth on flywheel or drive plate ring gear.	1. Refer to Group 8B - Battery/Starter/ Generator Service for starter removal procedures. Inspect ring gear and replace, if required.
	2. Starter assembly faulty.	2. Refer to Group 8B - Battery/Starter/ Generator Service, for starter service procedures. Replace starter assembly, if required.
STARTER DOES NOT ENGAGE	1. Starter improperly installed.	1. Refer to Group 8B - Battery/Starter/ Generator Service, for starter installation procedures.
	2. Starter relay faulty.	2. See Relay Test, in this group. Replace relay, if required.
	3. Ignition switch faulty.	3. Refer to Group 8D - Ignition Systems, for testing and service information. Replace or adjust switch, if required.
	4. Starter assembly faulty.	4. Refer to Group 8B - Battery/Starter/ Generator Service, for starter service procedures. Replace starter assembly, if required.

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COLD CRANKING TEST

(1) Battery must be fully-charged and load tested before proceeding. See Battery, in this group.

(2) Connect a suitable volt-ampere tester to the battery terminals (Fig. 2). Refer to the operating instructions provided with the tester being used.

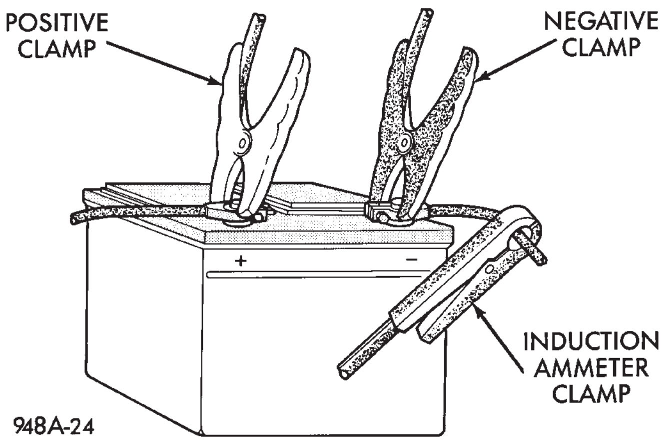


Fig. 2 Volt-Amps Tester Connections (Typical)

(3) Fully engage parking brake. Place manual transmission in NEUTRAL, automatic transmission in PARK.

(4) Verify that all lamps and accessories are OFF.

(5) Unplug Auto Shut-Down (ASD) relay from Power Distribution Center (PDC) to prevent engine from starting. Relay location is shown on underside of PDC cover.

(6) Rotate and hold the ignition switch in the START position. Note cranking voltage and amperage.

(a) If voltage reads above 9.6 volts and amperage draw reads above specifications, see Feed Circuit Tests.

(b) If voltage reads 12.5 volts or greater and amperage reads below specifications, see Control Circuit Tests.

A cold engine will increase starter current and reduce battery voltage.

FEED CIRCUIT TESTS

The starter feed circuit tests (voltage drop method) will determine if there is excessive resistance in the high-amperage circuit. When performing these tests, it is important that the voltmeter be connected properly. Connect voltmeter leads to the terminals that the cable connectors or clamps are attached to, not to the cable connectors or clamps. For example: When testing between the battery and solenoid, touch the voltmeter leads to the battery post and the solenoid threaded stud.

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing the tests, be certain the following procedures are accomplished:

- unplug Auto Shut-Down (ASD) relay from Power Distribution Center (PDC) to prevent engine from starting
- place transmission in NEUTRAL (manual transmission) or PARK (automatic transmission)
- parking brake is applied
- battery is fully-charged (see Battery, in this group).

(1) Connect positive lead of voltmeter to battery negative post. Connect negative lead of voltmeter to battery negative cable clamp (Fig. 3). Rotate and hold ignition switch in the START position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and post.

(2) Connect positive lead of voltmeter to battery positive post. Connect negative lead of voltmeter to battery positive cable clamp (Fig. 3). Rotate and hold ignition switch in the START position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and post.

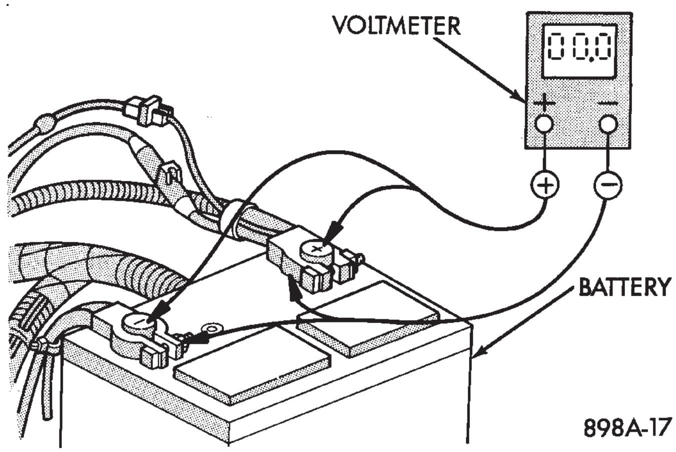


Fig. 3 Test Battery Connection Resistance

(3) Connect voltmeter to measure between the battery positive post and the starter solenoid battery stud (Fig. 4). Rotate and hold ignition switch in the START position. Observe voltmeter. If voltage reads above 0.2 volt, correct poor contact at battery cable to solenoid connection. Repeat test. If reading is still above 0.2 volt, replace battery positive cable.

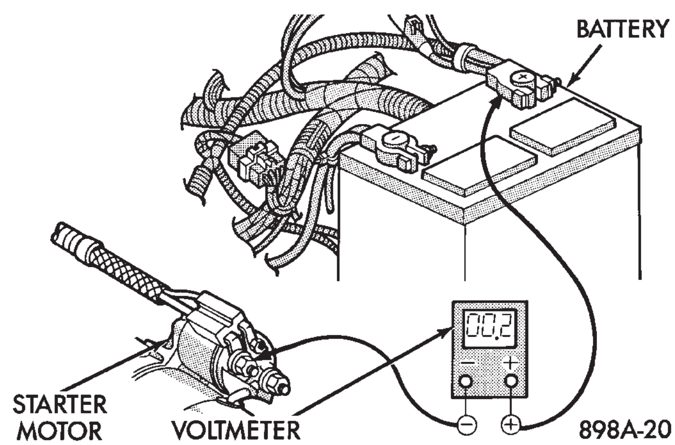


Fig. 4 Test Battery Positive Cable Resistance (Typical)

(4) Connect voltmeter to measure between the battery negative post and a good clean ground on the engine block (Fig. 5). Rotate and hold ignition switch in the START position. Observe voltmeter. If voltage reads above 0.2 volt, correct poor contact at battery negative cable attaching point. Repeat test. If reading is still above 0.2 volt, replace battery negative cable.

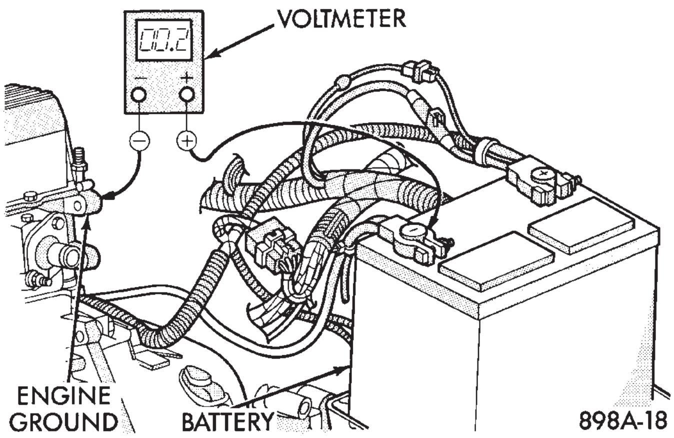


Fig. 5 Test Ground Circuit Resistance

(5) Connect positive lead of voltmeter to starter housing. Connect negative lead of voltmeter to battery negative terminal (Fig. 6). Rotate and hold ignition switch in the START position. Observe voltmeter. If voltage reads above 0.2 volt, correct poor starter to engine ground.

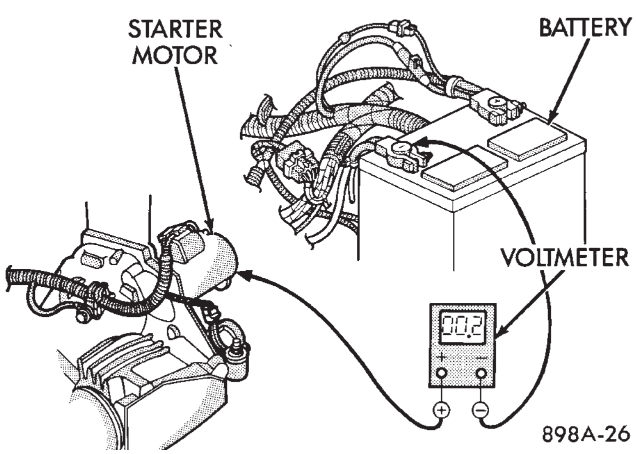


Fig. 6 Test Starter Ground (Typical)

If resistance tests detect no feed circuit problems, remove the starter and see Solenoid Test in this group.

CONTROL CIRCUIT TESTS

The starter control circuit consists of:
- starter solenoid
- starter relay
- ignition switch
- park/neutral position switch (automatic transmission)
- wiring harness and connections.

Test procedures for these components are as follows, and should be followed in the order described.

CAUTION: Before performing any test, unplug Auto Shut-Down (ASD) relay from Power Distribution Center (PDC) to prevent engine from starting.

SOLENOID TEST

Refer to Group 8B - Battery/Starter/Generator Service for starter removal procedures.

(1) Disconnect solenoid field coil wire from field coil terminal.

(2) Check for continuity between solenoid terminal and field coil terminal with a continuity tester. There should be continuity (Fig. 7).

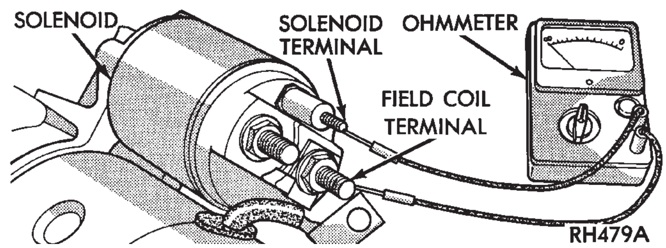


Fig. 7 Continuity Test Between Solenoid Terminal and Field Coil Terminal

(3) Check for continuity between solenoid terminal and solenoid case. There should be continuity (Fig. 8).

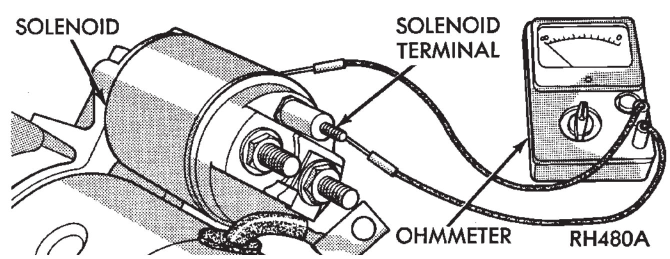


Fig. 8 Continuity Test Between Solenoid Terminal and Solenoid Case

(4) If there is continuity, solenoid is good. If there is no continuity in either test, solenoid has an open circuit and is faulty. Replace starter assembly.

(5) Connect solenoid field coil wire to field coil terminal.

(6) Install starter as described in Group 8B - Battery/Starter/Generator Service.

RELAY TEST

The starter relay is in the Power Distribution Center (PDC)(Figs. 9 or 10). Refer to the underside of the PDC cover for relay location.

Remove starter relay from PDC to perform the following tests:

(1) A relay in the de-energized position should have continuity between terminals 87A and 30, and no continuity between terminals 87 and 30. If OK, go to next step. If not OK, replace faulty relay.

(2) Resistance between terminals 85 and 86 (electromagnet) should be 75±5 ohms. If OK, go to next step. If not OK, replace faulty relay.

(3) Connect a battery to terminals 85 and 86. There should now be continuity between terminals 30 and 87, and no continuity between terminals 87A and 30. If OK, go to Relay Circuit Test. If not OK, replace faulty relay.

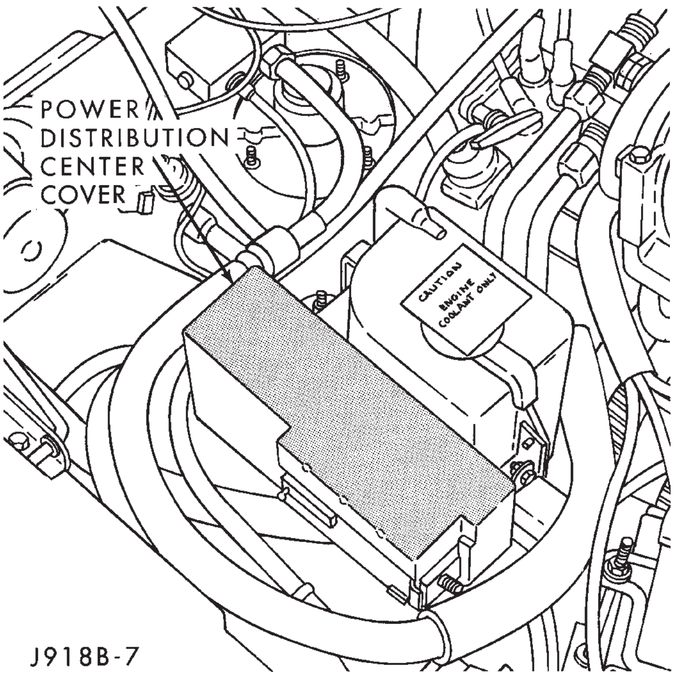


Fig. 9 Power Distribution Center—XJ

RELAY CIRCUIT TEST

(1) The common feed terminal (30) is connected to battery voltage and should be hot at all times. If OK, go to next step. If not OK, check circuit to fuse (F4 for YJ, F10 for XJ) in Power Distribution Center (PDC). Repair as required.

(2) The normally closed terminal (87A) is connected to terminal 30 in the de-energized position, but is not used for this application. Go to next step.

(3) The normally open terminal (87) is connected to the battery terminal (30) in the energized position. This terminal supplies battery voltage to the starter solenoid field coils. There should be continuity between cavity for relay terminal 87 and the starter solenoid terminal at all times. If OK, go to next step. If not OK, repair circuit to solenoid as required.

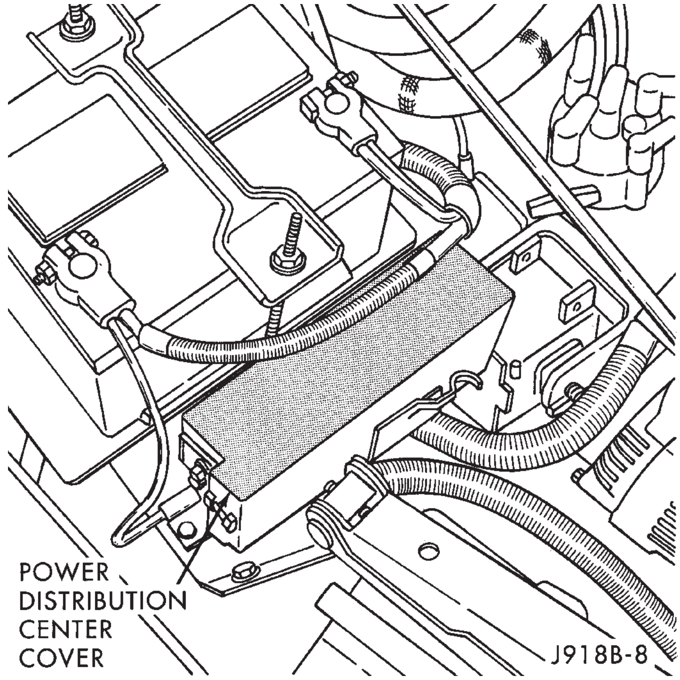
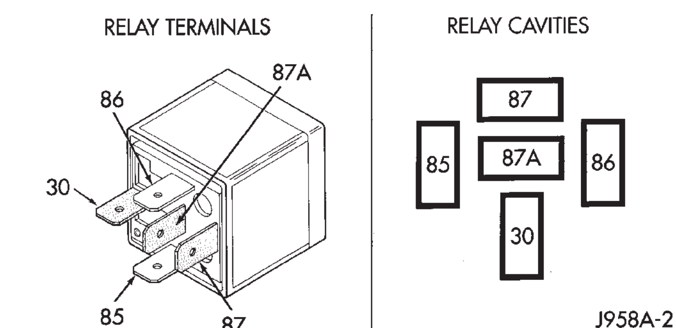


Fig. 10 Power Distribution Center—YJ

STARTER RELAY CONNECTIONS



TERMINAL LEGEND	
NUMBER	IDENTIFICATION
30	COMMON FEED
85	COIL GROUND
86	COIL BATTERY
87	NORMALLY OPEN
87A	NORMALLY CLOSED

(4) The coil battery terminal (86) is connected to the electromagnet in the relay. It is energized when the ignition switch is in the START position. Check for battery voltage at cavity for relay terminal 86 with ignition switch in the START position. If OK, go to next step. If not OK, refer to Group 8D - Ignition Systems for testing and service of the ignition switch.

(5) The coil ground terminal (85) is connected to the electromagnet in the relay. On vehicles with an automatic transmission, it is grounded through the park/neutral position switch. On vehicles with a manual transmission, it is grounded at all times. Check for continuity to ground at cavity for relay terminal 85. If not OK and vehicle has manual transmission, repair circuit as required. If not OK and vehicle has automatic transmission, refer to Group 21 - Transmission and Transfer Case for testing and service of the park/neutral position switch.

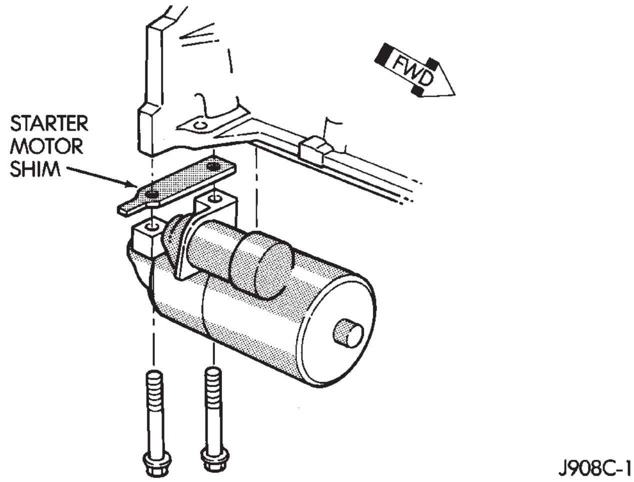


Fig. 11 Starter Shim

IGNITION SWITCH TEST

Refer to Group 8D - Ignition Systems for testing and service of this component.

PARK/NEUTRAL POSITION SWITCH TEST

Refer to Group 21 - Transmission and Transfer Case for testing and service of this component.

2.5L STARTER NOISE DIAGNOSIS

See Starter Noise Diagnosis chart. If the complaint is similar to Conditions 1 and 2 in chart, correction can be achieved by shimming starter according to the following procedures:

Disconnect the battery negative cable to prevent inadvertent starting of engine.

(1) If the complaint is similar to Condition 1, the starter must be moved toward the flywheel/drive plate ring gear by removing shims (Fig. 11).

Shim thickness is 0.381 mm (0.015 in.) and shims may be stacked if required.

(2) If the complaint is similar to Condition 2, the starter must be moved away from the flywheel/drive plate ring gear. This is done by installing shim(s) across both mounting pads. More than one shim may be required.

This is generally a condition that causes broken flywheel/drive plate ring gear teeth or broken starter housings.

STARTER NOISE DIAGNOSIS

CONDITION	POSSIBLE CAUSE	CORRECTION
1. VERY HIGH FREQUENCY WHINE BEFORE ENGINE STARTS; ENGINE STARTS OK.	1. Excessive distance between pinion gear and flywheel/drive plate gear.	1. Move starter motor toward flywheel/drive plate by removing shim(s), if possible.
2. VERY HIGH FREQUENCY WHINE AFTER ENGINE STARTS WITH IGNITION KEY RELEASED. ENGINE STARTS OK.	2. Insufficient distance between starter motor pinion gear and flywheel/drive plate runout can cause noise to be intermittent.	2. Shim starter motor away from flywheel/drive plate. Inspect flywheel/drive plate for damage; bent, unusual wear, and excessive runout. Replace flywheel/drive plate as necessary.
3. A LOUD "WHOOP" AFTER ENGINE STARTS WHILE STARTER MOTOR IS ENGAGED.	3. Most probably cause is defective overrunning clutch.	3. Replace starter motor.
4. A "RUMBLE," "GROWL," OR "KNOCK" AS STARTER MOTOR COASTS TO STOP AFTER ENGINE STARTS.	4. Most probable cause is bent or unbalanced starter motor armature.	4. Replace starter motor.

NOTE: A high frequency whine during cranking is normal for this starter motor.

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CHARGING SYSTEM

GENERAL INFORMATION

The charging system consists of:
- generator
- voltage regulator circuitry (within PCM)
- ignition switch
- battery
- generator warning lamp or voltmeter (depending on vehicle equipment)
- wiring harness and connections.

Following is a general description of the major charging system components. Refer to Group 8W - Wiring Diagrams for complete circuit descriptions and diagrams.

The charging system is turned on and off with the ignition switch. When the ignition switch is turned to the ON position, battery voltage is applied to the generator rotor through one of the two field terminals to produce a magnetic field. The generator is driven by the engine through a serpentine belt and pulley arrangement.

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil. Once the generator begins producing sufficient current, it also provides the current needed to energize the rotor.

The wye (Y) type stator winding connections deliver the induced AC current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified DC current is delivered to the vehicle electrical system through the generator battery and ground terminals.

The amount of DC current produced by the generator is controlled by the generator voltage regulator (field control) circuitry, contained within the Powertrain Control Module (PCM)(Fig. 1). This circuitry is connected in series with the second rotor field terminal and ground.

Voltage is regulated by cycling the ground path to control the strength of the rotor magnetic field. The generator voltage regulator circuitry monitors system line voltage and ambient temperature. It then compensates and regulates generator current output accordingly.

The generator is serviced only as a complete assembly. If the generator fails for any reason, the entire assembly must be replaced. The generator voltage regulator (field control) circuitry can be serviced only by replacing the entire PCM.

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including the generator voltage regulator (field control) circuitry, are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for any failure it detects. See Using On-Board Diagnostic System in this group for more information.

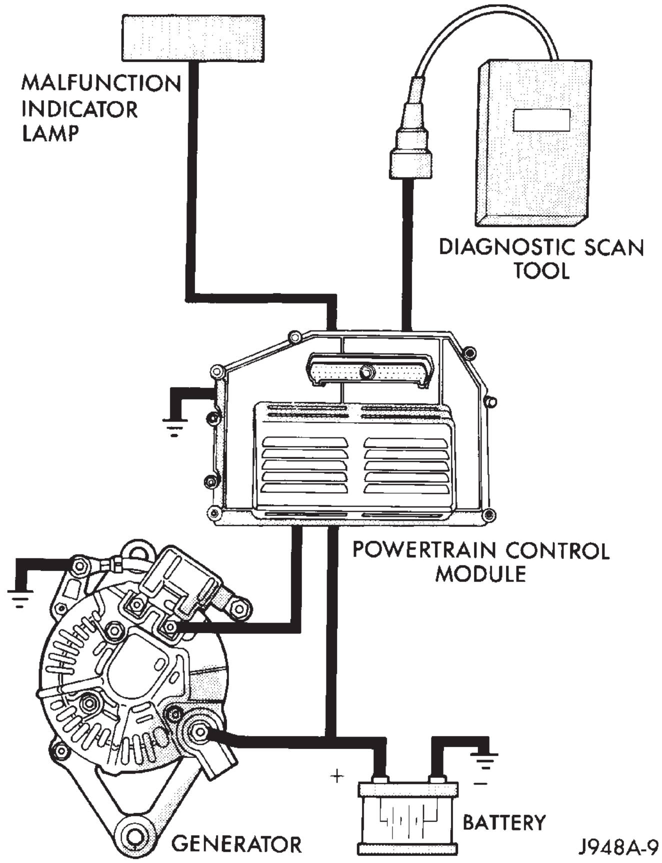

Fig. 1 Charging System Components (Typical)

DIAGNOSIS

When operating normally, the indicator lamp on models with the base instrument cluster will light when the ignition switch is turned to the ON or START position. After the engine starts, the indicator lamp goes off. With the engine running, the charge indicator lamp should light only when there is a problem in the charging system (base cluster only).

On models with a voltmeter, when the ignition switch is turned to the ON position, battery potential will register on the meter. During engine cranking a lower voltage will appear on the meter. With the engine running, a voltage reading higher than the first reading (ignition in ON) should register.

The following procedures may be used to diagnose the charging system if:
- the indicator or voltmeter do not operate properly
- an undercharged or overcharged battery condition occurs.

Remember that an undercharged battery is often caused by:

• accessories being left on with the engine not running
• a faulty or improperly adjusted switch that allows a lamp to stay on (see Ignition-Off Draw, in this group).

INSPECTION

(1) Inspect condition of battery cable terminals, battery posts, connections at engine block, starter solenoid and relay. They should be clean and tight. Repair as required.

(2) Inspect all fuses in the fuseblock module and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.

(3) Inspect the electrolyte level in the battery. If cell caps are removable, add water if required. If cell caps are not removable, replace battery if electrolyte level is low.

(4) Inspect generator mounting bolts for tightness. Replace or tighten bolts, if required. Refer to Group 8B - Battery/Starter/Generator Service for torque specifications.

(5) Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications in Group 7 - Cooling System.

(6) Inspect connections at generator field, battery output, and ground terminals. Also check ground connection at engine. They should all be clean and tight. Repair as required.

OUTPUT WIRE RESISTANCE TEST

This test will show the amount of voltage drop across the generator output wire, from the generator battery terminal to the battery positive post.

PREPARATION

(1) Before starting test make sure vehicle has a fully-charged battery. See Battery in this group for more information.

(2) Turn ignition switch to OFF.

(3) Disconnect negative cable from battery.

(4) Disconnect generator output wire from generator battery output terminal.

(5) Connect a 0-150 ampere scale DC ammeter (Fig. 2). Install in series between generator battery output terminal and disconnected generator output wire. Connect positive lead to generator battery output terminal and negative lead to disconnected generator output wire.

(6) Connect positive lead of a test voltmeter (range 0-18 volts minimum) to disconnected generator output wire. Connect negative lead of test voltmeter to battery positive cable at positive post.

(7) Connect one end of a jumper wire to ground and with other end probe green K20 field wire at back of generator (Fig. 2). This will generate a DTC.

CAUTION: Do not connect green/orange A142 field wire to ground. Refer to Group 8W - Wiring Diagrams for more information.

(8) Connect an engine tachometer, then connect battery negative cable to battery.

(9) Connect a variable carbon pile rheostat between battery terminals. Be sure carbon pile is in OPEN or OFF position before connecting leads. See Load Test in this group for instructions.

TEST

(1) Start engine. Immediately after starting, reduce engine speed to idle.

(2) Adjust engine speed and carbon pile to maintain 20 amperes flowing in circuit. Observe voltmeter reading. Voltmeter reading should not exceed 0.5 volts.

RESULTS

If a higher voltage drop is indicated, inspect, clean and tighten all connections. This includes any connection between generator battery output terminal and battery positive post. A voltage drop test may be performed at each connection to locate the connection with excessive resistance. If resistance tests satisfactorily, reduce engine speed, turn OFF carbon pile and turn OFF ignition switch.

(1) Disconnect negative cable from battery.

(2) Remove test ammeter, voltmeter, carbon pile, and tachometer.

(3) Remove jumper wire.

(4) Connect generator output wire to generator battery output terminal. Tighten nut to 8.5±1.5 N·m (75±15 in. lbs.).

(5) Connect negative cable to battery.

(6) Use DRB scan tool to erase DTC.

CURRENT OUTPUT TEST

The generator current output test determines whether generator can deliver its rated current output.

PREPARATION

(1) Before starting test make sure vehicle has a fully-charged battery. See Battery in this group for more information.

(2) Disconnect negative cable from battery.

(3) Disconnect generator output wire at the generator battery output terminal.

(4) Connect a 0-150 ampere scale DC ammeter (Fig. 3). Install in series between generator battery output terminal and disconnected generator output wire. Connect positive lead to generator battery output terminal and negative lead to disconnected generator output wire.

CHARGING SYSTEM DIAGNOSIS

CONDITION	POSSIBLE CAUSES	CORRECTION
LOW OR UNSTEADY CHARGING.	1. Battery discharged or faulty.	1. See Battery, in this group. Charge or replace battery, if required.
	2. Loose or faulty generator drive belt.	2. Refer to Group 7 – Cooling System, for belt inspection and tightening procedures. Replace or tighten belt, if required.
	3. Loose generator mounting.	3. Refer to Group 8B - Battery/Starter/Generator Service, for generator service procedures. Tighten generator mounting, if required.
	4. Loose or corroded charging circuit wiring connections.	4. Inspect all charging circuit connections, including grounds and fuses. Clean or tighten, if required.
	5. High resistance in generator output wire.	5. See Ouput Wire Resistance Test, in this group. Test and repair, if required.
	6. Generator assembly faulty.	6. See Current Output Test, in this group. Test and replace, if required.
	7. Faulty generator field control circuit.	7. See Using On-Board Diagnostic System, in this group. Diagnose and repair, if required.
OVER-CHARGING.	1. Short in generator field control circuit.	1. See Using On-Board Diagnostic System, in this group. Diagnose and repair, if required.
	2. Generator assembly faulty.	2. See Current Output Test, in this group. Test and replace, if required.
GENERATOR NOISY.	1. Loose, worn, or damaged drive belt.	1. Refer to Group 7 – Cooling System, for diagnosis and repair of drive belt problems
	2. Drive belt pulleys misaligned.	2. Refer to Group 7 – Cooling System, for diagnosis and repair of pulley misalignment.
	3. Generator assembly faulty.	3. Refer to Group 8B – Battery/Starter/Generator Service, for generator service procedures.

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(5) Connect positive lead of a test voltmeter (range 0-18 volts minimum) to generator battery output terminal.

(6) Connect negative lead of test voltmeter to a good ground.

(7) Connect an engine tachometer, then connect battery negative cable to battery.

(8) Connect a variable carbon pile rheostat between battery terminals. Be sure carbon pile is in OPEN or OFF position before connecting leads. See Load Test in this group for instructions.

(9) Connect one end of a jumper wire to ground and with other end probe green K20 field wire at back of generator (Fig. 3). This will generate a DTC.

CAUTION: Do not connect green/orange A142 field wire to ground. Refer to Group 8W - Wiring Diagrams for more information.

TEST

(1) Start engine. Immediately after starting, reduce engine speed to idle.

(2) Adjust carbon pile and engine speed in increments until a speed of 1250 rpm and voltmeter reading of 15 volts is obtained.

CAUTION: Do not allow voltage meter to read above 16 volts.

(3) The ammeter reading must be within limits shown in Generator Output Voltage Specifications.

RESULTS

(1) If reading is less than specified and generator output wire resistance is not excessive, generator should be replaced. Refer to Group 8B - Battery/Starter/Generator Service.

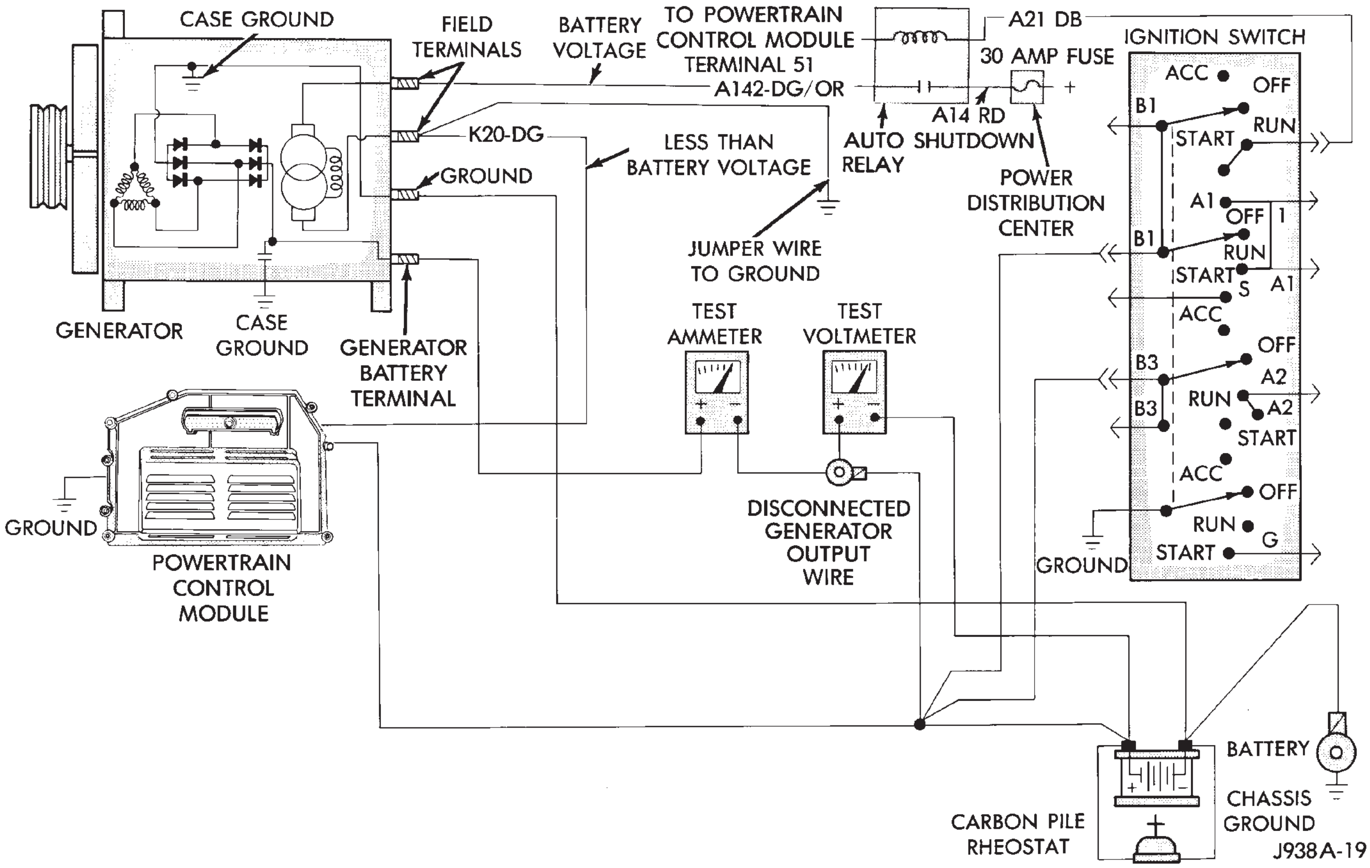

Fig. 2 Generator Output Wire Resistance Test (Typical)

(2) After current output test is completed, reduce engine speed, turn OFF carbon pile and turn OFF ignition switch.

(3) Disconnect negative cable from battery.

(4) Remove test ammeter, voltmeter, tachometer and carbon pile.

(5) Remove jumper wire (Fig. 3).

(6) Connect generator output wire to generator battery output terminal. Tighten nut to 8.5±1.5 N·m (75±15 in. lbs.).

(7) Connect negative cable to battery.

(8) Use DRB scan tool to erase DTC.

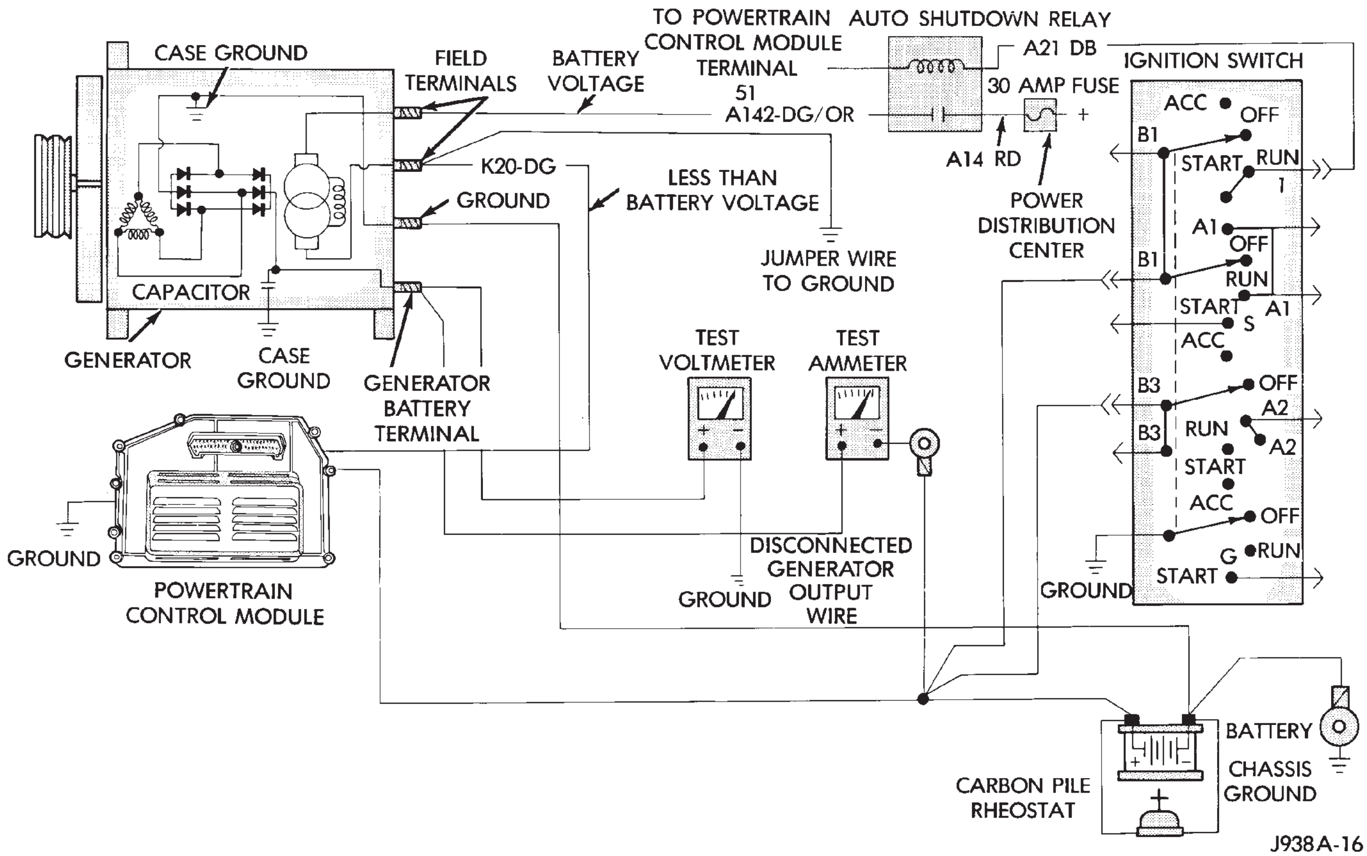

Fig. 3 Generator Current Output Test (Typical)

USING ON-BOARD DIAGNOSTIC SYSTEM

GENERAL INFORMATION

The Powertrain Control Module (PCM) monitors critical input and output circuits of the charging system, making sure they are operational. A Diagnostic Trouble Code (DTC) is assigned to each input and output circuit monitored by the OBD system. Some circuits are checked continuously and some are checked only under certain conditions.

If the OBD system senses that a monitored circuit is bad, it will put a DTC into electronic memory. The DTC will stay in electronic memory as long as the circuit continues to be bad. The PCM is programmed to clear the memory after 50 engine starts, if the problem does not occur again.

DIAGNOSTIC TROUBLE CODES

Diagnostic Trouble Codes (DTC) are two-digit numbers flashed on the malfunction indicator (Check Engine) lamp that identify which circuit is bad. A DTC description can also be read using the DRB scan tool. Refer to Group 14 - Fuel Systems for more information.

A DTC does not identify which component in a circuit is bad. Thus, a DTC should be treated as a symptom, not as the cause for the problem. In some cases, because of the design of the diagnostic test procedure, a DTC can be the reason for another DTC to be set. Therefore, it is important that the test procedures be followed in sequence, to understand what caused a DTC to be set.

See Generator Diagnostic Trouble Code chart for DTC's which apply to the charging system. Refer to the Powertrain Diagnostic Procedures manual to diagnose an on-board diagnostic system trouble code.

RETRIEVING DIAGNOSTIC TROUBLE CODES

To start this function, cycle the ignition switch ON-OFF-ON-OFF-ON within 5 seconds. This will cause any DTC stored in the PCM memory to be displayed. The malfunction indicator (Check Engine) lamp will display a DTC by flashing on and off. There is a short pause between flashes and a longer pause between digits. All DTC's displayed are two-digit numbers, with a four-second pause between codes.

An example of a DTC is as follows:

(1) Lamp on for 2 seconds, then turns off.

(2) Lamp flashes 4 times pauses and then flashes 1 time.

(3) Lamp pauses for 4 seconds, flashes 4 times, pauses, then flashes 7 times.

The two DTC's are 41 and 47. Any number of DTC's can be displayed, as long as they are in memory. The lamp will flash until all stored DTC's are displayed (55 = end of test).

GENERATOR DIAGNOSTIC TROUBLE CODE

Diagnostic Trouble Code	DRB Scan Tool Display	Description of Diagnostic Trouble Code
12*	Battery Disconnect	Direct battery input to PCM was disconnected within the last 50 key-on cycles.
41**	Generator Field Not Switching Properly	An open or shorted condition detected in the generator field control circuit.
46**	Charging System Voltage Too High	Battery voltage sense input above target charging voltage during engine operation.
47**	Charging System Voltage Too Low	Battery voltage sense input below target charging during engine operation. Also, no significant change detected in battery voltage during active test of generator output.
55*	N/A	Completion of fault code display on Check Engine lamp.

* Check Engine lamp will not illuminate at all times if this Diagnostic Trouble Code was recorded. Cycle ignition key as described in manual and observe code flashed by Check Engine lamp.

** Check Engine lamp will illuminate during engine operation if this Diagnostic Trouble Code was recorded.

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SPECIFICATIONS

BATTERY SPECIFICATIONS

BATTERY CLASSIFICATIONS AND RATINGS

Group Size	Cold Crank AMPS	Reserve Capacity (Min.)	Engine	Vehicle Series
58	430	80	2.5L & 4.0L	All
58	500	85	2.5L, 4.0L	All

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STARTING SYSTEM SPECIFICATIONS

4.0L STARTER AND SOLENOID TESTING SPECIFICATIONS

Description	Specifications @ 20°C (68°F)
No Load Test With 11.2 volts Max. Amps Min. RPM	 80 2500
Solenoid Hold-in Winding Voltage	3.5V Max.
Solenoid Pull-in Winding Voltage	7.8V Max.

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4.0L STARTING SYSTEM COLD CRANKING SPECIFICATIONS

Description	Specifications @ 20°C (68°F)
Battery Test Voltage	12.5 Volts
Cold Cranking Voltage (Minimum)	9.6 Volts
Cold Cranking Amps	160 Amps

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2.5L STARTER AND SOLENOID TESTING SPECIFICATIONS

Description	Specifications @ 20°C (68°F)
No Load Test With 11.2 volts Max. Amps Min. RPM	 90 2600
Solenoid Hold-in Winding Voltage	2.6V-3.5V Max.
Solenoid Pull-in Winding Voltage	6V-7.8V Max.

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2.5L STARTING SYSTEM COLD CRANKING SPECIFICATIONS

Battery Test Voltage	12.5 Volts
Cold Cranking Voltage (Minimum)	9.6 Volts
Cold Cranking Amps	130 Amps

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CHARGING SYSTEM SPECIFICATIONS

OUTPUT VOLTAGE SPECIFICATIONS

PCM Temperature °C (°F)	Acceptable Voltage Range
−40 to −6.7 (−40 to 20)	14.5 to 15.0
−6.7 to 26.7 (20 to 80)	13.87 to 15.0
26.7 to 60 (80 to 140)	13.25 to 14.37
60 to 71.1 (140 to 160)	13.25 to 13.75

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GENERATOR RATINGS

Type	Part Number	Engine	Rating
Nippondenso	56005684	2.5L & 4.0L	75
Nippondenso	56005685	2.5L & 4.0L	90

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