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SECTION 03A — Emission Control System

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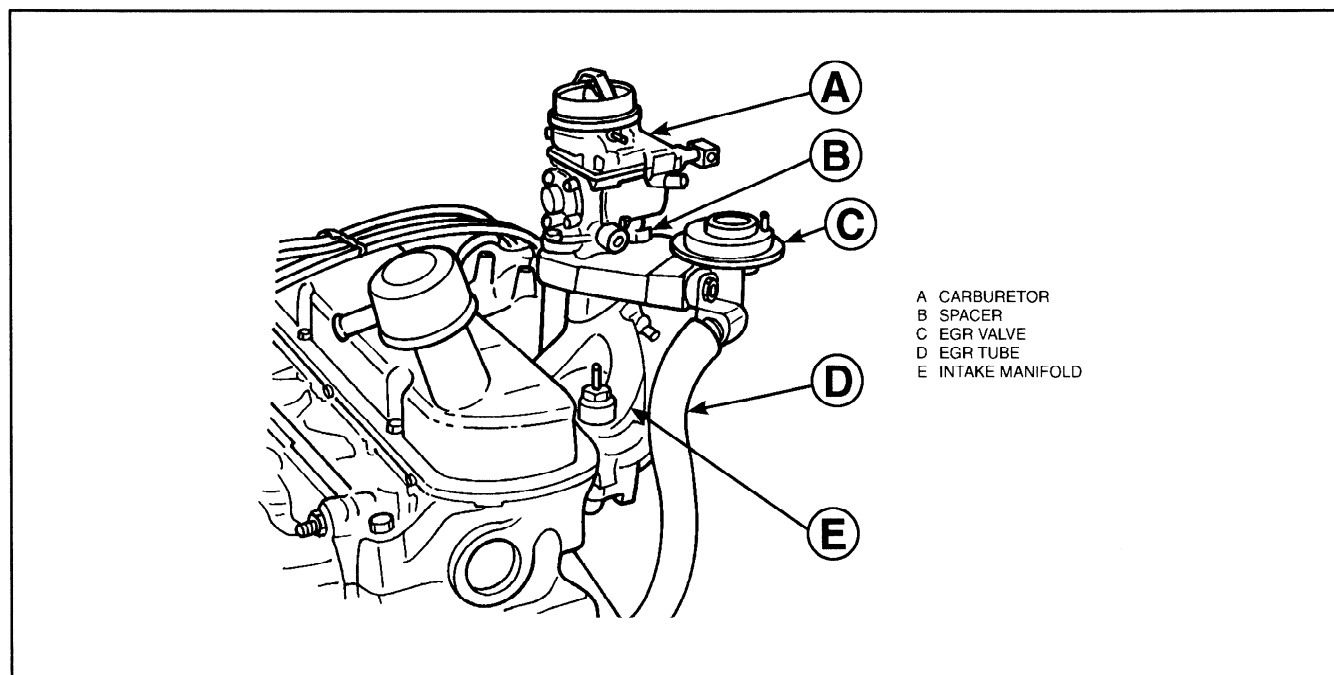
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DESCRIPTION AND OPERATION

Exhaust Gas Recirculation (EGR) Valve

The exhaust gas recirculation (EGR) system feeds a controlled amount of exhaust gas back through the

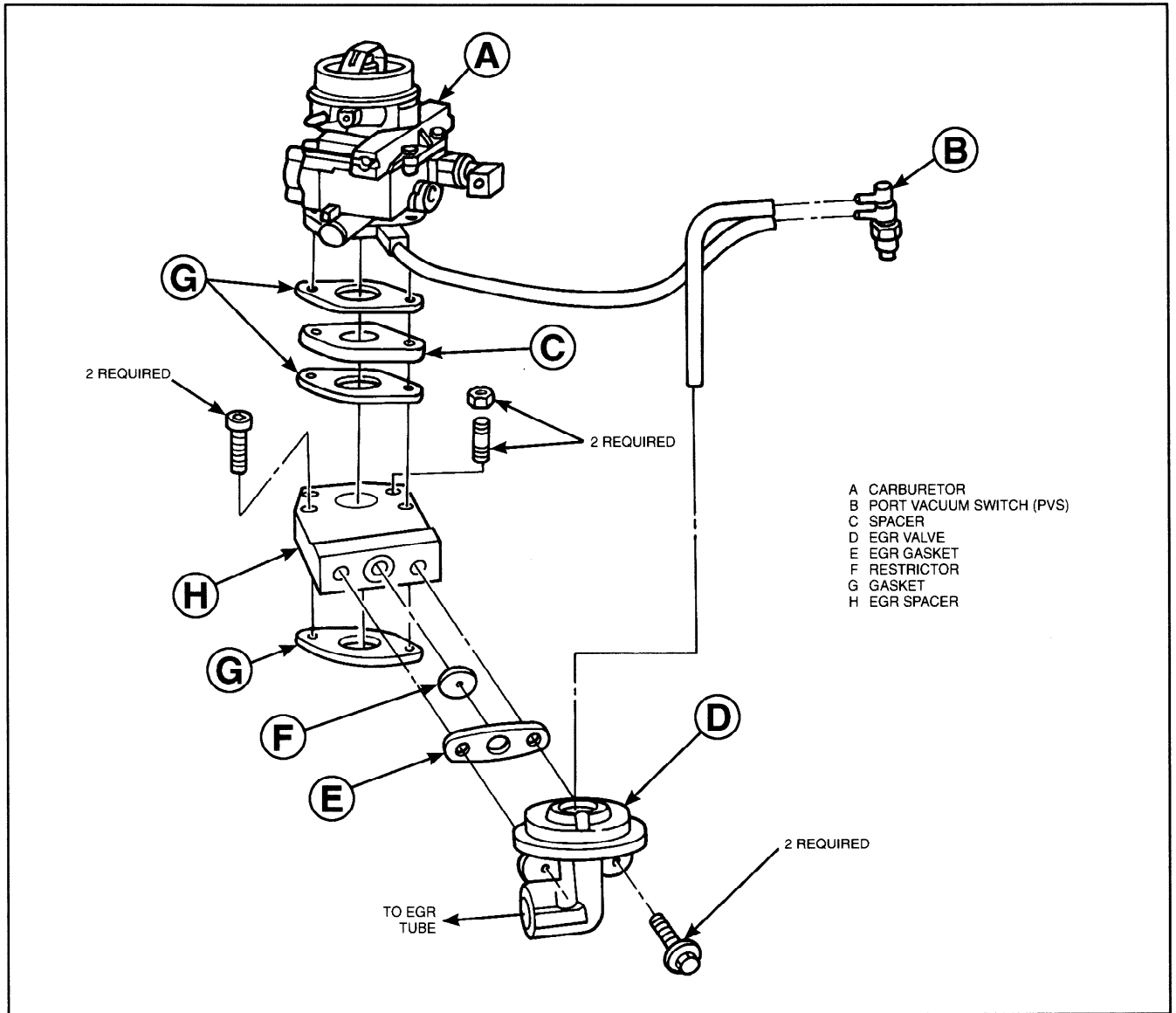
cylinders to reduce the combustion temperature. This reduces the formation of an atmospheric pollutant known as "oxides of nitrogen" (NOx).



The EGR valve is a vacuum-operated flow-control valve. It is attached to the carburetor by an EGR valve adapter.

Between the EGR valve adapter and the carburetor is a spacer which has gaskets on both sides.

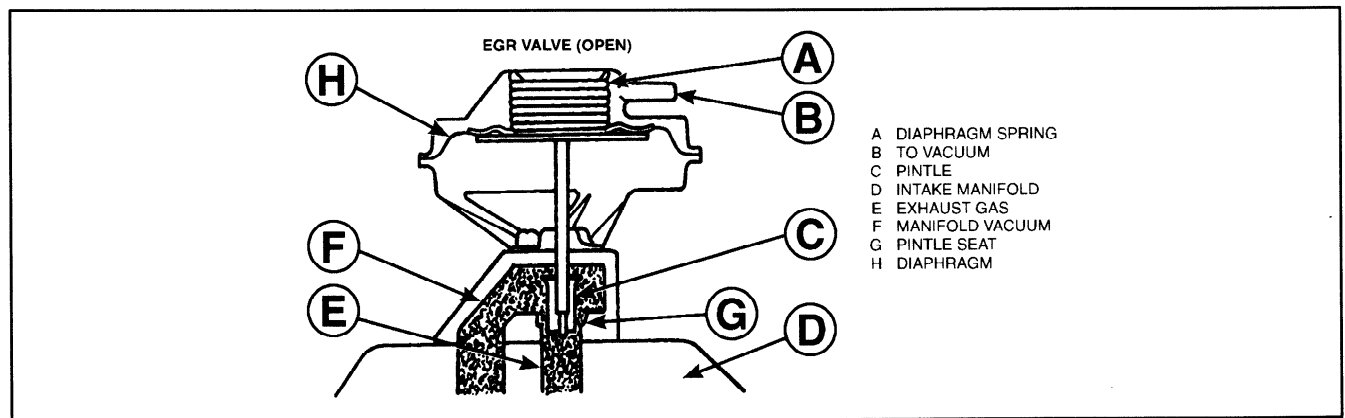
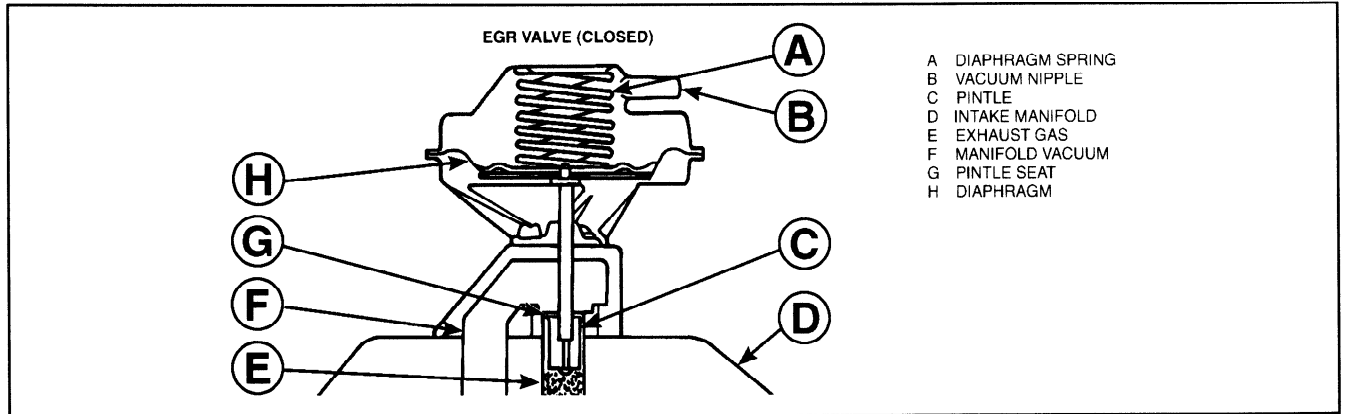
DESCRIPTION AND OPERATION (Continued)



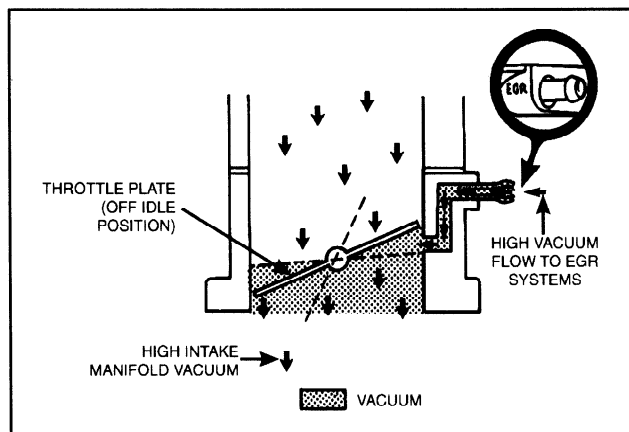
The EGR valve is operated by a vacuum signal from the carburetor, which actuates the valve diaphragm. As the vacuum increases sufficiently to overcome the diaphragm

spring, the valve is opened, allowing EGR flow. The amount of flow is dependent on the location of a tapered pintle, which is a direct result of the vacuum signal.

DESCRIPTION AND OPERATION (Continued)



The EGR vacuum port is open to vacuum when the throttle plate is opened slightly (off idle). Vacuum is then available to the EGR control valve. Vacuum level decreases as the throttle plate opens.



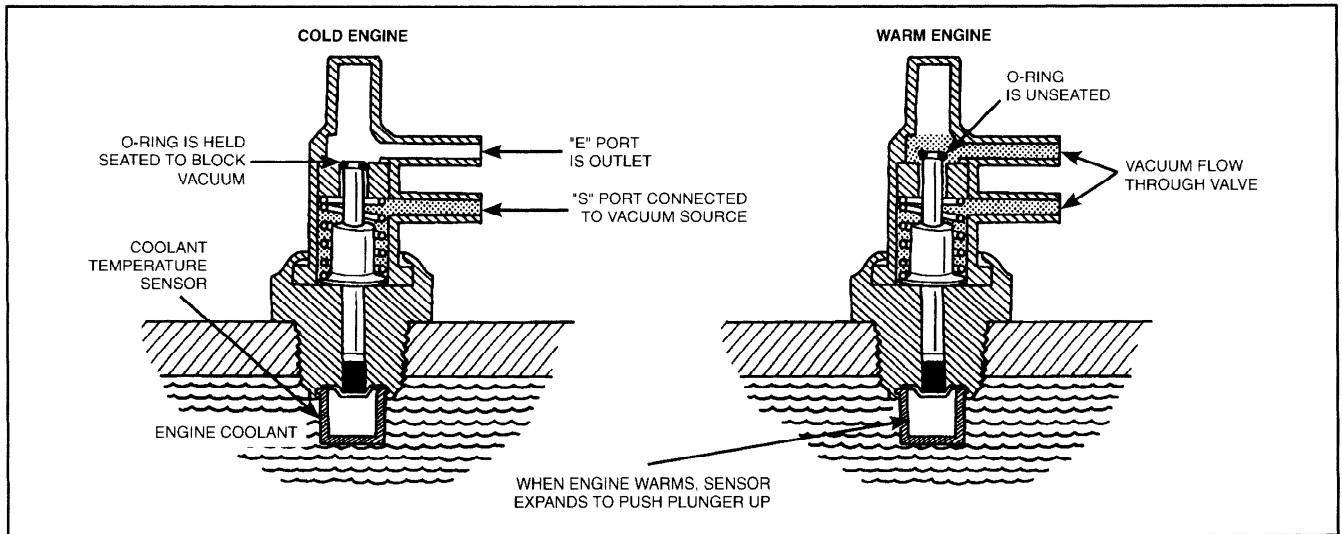
At closed throttle, the EGR port is blocked from vacuum. At wide open throttle, EGR vacuum is weak to zero and will cause the EGR valve to close for maximum engine power. Note that at idle (when EGR vacuum is off) the EGR system is least needed because NO_x formation is at a minimum.

Under certain circumstances, the EGR valve will usually be off. These include:

1. At idle, when the engine needs a richer mixture.
2. When the engine is cold.
3. When there is a heavy load (wide-open throttle).

At idle and at wide-open throttle, there is no vacuum at the EGR vacuum port. To control EGR at various engine temperatures, a port vacuum switch (PVS) is used.

DESCRIPTION AND OPERATION (Continued)



The two-port PVS senses engine coolant temperature so that it can cut off vacuum to the EGR valve when the engine is cold, and connect vacuum to the EGR valve when the engine is warm.

Crankcase Emission Control System

The Crankcase Emission Control System consists of an oil filler cap (including PCV valve) with two connecting hoses, one of which passes to the inlet manifold and the other to the air cleaner. The result is a closed ventilation system in which the fumes from the crankcase pass back via the inlet manifold into the cylinders for combustion.

DIAGNOSIS AND TESTING

Symptoms of EGR System Malfunctions

Many problems of poor engine performance are incorrectly diagnosed as being related to the EGR valve or EGR system. Therefore, it is important to know what engine symptoms **can** be EGR-related and how to test the system.

Rough Idle

This can be caused by an EGR valve stuck **open**, by dirt on the valve seat, or by loose mounting bolts. Loose mounting will cause a vacuum leak and a hissing noise. A stuck valve can be diagnosed by a functional test and by visual inspection.

Surge, Stall, or Won't Start

Can be caused by the valve stuck **open**.

Detonation (Spark Knock)

Any condition that prevents poor EGR gas flow can cause detonation. This includes a valve stuck closed, leaking valve diaphragm, restrictions in flow passages, EGR disconnected, or a problem in the vacuum source. On engines with high spark advance, detonation is serious enough to destroy an engine. Diagnose the condition by performing the tests in this section.

CAUTION: Improper use of leaded gasoline can plug up an EGR valve with deposits that restrict flow.

Poor Fuel Economy

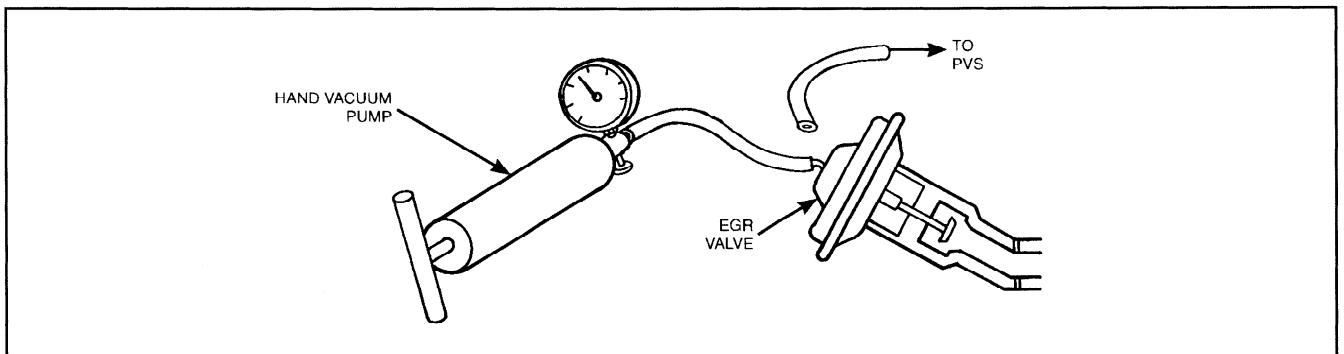
This is an EGR condition only if it is related to detonation or some other symptom of restricted or zero EGR flow.

EGR System Gas Flow Test

The exhaust gas flow test must be made with the engine idling and hot. It tells you if the gas flow passages are open.

1. Remove the vacuum line from the valve diaphragm. Plug the line to prevent a vacuum leak or dirt entry.
2. Attach a hand vacuum pump to the valve diaphragm.
3. Apply 15 inches of vacuum to the valve, a little at a time.

If the gas flow is okay, the engine will begin to idle roughly at some point, or it may stall. If the idle doesn't change, there is a restricted passage in the valve or the spacer. Remove the valve for inspection. If the valve diaphragm fails to hold vacuum, install a new EGR valve.

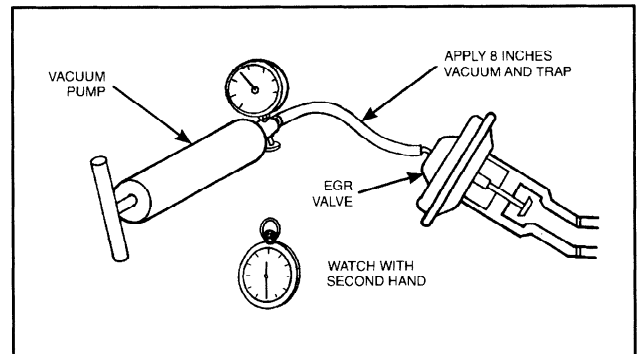


Diaphragm Leak Test

The diaphragm leak test can be performed with the engine off.

1. Attach a hand vacuum pump to the vacuum nipple of the EGR valve.
2. Apply eight inches of vacuum and trap (hold) it.

The diaphragm must hold 7-8 inches of vacuum for at least 30 seconds. If it holds vacuum, the diaphragm is okay. Proceed to the Source Vacuum test. If the diaphragm won't hold vacuum, replace the EGR valve.



DIAGNOSIS AND TESTING (Continued)

EGR Valve Leakage Check

Perform this test if the engine stalls, idles roughly, or runs poorly.

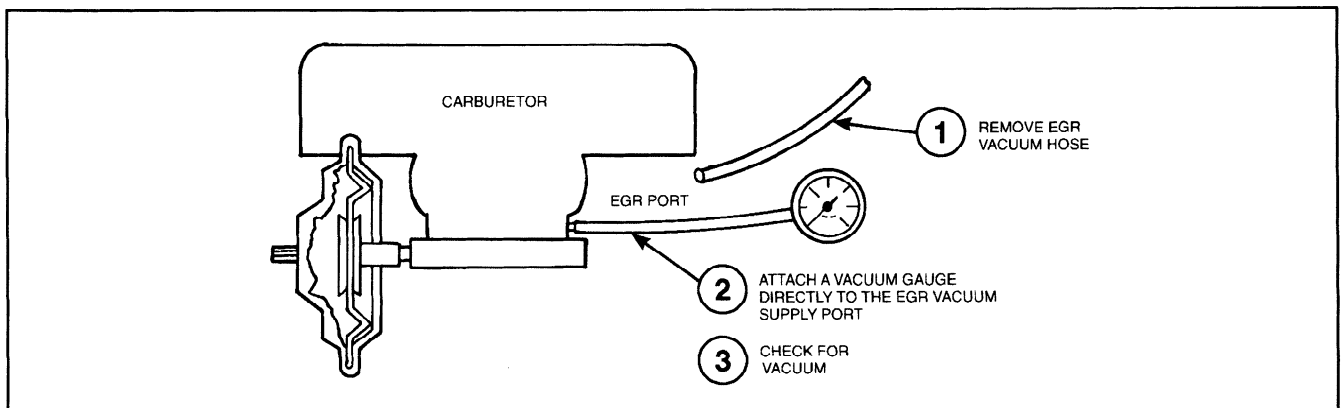
1. Remove and cap the EGR valve vacuum hose. Start the engine. If the engine idle quality improves noticeably, double-check the vacuum hose routing because the valve may have a vacuum supply at idle.
2. If the engine idle quality does not improve, remove the EGR valve from the spacer. Block the EGR passages with a plate or install a known good EGR valve. Start the engine. If the idle quality is still bad, the problem is elsewhere. Reinstall the EGR valve. If the idle quality improves noticeably, the EGR valve has excessive leakage and should be replaced.

Testing for EGR Source Vacuum

Occasionally the EGR system may fail to operate because the vacuum port on the carburetor is plugged, or because of a vacuum leak. To test for source vacuum:

1. Remove the EGR supply vacuum hose from its connection at the carburetor.
2. Attach a vacuum gauge to the source.
3. Start the engine and watch the gauge as you momentarily accelerate to half throttle 3000 rpm maximum). The vacuum should rise at off-idle, decrease at half throttle, and go to zero at closed throttle.

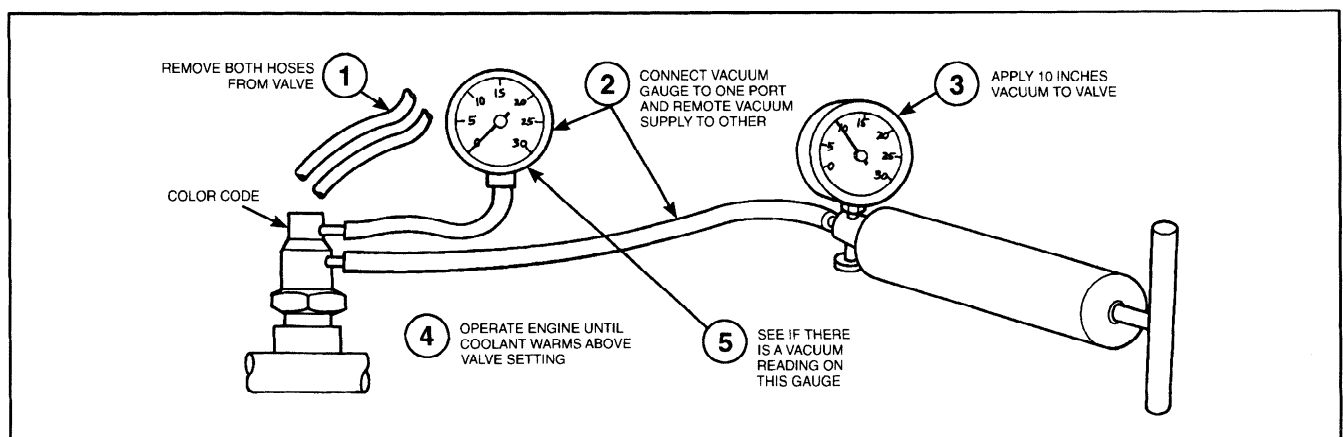
If the source vacuum is okay, test the PVS and inspect the hoses. If the source vacuum is not okay, check for an obstruction in the carburetor or for a vacuum leak caused by loose mounting.



Testing the 2-Port PVS Valve

The 2-port PVS valve is okay if it blocks vacuum from the EGR valve when the engine is cold and allows a vacuum to get to the valve when the engine is hot.

WARNING: LET THE ENGINE COOL AND RELEASE COOLING SYSTEM PRESSURE BEFORE REMOVING THE VALVE, OR YOU COULD BE BURNED. IT ALSO MAY BE NECESSARY TO DRAIN OUT SOME OF THE COOLANT.



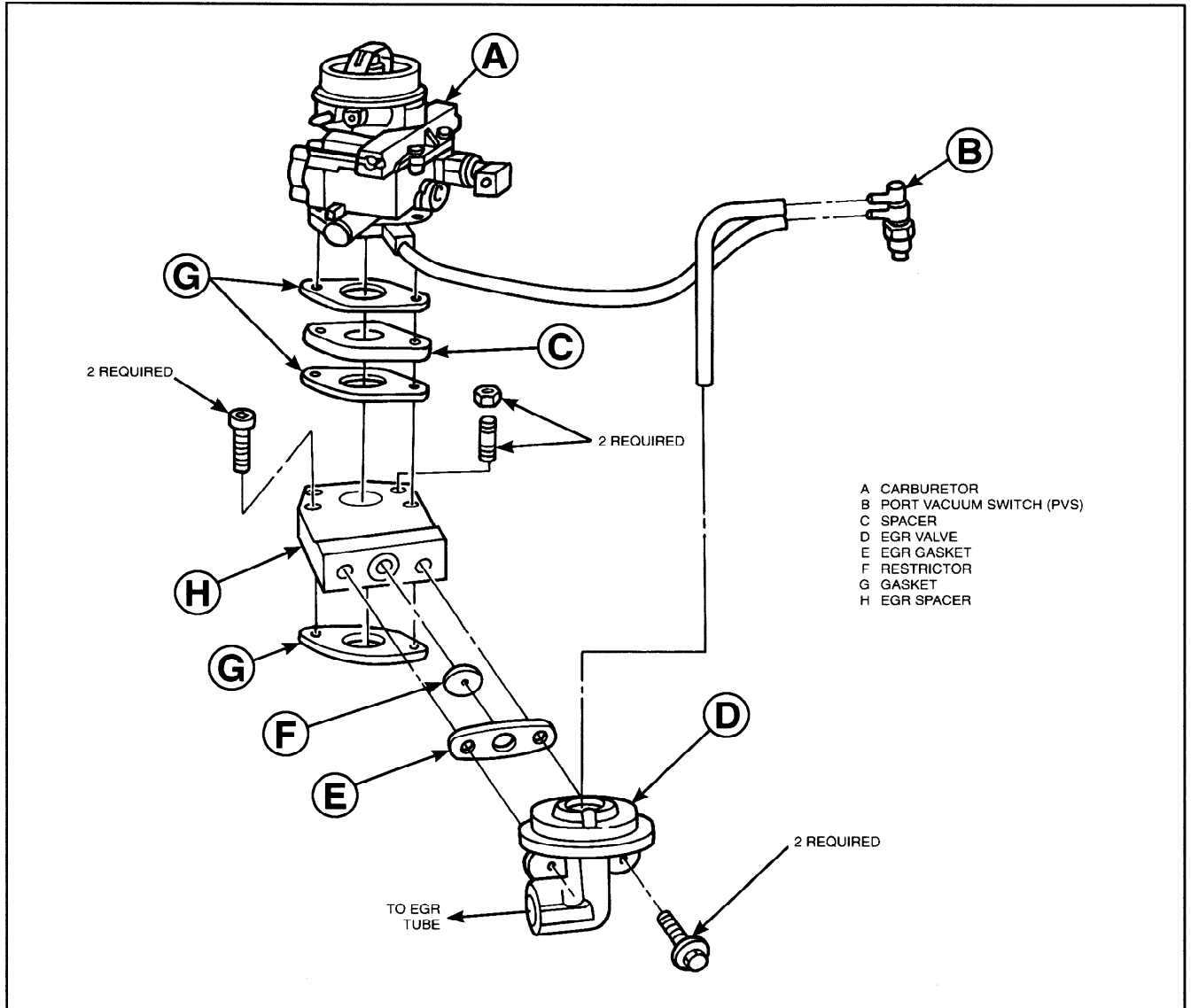
1. Remove both hoses from the PVS valve.
2. Connect a vacuum gauge to one port of the PVS valve and connect a vacuum pump to the other port.
3. Apply 10 inches of vacuum to the PVS valve.
4. Run the engine until the coolant is warmer than the PVS valve setting. PVS valves are color coded. This engine has a black PVS valve that opens at 38°C (100°F).
5. See if there is a vacuum reading on the gauge that is connected directly to the PVS valve.

There should be a vacuum reading on the gauge. If there is no vacuum, replace the PVS valve.

REMOVAL AND INSTALLATION

Removal

1. Remove the vacuum hose that goes to the PVS valve.
2. Remove the EGR hose.
3. Remove the two EGR valve mounting bolts.
4. Remove the EGR valve gasket.
5. Remove the EGR restrictor.



Installation

1. Seat the EGR restrictor into the spacer block. A small amount of grease may be applied to the EGR restrictor prior to installation. This will ensure that the EGR restrictor does not become dislodged during the installation of the EGR valve gasket and the EGR valve. Do not allow grease to block the hole in the EGR restrictor.
2. Install the EGR valve gasket.
3. Install the EGR valve.
4. Install the two EGR valve mounting bolts. Tighten to 16-20 N•m (12-15 ft. lbs.).
5. Install the EGR hose. Tighten to 34-47 N•m (25-35 ft. lbs.).
6. Attach the vacuum hose that comes from the PVS valve.

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SECTION 04 — Charging System

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DESCRIPTION AND OPERATION

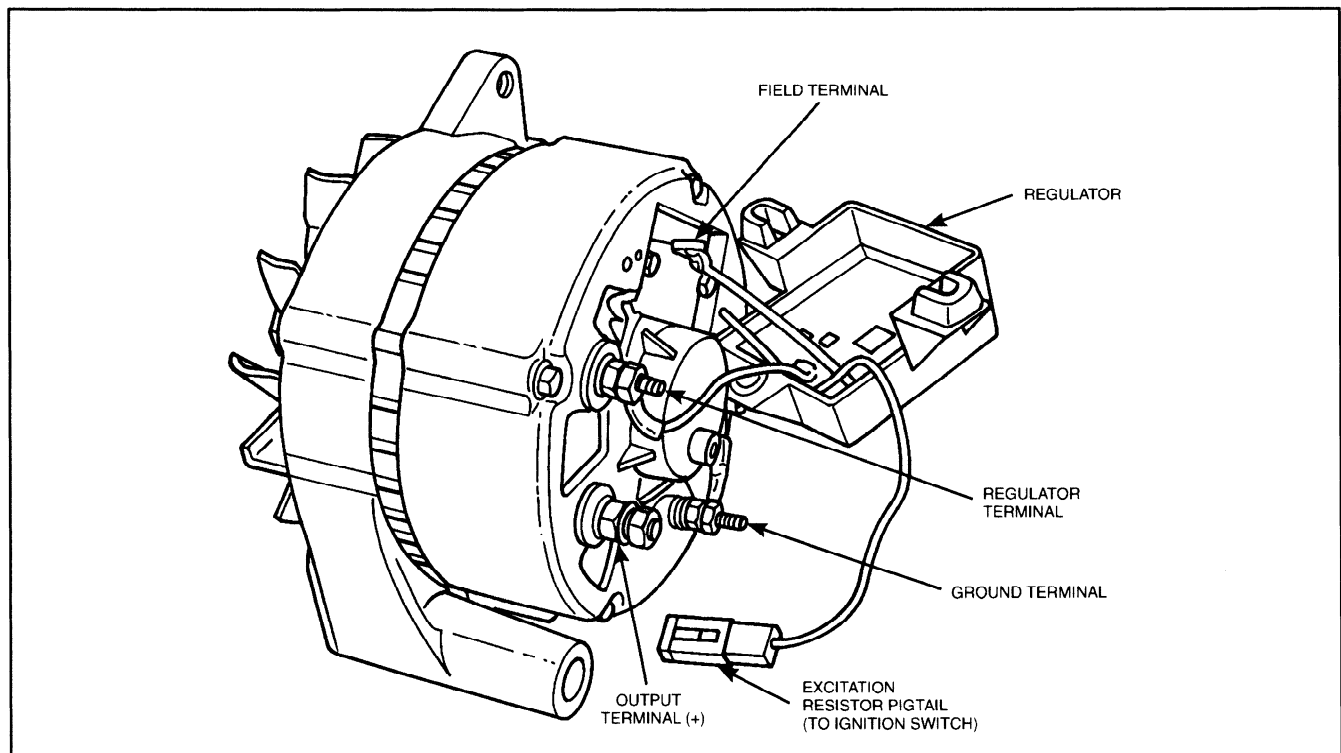
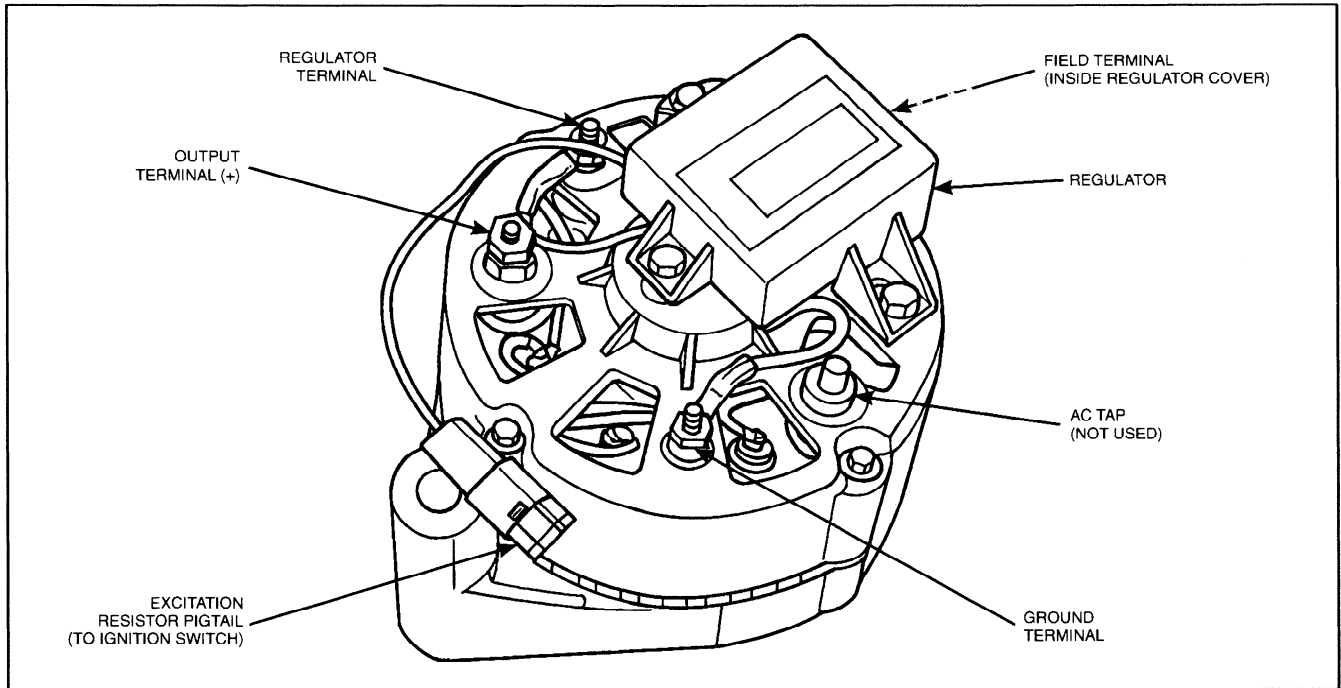
Generator

The generator charging system is a negative ground system, and consists of an generator, a regulator, a charge indicator, a storage battery, and associated wiring.

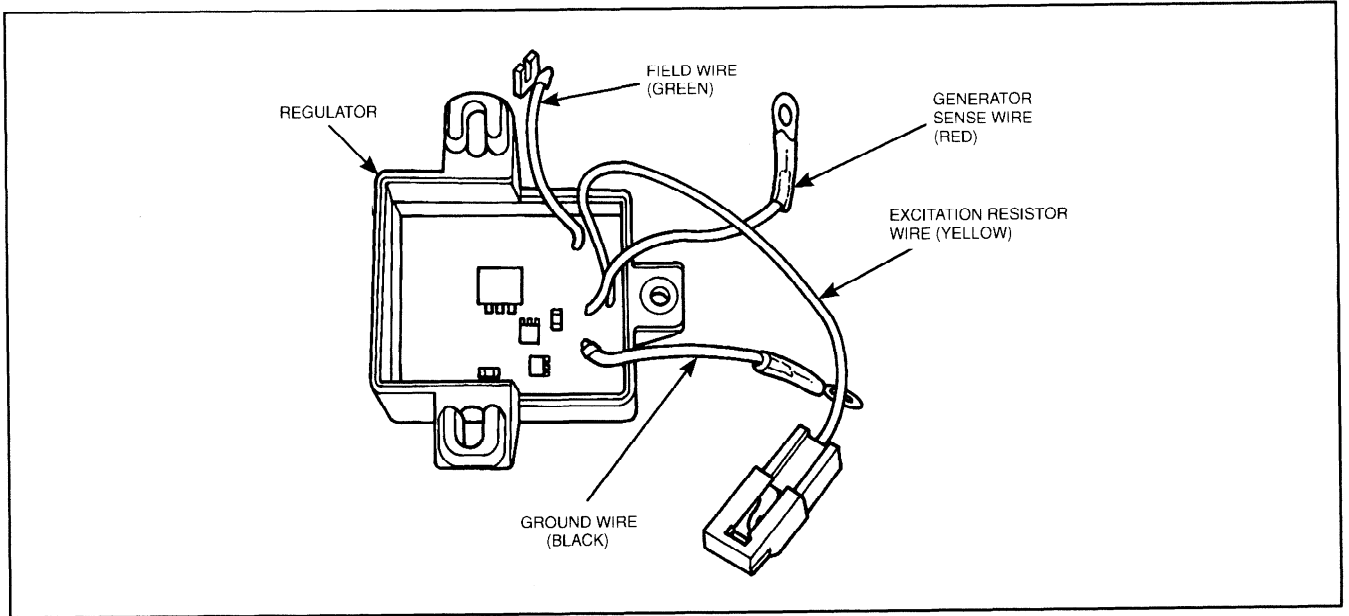
The present VSG range uses a Prestolite 37-amp or 51-amp generator. These units have a self-contained regulator mounted directly to the generator case. The generator is belt driven from the engine. Current is supplied

from the generator-regulator system to the rotating field of the generator through two brushes to two slip rings.

The generator produces power in the form of alternating current. The alternating current is rectified to direct current by six diodes. The generator regulator automatically adjusts the generator field current to maintain the generator output voltage within prescribed limits to correctly charge the battery.



DESCRIPTION AND OPERATION (Continued)



DIAGNOSIS AND TESTING

Preliminary Information

Before performing charging system tests on the engine, note the complaint such as: slow cranking, battery dead or using an excessive amount of water, top of battery wet, ammeter shows charge at all times and/or no charge, generator warning lamp does not come on and/or never goes out, voltmeter shows above or below open circuit nominal voltage. This information will aid in isolating the part of the system causing the symptom.

Next, visually inspect as follows:

1. Check battery posts and battery cable terminals for clean and tight connections. Remove the battery cables (if corroded), clean and install them securely.
2. Check for clean and tight wiring connections at the generator, regulator and engine. Inspect for evidence of arcing.
3. Check the generator belt tension using belt tension gauge T63L-8620-A, Model 210019 or equivalent and tighten to specification (if necessary).

Isolating the Problem

Battery, starting system, and light systems problems can be caused by poor charging system performance. It is also possible to suspect the charging system because of an overload in another area of the electrical system.

To avoid guesswork, it is necessary to isolate the battery, the charging system, and the electrical circuits to correctly identify the area where the difficulty lies. The best method to do this is to check the battery first before any electrical system diagnosis. The battery must be in proper state of charge. The battery must be operating properly before the other areas of the electrical system can perform normally.

Battery Testing

WARNING: KEEP BATTERIES OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES, OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY. HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

WARNING: BATTERIES ARE HEAVY, WEIGHING 30 LBS. OR MORE. LIFT THEM WITH YOUR LEGS RATHER THAN YOUR BACK TO PREVENT MUSCLE STRAINS, AND BE CAREFUL NOT TO DROP THEM (POSSIBLE BREAKAGE) OR TO SPILL THE CONTENTS (SULFURIC ACID).

CAUTION: 12-volt starting motors can be damaged beyond repair if connected to a 24-volt power supply (two 12-volt batteries in series, or a 24-volt motor-generator set), even when cranking loads are relatively light. Extensive starting motor damage is more likely if the starter is connected to a 24-volt supply while being subjected to prolonged heavy cranking loads such as attempting to start an engine in subzero temperature.

Tests are made on a battery to determine the state of charge and also its capacity or ability to crank an engine. The ultimate result of these tests is to show that the battery is good, needs recharging, or must be replaced.

Before attempting to test a battery, it is important to give it a thorough examination to determine if it has been damaged. Remove battery cable clamps, negative (-) terminal first. Check for dirty or corroded connections and loose battery posts. Remove hold downs and heat shields and inspect for a broken or cracked case or cover. If the battery is worn or damaged, if there is a loose or broken post, or if there is a cracked case or cover, replace the battery.

The battery capacity test should be run next to remove any surface charge prior to determining the state of charge of a maintenance free battery.

Capacity Test

A high rate discharge tester (Rotunda Battery-Starter Tester 02-0204) or equivalent in conjunction with a voltmeter is used for this test.

1. Turn the control knob on the Battery-Starter Tester to the "OFF" position.
2. Turn the voltmeter selector switch to the 20-volt position and test selector switch to "AMP".
3. Connect both positive test leads to the positive (+) battery post and both negative leads to the negative (-) battery post. The voltmeter clips must contact the battery posts and not the high-rate discharge tester clips. Unless this is done, the actual battery terminal voltage will not be indicated.
4. Turn the load control knob in a clockwise direction until the ammeter reaches the applicable discharge rate specified in the discharge rate table.
5. With the ammeter reading the required load for 15 seconds, note the voltmeter reading. Avoid leaving the high discharge load on the battery for periods longer than 15 seconds.

If the voltmeter reading is above the minimum specified in the table with the test equipment for that temperature, the battery has a good output capacity and will readily accept a charge, if required. Check the state of charge.

If the voltage reading obtained during the capacity test is below the minimum specified in the table, check the state of charge.

DIAGNOSIS AND TESTING (Continued)

BATTERY DISCHARGE RATES

Ampere Hours	Discharge Rate Amperes
45	190
53	200
63	260
68	235
71	235
85	240
90	310

TEMPERATURE CORRECTION CHART — ALL BATTERIES

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

System Connections

Check that all charging system connections, cables, and wires are sound, clean, and tight. This includes:

- Battery cables
- Battery connections
- Starter solenoid connections
- Starter ground
- Regulator terminal connections
- Generator wiring harness

Generator Connections

1. Check all the harness connections to the generator. Make sure they are clean and tight.
2. Inspect the soldered connections to the output diode and the ground diode. These connections are visible through the ventilation holes in the rear housing of the generator.

Electrical Testing Precautions

Observe the following precautions to avoid permanent damage to the regulator or to the generator diodes:

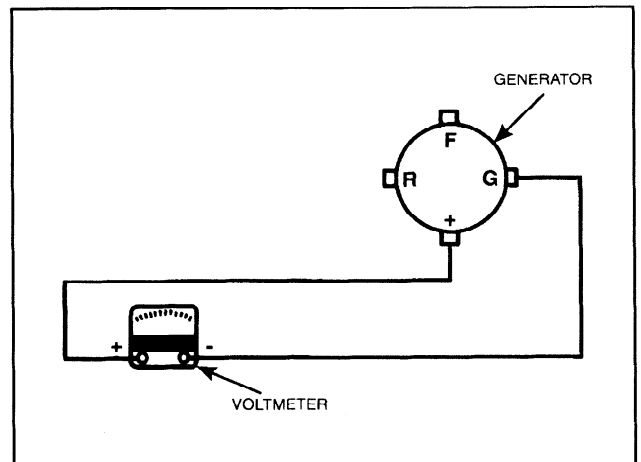
1. Do not disconnect the generator output lead, the ground lead, or the battery cable while the engine is running.
2. Do not disconnect the generator field terminal or the regulator connection while the engine is running.

3. Do not short the generator field terminal or field lead to ground.
4. Disconnect the battery ground terminal before removing the generator or the generator brush holder assembly.
5. Never reverse polarity when charging or replacing the battery.

Output Voltage Test

Perform this test if the trouble symptom is a warning light indication while running, or a no-voltage indication on the voltmeter. This test will check the generator output to verify that the problem is in the charging system and not in the instrument circuit. If the regulator is hot, do not perform this test until the regulator has cooled down. The regulator will respond to, and regulate at, a lower voltage as the temperature rises. This offsets the tendency toward battery overcharging in warm weather. This built-in temperature compensation reduces generator output by about one volt per 55°C (100°F) temperature rise.

1. Key OFF.
2. Check the voltage at the generator output terminal. It should be battery voltage.
3. Start the engine.
4. With the engine running at 1000 to 1200 rpm, check the voltage at the generator output terminal. The voltage should rise to 13.6 to 14.4 volts as soon as the starting discharge has been restored.



5. After the voltage stabilizes, turn on any accessories one by one while observing the output voltage. If it stays above battery voltage under load, but the warning light is on, or if the voltmeter indicates no voltage, the cause may be a blown fuse feeding the instrument circuit.

DIAGNOSIS AND TESTING (Continued)

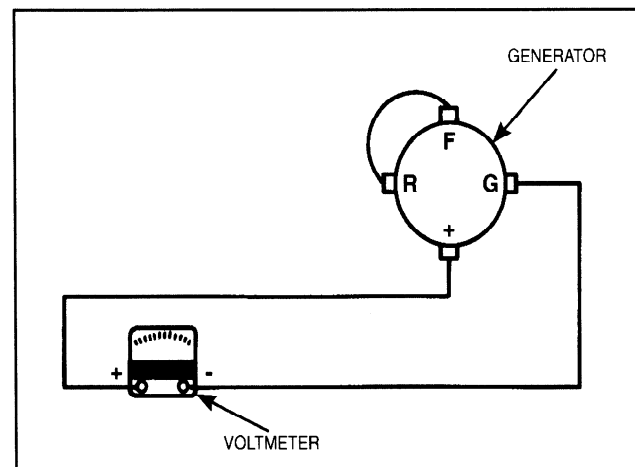
Regulator Bypass Test

Perform this test if the Output Voltage Test indicates less than 13.6 volts at light load.

1. Key OFF.
2. Disconnect the field lead from the "F" terminal.
3. Connect a jumper from the "F" terminal to the "R" terminal.
4. Start the engine.

CAUTION: Be sure to keep the rpm low, as an unregulated generator can produce voltage high enough to cause damage.

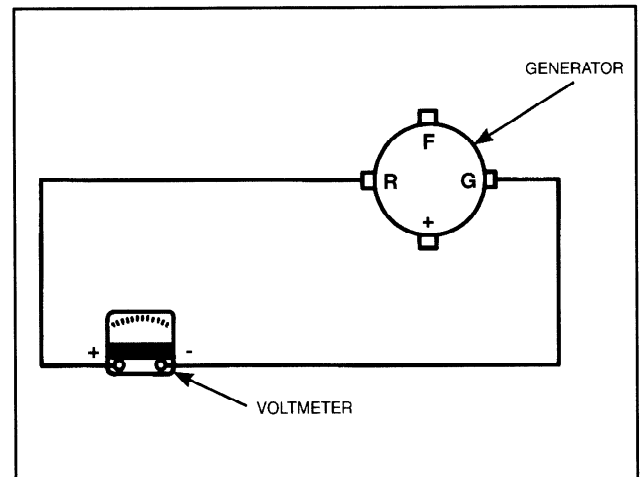
5. With the engine running at idle, check the output voltage.



- If the output voltage is still low, the problem is in the generator.
- If the output voltage rises above 13.6 volts with the regulator bypassed, check the regulator circuit for low output (although the problem may still be partly or entirely in the generator). Possible generator problems include:
 - Defective output or field diodes.
 - Excess resistance in the field circuit, which includes the regulator.
 - Excess resistance in the charging circuit external to the generator.

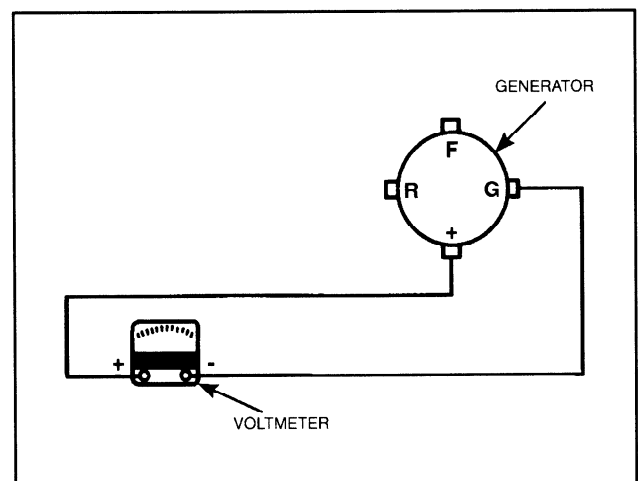
Key-Off Check

1. Key OFF.
2. Remove the jumper between the "R" and "F" terminals, if present.
3. Connect the field lead to the "F" terminal, if it is not already corrected.
4. Check the voltage at the "R" terminal. If any voltage is present, it indicates a shorted output diode or diodes. This causes undercharging and also allows the battery to discharge through the regulator and field with the engine stopped.



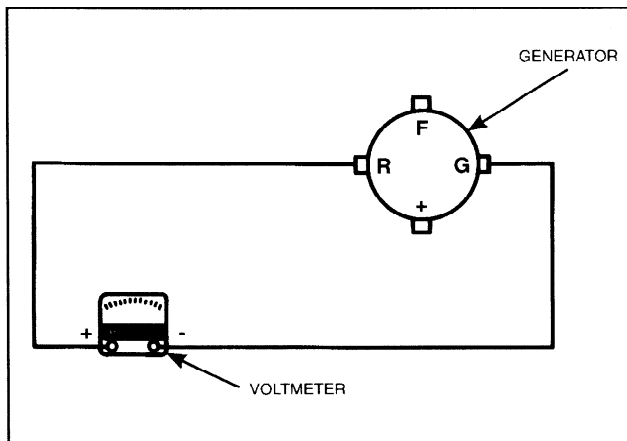
Regulator Sense Voltage

1. Start the engine.
2. With the engine running at 1000 to 1200 rpm, check the voltage from the "O" terminal to ground.



DIAGNOSIS AND TESTING (Continued)

- With the engine running at 1000 to 1200 rpm, check the voltage from the "R" terminal to ground.



Even if the output voltage is low, the "R" terminal voltage should be within 0.5 volt of the "O" terminal voltage. If the "R" terminal voltage is higher than the output voltage, it indicates an open diode or diodes, and the higher "R" voltage would signal the regulator to reduce output before normal charging voltage could be built up. This causes an undercharging condition.

If the voltage at the "R" terminal is more than 0.5 volt lower than the output voltage, one or more of the field diodes is defective. In this condition, the regulator would normally increase the generator output to bring the sense voltage up to the regulating value, and an overcharging condition would result.

- Continue with External Circuit Tests.

External Circuit Tests

This test checks the circuit between the generator and the battery by measuring the voltage from each battery terminal to ground.

- With the engine running at 1000 to 1200 rpm, measure the voltage from the positive (+) battery terminal to ground. Voltage at the positive (+) terminal should be the same as the generator output voltage. If it is lower by more than 0.2 volt, excess resistance is present in the generator output lead or in the battery positive cable or connections. Check for wire or cable damage, or for loose or dirty connections.
- Measure the voltage from the battery negative (-) terminal to ground. It should be zero. If it is more than

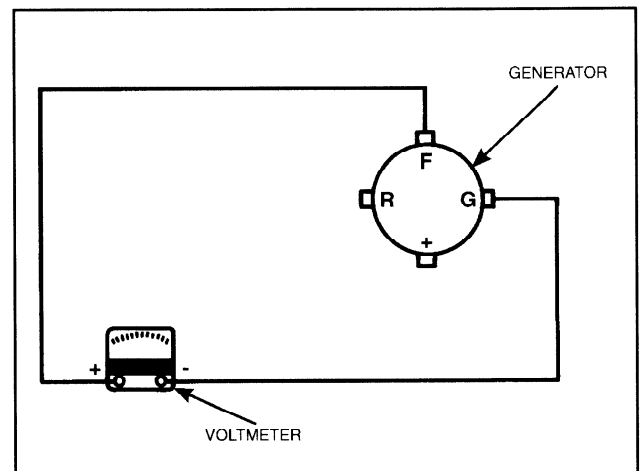
0.2 volt, check the ground circuit. The following connections must be clean and tight:

- Generator mounting bolts
- Generator and engine mounting surfaces
- Ground cable connections to the engine and battery

Field Voltage Test

This test checks for initial excitation voltage at the "F" terminal. Perform this test if the output voltage did not rise above battery voltage in the output voltage test, but did rise with the regulator bypassed.

- Make sure the field lead is connected.
- Key ON.
- Measure the field voltage by carefully probing the "F" terminal.



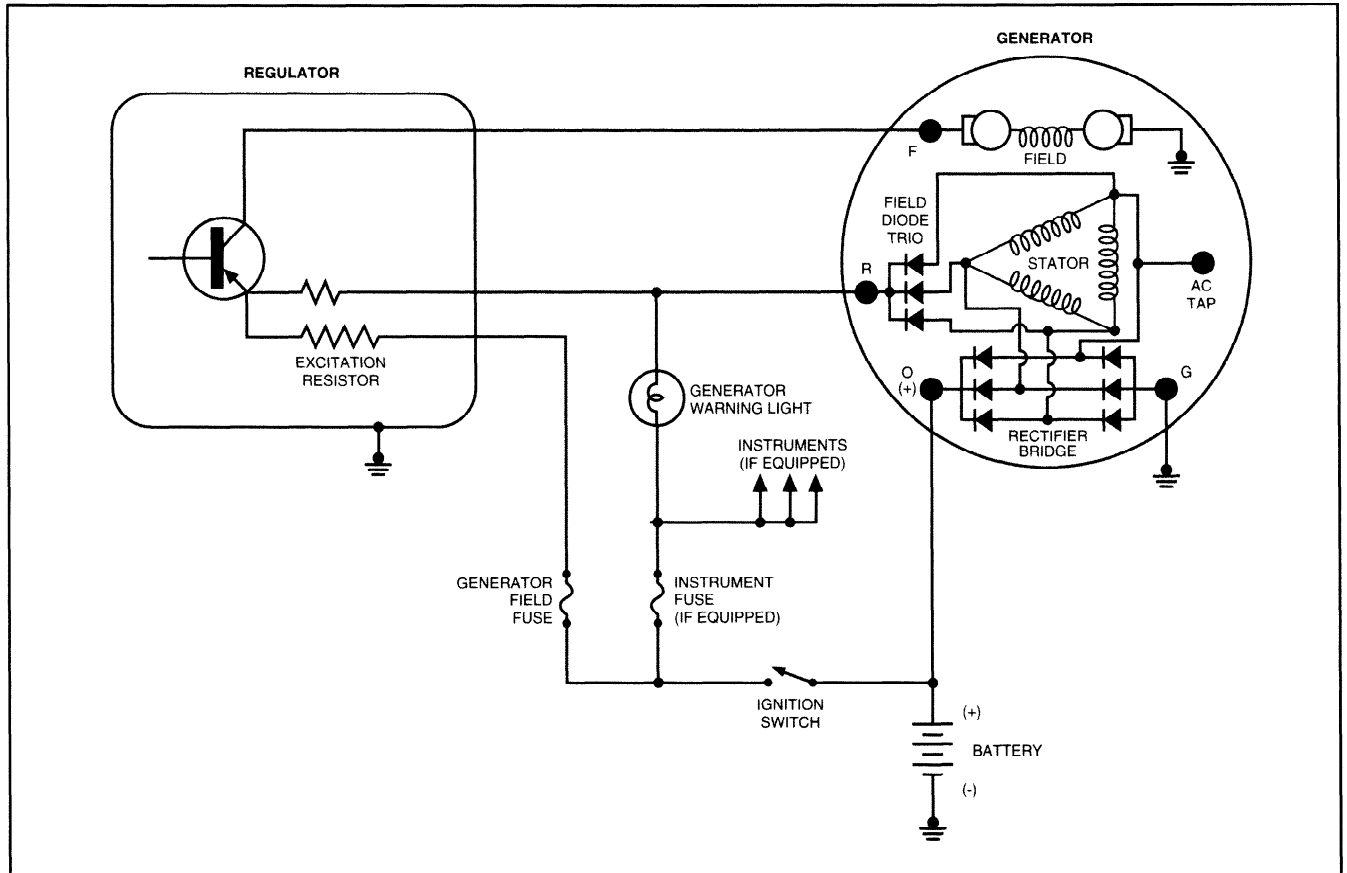
CAUTION: To avoid grounding the field and causing component damage, use a taped probe or connect the field lead through a jumper to provide meter probe access to the terminal.

A reading of 1.5 to 3.0 volts is normal. A zero-volt reading indicates an open in the initial excitation circuit, either in the regulator or in the circuit between the battery and the regulator.

If battery voltage appears at the "F" terminal, an open is present in the field circuit, either in the coil or in the brushes. The meaning of voltage readings between these extremes depends on the specific equipment being tested.

DIAGNOSIS AND TESTING (Continued)

Initial Excitation Circuits



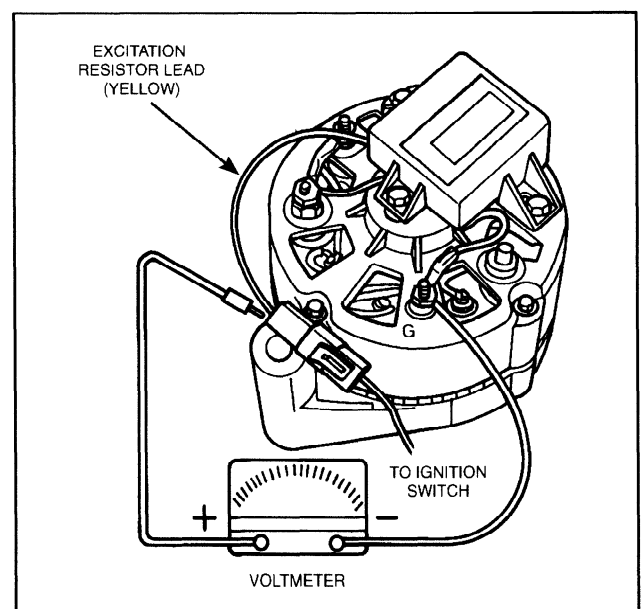
Initial excitation voltage reaches the field terminal through an excitation lead from the ignition switch to the regulator, and an excitation resistor inside the regulator. If the circuit is equipped with a voltmeter, this is the only path. If the circuit is equipped with a generator warning light, the warning light provides an alternate path in parallel with the excitation resistor. This excitation function of the warning light is an incidental result of its being positioned in the circuit so as to compare battery and output voltages, but it is important because it can mask an open in the excitation circuit.

Normally, initial excitation current is drawn through both paths, but either one will pass sufficient current if the other is open. If the excitation resistor is open, or higher in value than it should be, there will still be excitation current to magnetize the field at startup, but the voltage at the field terminal will be lower because of the larger voltage drop through the increased resistance. Likewise, if the warning light bulb is burned out, the excitation resistor will provide field current, but also at reduced voltage. A burned-out bulb is easily detected if it fails to light when the key is turned ON, and the other warning lights and gauges respond normally.

Regulator Input Test

This test measures excitation supply voltage to the regulator. Perform this test if the field terminal voltage is less than 1.5 volts.

1. Key ON.
2. Carefully probe the yellow wire terminal in the pigtail connector for the regulator excitation lead. Battery voltage should be present.



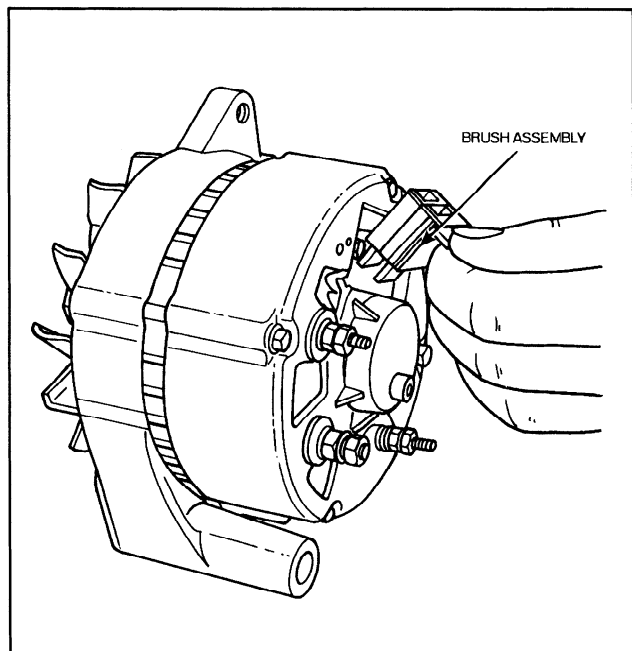
DIAGNOSIS AND TESTING (Continued)

3. If battery voltage is not present, check the circuit from the ignition switch, through the alternator field fuse (if so equipped) to the pigtail connector for the regulator excitation lead. If battery voltage is present at the yellow regulator lead, but the regulator output is low, replace the regulator.

Generator Brush Check

If the field terminal voltage is more than 3.0 volts, undercharging may be caused by high resistance in the generator field circuit, even though generator output was increased in the regulator bypass test. Even if field circuit resistance is normal, it may be a combination of low field coil resistance (due to a partially shorted coil) and high brush resistance.

1. Disconnect the battery ground cable at the battery.
2. Remove the regulator housing.
3. Remove the field wire from the field terminal.
4. Remove the generator brush holder assembly.

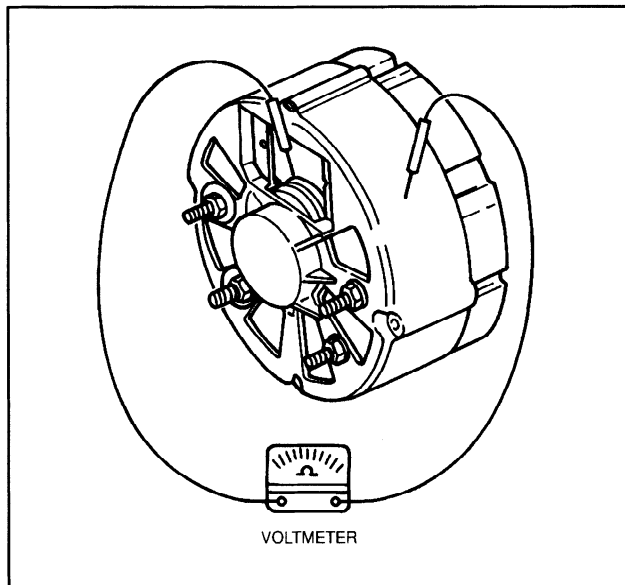


5. Inspect the brushes for abnormal wear, damage, dirty contact surfaces, or sticky movement.
6. Clean and free up the brushes or replace the assembly.
7. While the brush holder is out, release belt tension to allow free rotation of the rotor and clean the slip rings with crocus cloth or fine abrasive.

Field Ground and Open Tests

This test uses an ohmmeter to check for opens or shorts to ground in the field.

1. Touch the meter probes to either of the slip rings and to ground. If the meter shows continuity or low resistance, there is a grounded condition. In that case, replace the rotor.

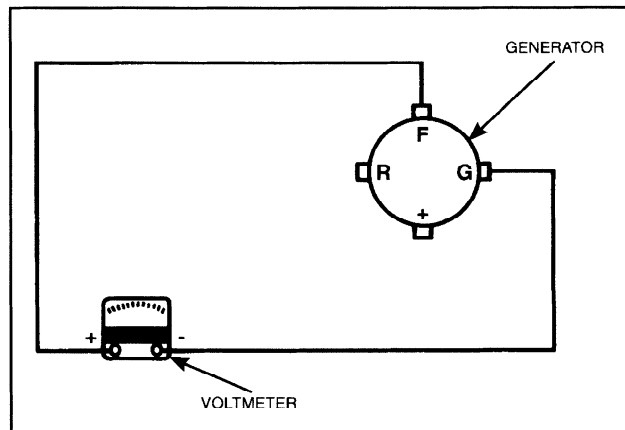


2. Measure the resistance from one slip ring to the other. Field coil resistance should be 4 to 5 ohms. If the ohmmeter indicates a high resistance between the slip rings, the field is partially open. In that case, replace the rotor.

Field Voltage Test

With the slip rings clean, and known good brushes installed, repeat the field excitation voltage test at the "F" terminal.

1. Key ON.
2. Release belt tension to allow the rotor to spin freely.
3. While spinning the rotor by hand to assure good brush contact, probe the "F" terminal and observe the voltage. If it still does not fall within the 1.5 to 3.0 volt range, the field coil resistance is incorrect. In that case, replace the rotor.



DIAGNOSIS AND TESTING (Continued)

If the foregoing test sequence does not identify the cause of undercharging, it may be due to low regulator output when the system is operating under load.

4. Engine ON.
5. While running the engine at 1600 rpm, measure the "F" terminal voltage. Field voltage should be 10.5 to 11.5 volts initially, and quickly taper off to 7.5 to 8.5 volts as the starting discharge is re-charged. If the voltage is low or fluctuating, the regulator is defective. In that case, replace the regulator.

Overcharging

If the output voltage test indicates an overcharging condition (greater than 14.4 volts), it usually indicates a defective regulator, but not always. If the regulator sense voltage at the "R" terminal is lower than the output voltage

by more than 0.5 volt due to a defective diode trio, a good regulator will increase field current and generator output in an effort to bring the sense voltage up to regulating value. Whether and to what extent the system will overcharge will depend on the nature and degree of the field diode failure, as field current must pass through the field diodes.

Generator Disassembly

If the foregoing series of on-equipment tests has not identified the cause of charging system malfunctions, remove and disassemble the generator for further tests. See "Overhaul" in this section. If specialized test equipment is available for checking diodes and stator windings under operating-load conditions, follow the equipment manufacturer's instructions. If this equipment is not available, refer the job to the nearest Authorized Service Station.

ADJUSTMENTS

Belt Adjustments

1. Check the belt tension with Tool T63L-8620-A. The belt should be within specifications (Specifications Section).
2. If the belt is not within specification, loosen the generator mounting bolt to a snug position and loosen the adjusting arm bolts.
3. **Apply pressure on the generator front housing only** and tighten the adjusting arm to generator bolt.
4. Check the belt tension using Tool T63L-8620-A. Adjust the belt for specified tension.
5. Tighten all mounting bolts.

REMOVAL AND INSTALLATION

Removal

1. Disconnect the battery ground cable.
2. Loosen the generator mounting bolts and remove the adjustment arm-to-generator attaching bolt.
3. Remove the electrical connector from the generator.
4. Disengage the generator belt. Remove the generator mounting bolt, and remove the generator.

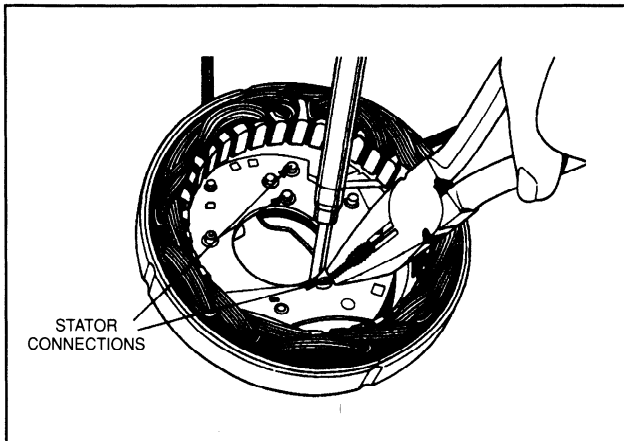
Installation

1. Install the generator wiring connector. Position the generator to the engine, and install the spacer (if used) and the generator mounting bolt. Tighten the bolt only finger tight.
2. Install the adjustment arm-to-generator attaching bolt.
3. Position the belt on the pulley and adjust the belt tension using Tool T63L-8620-A. Apply pressure on the generator front housing only, when tightening the belt. Tighten the adjusting arm bolt and the mounting bolt.
4. Connect the battery ground cable.

OVERHAUL

Disassembly

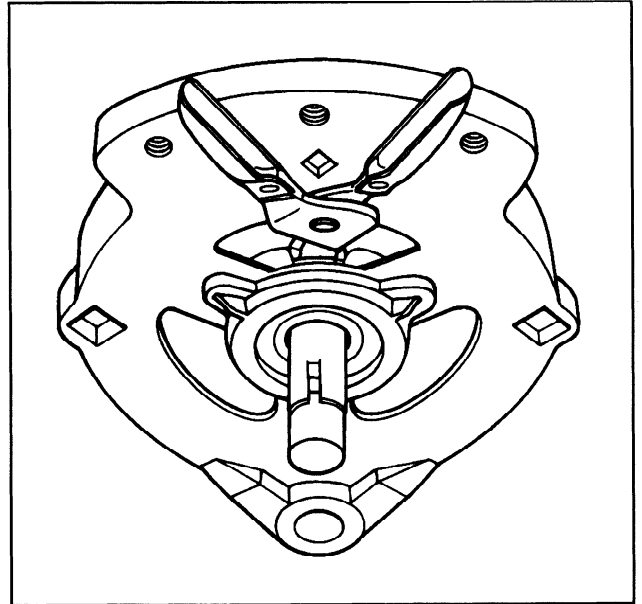
1. Mark both end housings and the stator with a scribe mark for assembly.
2. Remove retaining nut, lockwasher, spacer pulley, spacer, dish washer, fan and fan spacer.
NOTE: Observe position and direction of spacer and dished washer between pulley and fan.
3. Remove regulator and brush holder.
4. Remove four through bolts.
5. Separate the front housing and rotor from the stator and rear housing.
6. Press rotor out of front housing.
7. Remove front bearing retainer and bearing.
8. Support rear bearing with a large washer, incorporating a cut out to accommodate the rotor shaft, and press bearing from shaft.
9. Remove rectifier (diode) assembly retaining screws and lift out stator and rectifier assembly.
10. Unsolder stator to rectifier connections using a pair of pliers as a heat sink to reduce heat spread to diodes.



Releasing Front Bearing Retainer

To remove the front bearing, which is pressed on the rotor shaft, it must first be removed from the front housing. It is retained in the housing by a snap ring which is accessible from the front when the pulley and fan are removed.

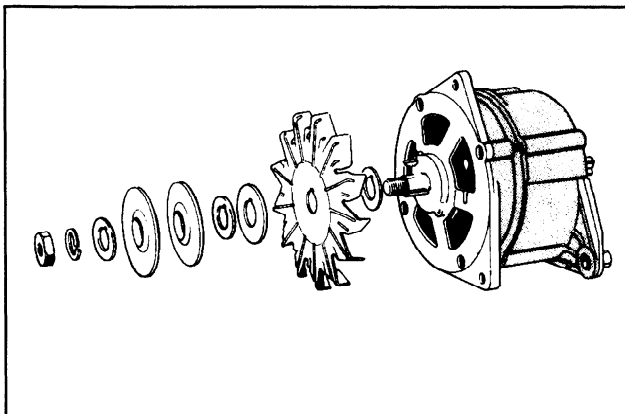
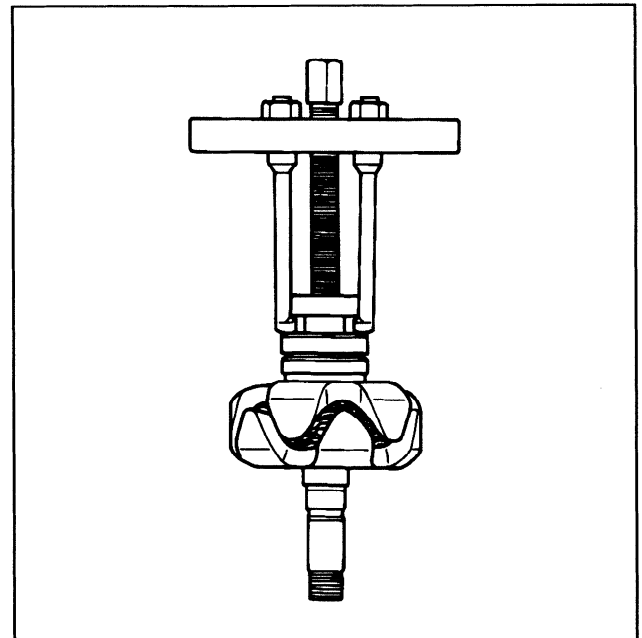
1. With a pair of snap ring pliers, squeeze the ears of the snap ring together.
2. Rock the snap ring out of its groove.



3. Press or tap the rotor shaft and bearing out of the front housing.

Front or Rear Bearing Removal

Remove the bearing from the shaft with a suitable puller and adapter.

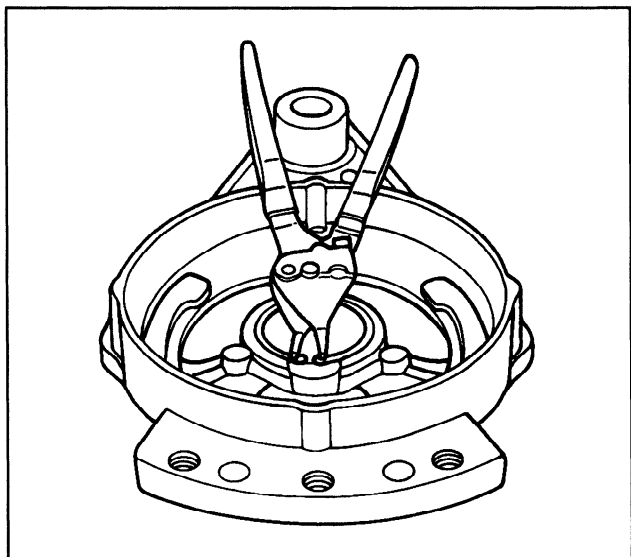


OVERHAUL (Continued)

Front Bearing Installation

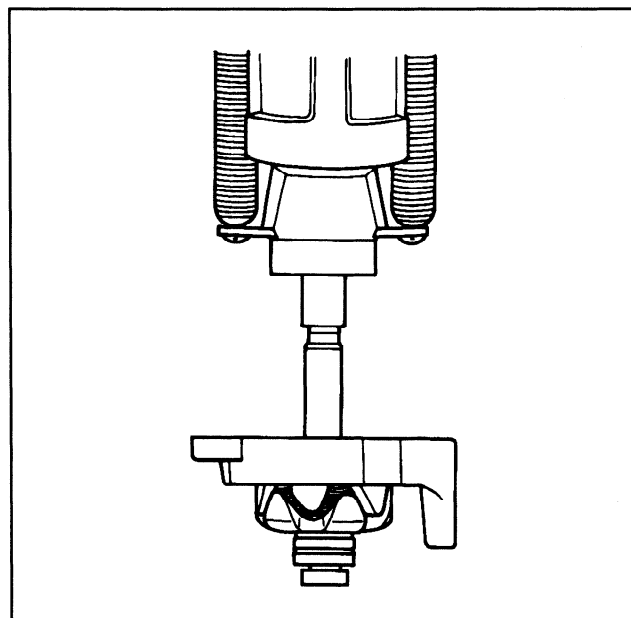
Bearing installation is not the reverse of the removal procedure, because the snap ring which retains the front bearing cannot be installed with the bearing in place on the rotor shaft.

1. Seat the bearing in the front housing.
2. Install the snap ring.

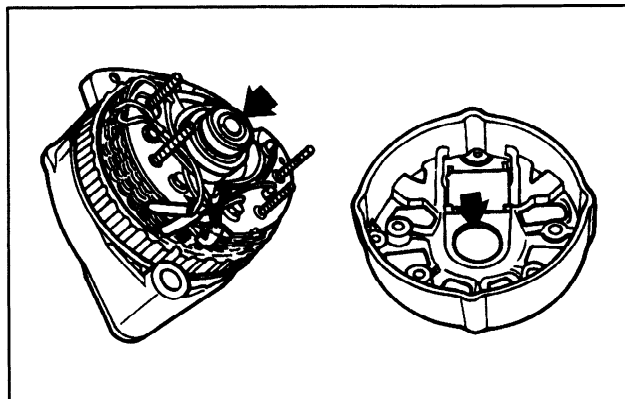


Pressing Front Bearing Onto Shaft

1. Using a suitable sleeve, such as a 17mm (11/16 inch) deep socket, press the bearing (with front housing) onto the rotor shaft. **Apply force to the inner race only.**
2. Press the bearing on until the inner race touches the shoulder on the shaft.



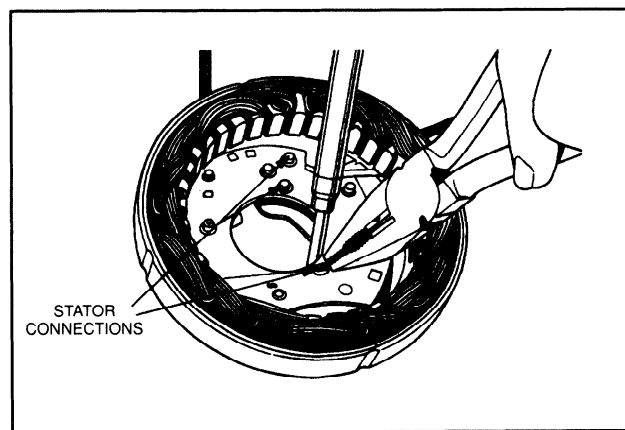
Rear Bearing Recess



The rear bearing is not locked into its recess in the rear housing. The outer race is prevented from turning by a snug fit in the recess, plus the added friction of a rubber seal ring in a groove in the recess. **Replace the seal ring whenever the generator is disassembled.**

Assembly

1. Resolder stator to rectifier. Use a pair of pliers as a heat sink to reduce heat spread to diodes.



2. Position stator and rectifier assembly in rear housing and install retaining screws.
3. Press rear bearing onto rotor shaft.
4. Install front bearing into front housing. Position retainer plate and install retaining screws.
5. Install rotor to front housing.
6. Position the rear housing and stator assembly over the rotor and align the scribe marks made during disassembly. Seat the machined portion of the stator core into the step in both end housings. Install the housing through bolts.
7. Install the fan spacer, fan, dished washer, spacer, pulley spacer, lockwasher and nut. Tighten nut.

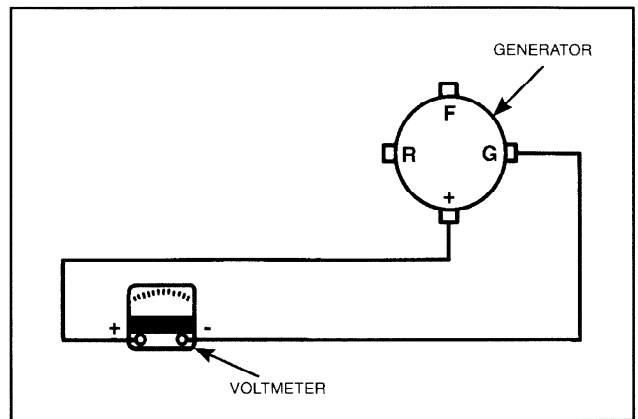
OVERHAUL (Continued)

NOTE: Dished washer must be fitted correctly, with the outer circumference pressing against the fan. In this way, it acts as a vibration damper and prevents fatigue failures.

Output Voltage Test

If possible, check the generator on a bench tester before re-installing. After bench-testing, or if bench-testing is not available, re-install the generator to the engine:

1. Install and connect the generator.
2. Apply proper tension to the drive belt.
3. Make sure the battery cable connections are tight.
4. Key ON.
5. With the engine running at 1000 to 1200 rpm, measure the voltage from the output terminal to ground.



6. Gradually increase the electrical load while observing the voltage reading. If voltage stays between 13.6 and 14.4 volts under all but extreme load conditions, the charging system is working properly.

SECTION TITLE	PAGE	SECTION TITLE	PAGE
BASIC ENGINE	01-1	STARTING SYSTEM	05-1
IGNITION SYSTEM – DISTRIBUTORLESS	02-1	GOVERNOR	06-1
FUEL SYSTEM	03-1	COOLING SYSTEM	07-1
EMISSION CONTROL SYSTEM	03A-1	SPECIFICATIONS	08-1
CHARGING SYSTEM	04-1		

SECTION 05 — Starting System

SUBJECT	PAGE	SUBJECT	PAGE
DESCRIPTION AND OPERATION	05-3	REMOVAL AND INSTALLATION	05-7
TESTING	05-4	OVERHAUL	05-8
Road Service	05-4	Disassembly	05-8
On-Engine Testing	05-4	Cleaning and Inspection	05-8
Starter Cranking Circuit Test	05-4	Assembly	05-10
Starter Load Test	05-5	Permanent-Magnet Starter	05-11
Starter Solenoid Test	05-5	Overhaul	05-11
Bench Tests	05-5	Disassembly	05-11
Starter No-Load Test	05-5	Assembly	05-12
Armature Open Circuit Test	05-6		
Armature and Field Grounded Circuit Test	05-6		

BLANK

DESCRIPTION AND OPERATION

There are two starters available in the VSG range. Most engines are equipped with the Bosch electromagnetic field starter which is detailed in this section. Some engines are equipped with the United Technologies permanent magnet starter. This starter features an inertially-actuated pinion gear which is described later in this section.

The electromagnetic field starter is a four pole, four brush motor with a series field and a solenoid-operated roller clutch drive.

The solenoid assembly is mounted to a flange on the starter drive housing. The entire shift lever mechanism and the solenoid plunger are enclosed in the drive housing, thus protecting them from exposure to dirt and road splash.

The solenoid incorporates two windings, a pull-in-winding and a hold-in winding. Together they provide sufficient magnetic attraction to pull the solenoid plunger into the solenoid.

Engine cranking occurs when the starter solenoid on the starter is energized through the starter control (ignition) switch. When energized, the solenoid shifts the starting motor pinion into mesh with the engine flywheel ring gear.

Simultaneously, the main contacts of the solenoid are closed and battery current is directed to the starting motor causing the armature to rotate.

After the engine starts, the starter drive is disengaged when the ignition switch is returned from the start to the ON or RUN position. This opens the circuit to the starter solenoid and the solenoid return spring causes the shift lever to disengage the starter drive from the engine flywheel ring gear.

The starting motor is protected from excessive speed by an overrunning clutch incorporated in the starter drive assembly. The overrunning clutch permits the drive pinion gear to rotate faster than the armature thus disengaging itself from the engine flywheel ring gear when the engine starts.

TESTING

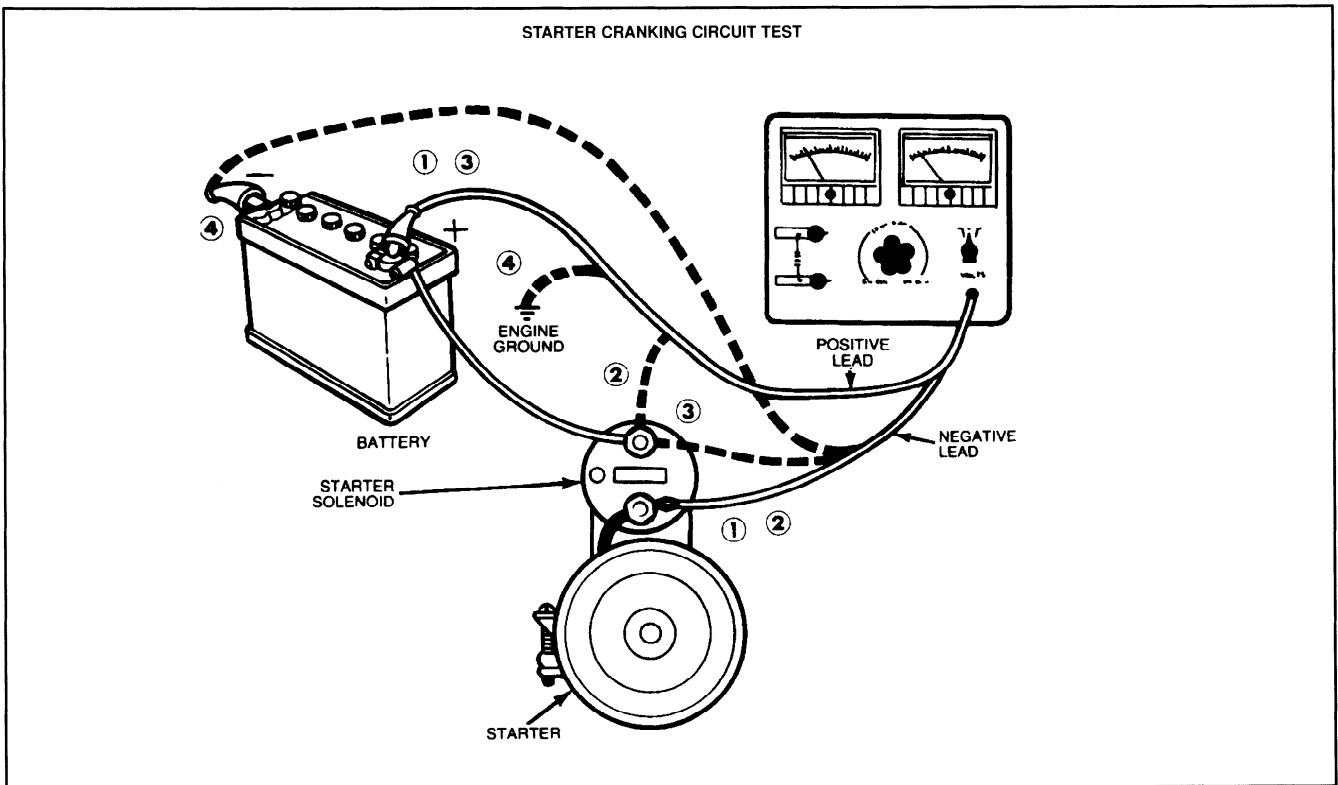
Road Service

On road service calls, connect a booster battery to the system for cases of a starter that will not crank the engine or a starter that cranks the engine very slowly. If the starter does not turn the engine over, even with the booster battery attached, refer to the following tests. **Be certain that correct battery polarity is observed when using a booster battery; positive to positive, and negative to negative connection of the auxiliary cables.**

On Engine Testing

Starter Cranking Circuit Test

These tests will determine whether or not there is excessive resistance in the cranking circuit. Make each test connection as shown. While cranking the engine, observe the voltage drop reading for each test. **Disconnect and ground the high tension lead from the ignition coil to prevent the engine from starting. Connect a remote control switch between the battery terminal of the starter relay and the S terminal of the relay.**



The voltage drop in the circuit will be indicated by the voltmeter (0 to 2 volt range). Maximum allowable voltage drop should be:

1. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery positive terminal (Connection No. 1) 0.5 volt.
2. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery terminal of the starter solenoid (Connection No. 2) 0.3 volt.
3. With the voltmeter negative lead connected to the battery terminal of the starter solenoid and the positive lead connected to the positive terminal of the battery (Connection No. 3) 0.2 volt.
4. With the voltmeter negative lead connected to the negative terminal of the battery and the positive lead connected to the engine ground (Connection No. 4) 0.1 volt.

TESTING (Continued)

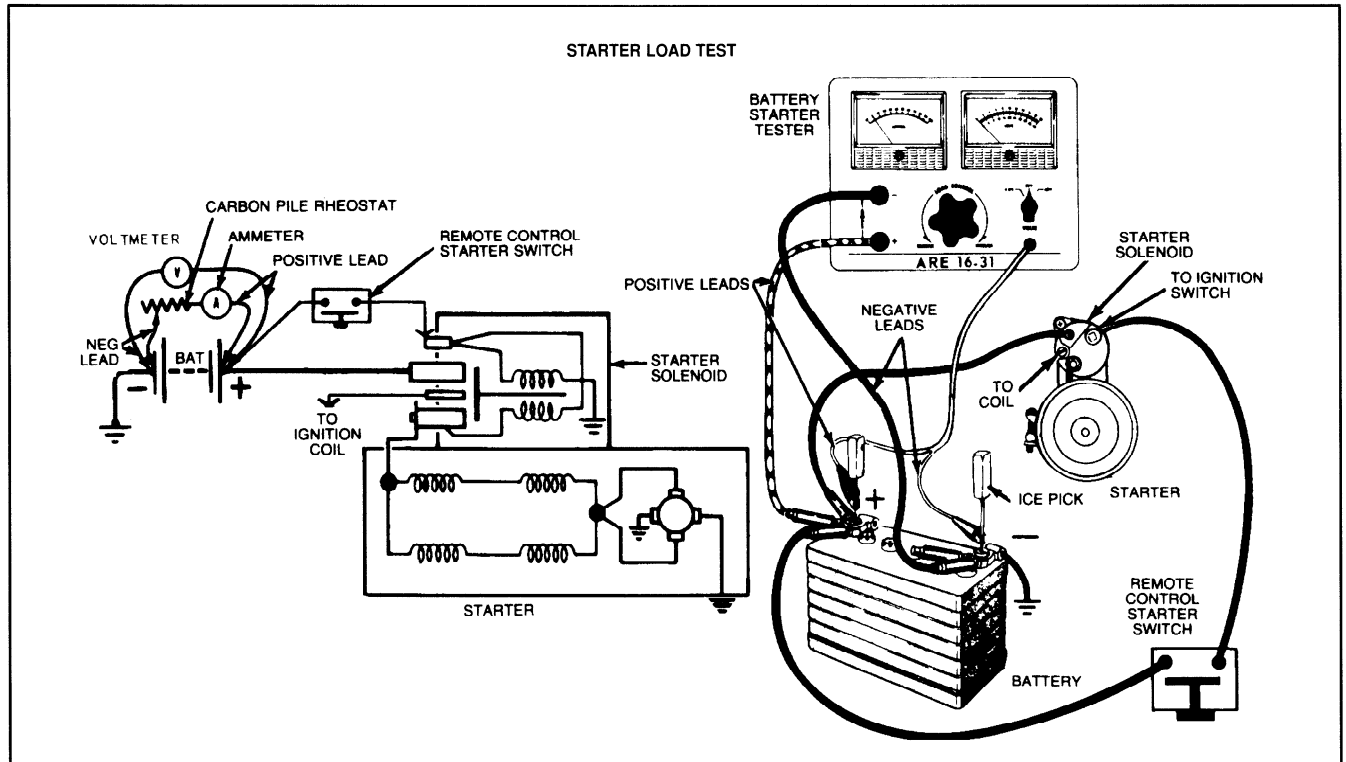
Starter Load Test

Connect the test equipment as shown. Be sure that no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum counterclockwise position).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting and grounding the high tension lead from

the ignition coil, and by connecting a jumper from the battery terminal of the starter solenoid to the ignition switch S terminal of the solenoid.

Stop cranking the engine, and adjust the load of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load.



Starter Solenoid Test

If the solenoid does not pull in, in the Starter Load Test, measure the voltage between the starter-mounted solenoid switch terminal and ground with the ignition switch closed. If the voltage is 10 or more volts, a worn or damaged solenoid is indicated. Remove the starter assembly for solenoid replacement.

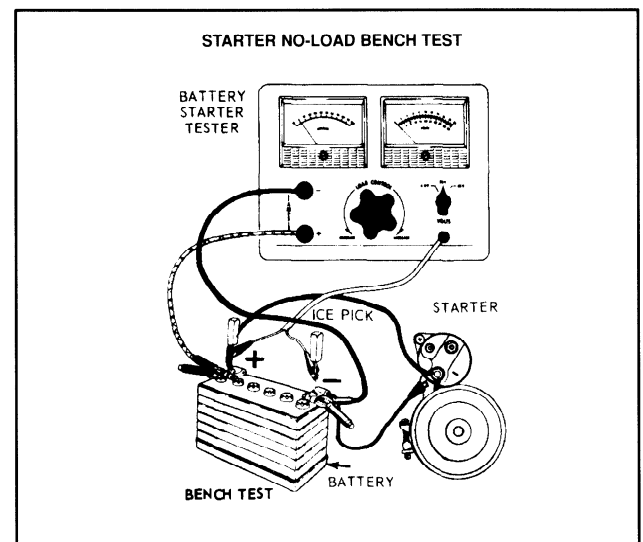
Disconnect the starter from the battery, and adjust the load of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw.

Bench Tests

Starter No-Load Test

The starter no-load test will uncover such faults as open or shorted windings, rubbing armature, and bent armature shaft. The starter can be tested, at no-load, on the test bench only.

Make the test connections as shown. The starter will run at no-load. Be sure that no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.



TESTING (Continued)

Armature Open Circuit Test

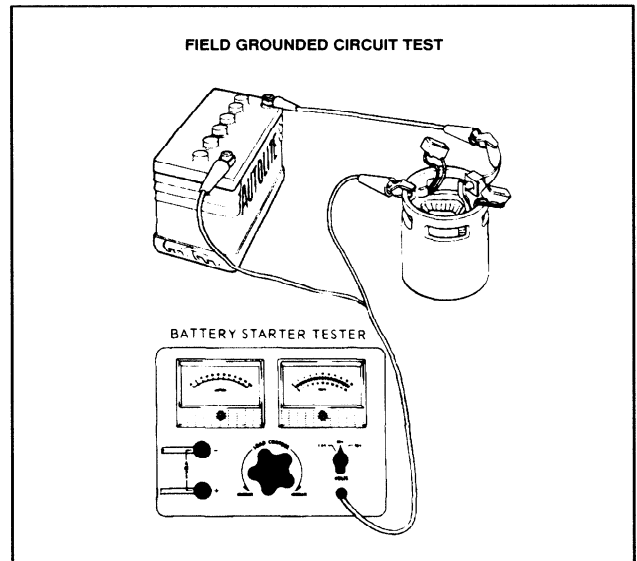
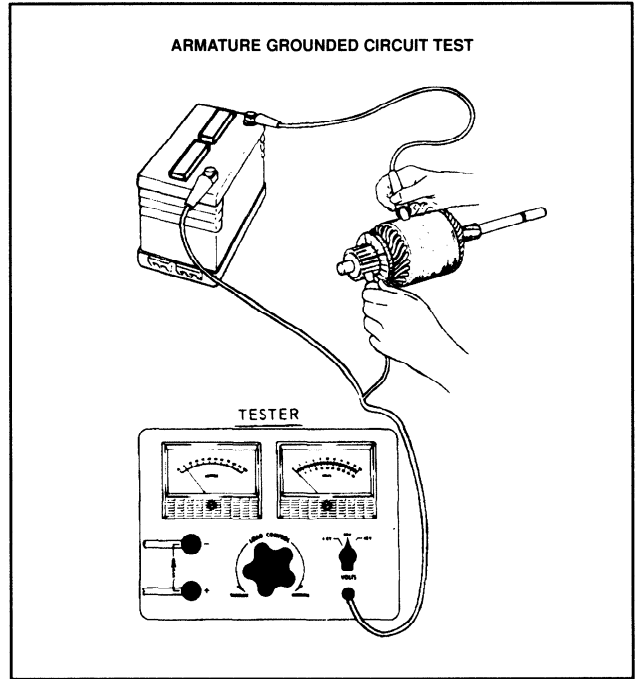
An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

Armature and Field Grounded Circuit Test

The test will determine if the winding insulation has failed, permitting a conductor to touch the frame or armature core.

To determine if the armature windings are grounded, make the connection as shown. If the voltmeter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by first disconnecting the grounded end of the winding where it terminates at the frame, then making the connections as shown. If the voltmeter indicates any voltage, the field windings are grounded.



REMOVAL AND INSTALLATION

Removal

1. Disconnect the battery ground cable.
2. Disconnect the cable and wires at the terminals on the solenoid.
3. Remove the starter mounting bolts and remove the starter assembly.

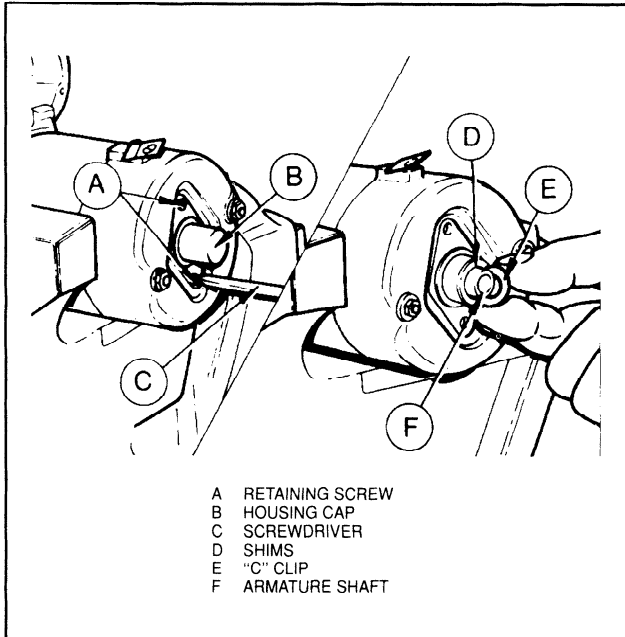
Installation

1. Position the starter assembly to the starter mounting plate and start the mounting bolts.
2. Snug the starting motor mounting bolts while holding the starter squarely against the mounting surface and fully inserted into the pilot hole. Tighten the mounting bolts.
3. Connect the cable and wires to the terminals on the solenoid. Connect the battery ground cable.

OVERHAUL

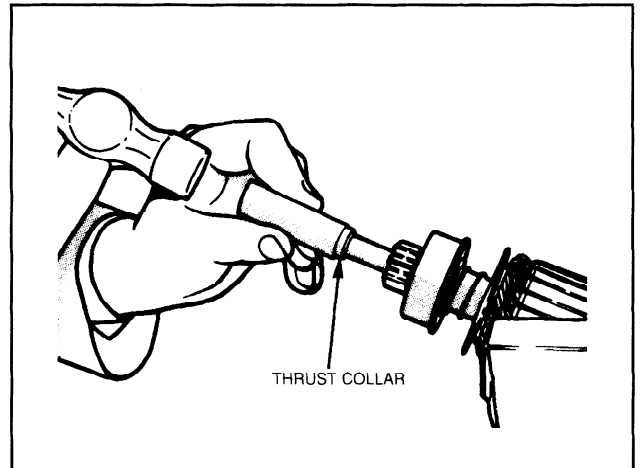
Disassembly

1. Clamp starter motor in vise fitted with protective soft jaws. Remove nut and washer retaining field winding cable to solenoid and remove cable from stud.
2. Remove solenoid by removing three screws.
3. Remove two screws retaining commutator end housing cap, remove cap and rubber seal.



4. Wipe grease from armature shaft, and remove "C" clip and shims from armature end.
5. Remove through bolts or two nuts and washers and lift off commutator end housing.
6. Remove brushes from brush holder assembly by carefully lifting brush retaining/tensioning springs clear and sliding brushes from their holder. Remove brush holder assembly.
7. Separate drive end housing and armature assembly from frame by tapping apart.
8. Remove rubber insert from drive end housing. Remove actuating arm pivot retaining nut and slide pivot pin from housing.
9. Withdraw armature assembly, complete with actuating arm, from drive end housing. Unhook actuating arm from drive pinion flange.

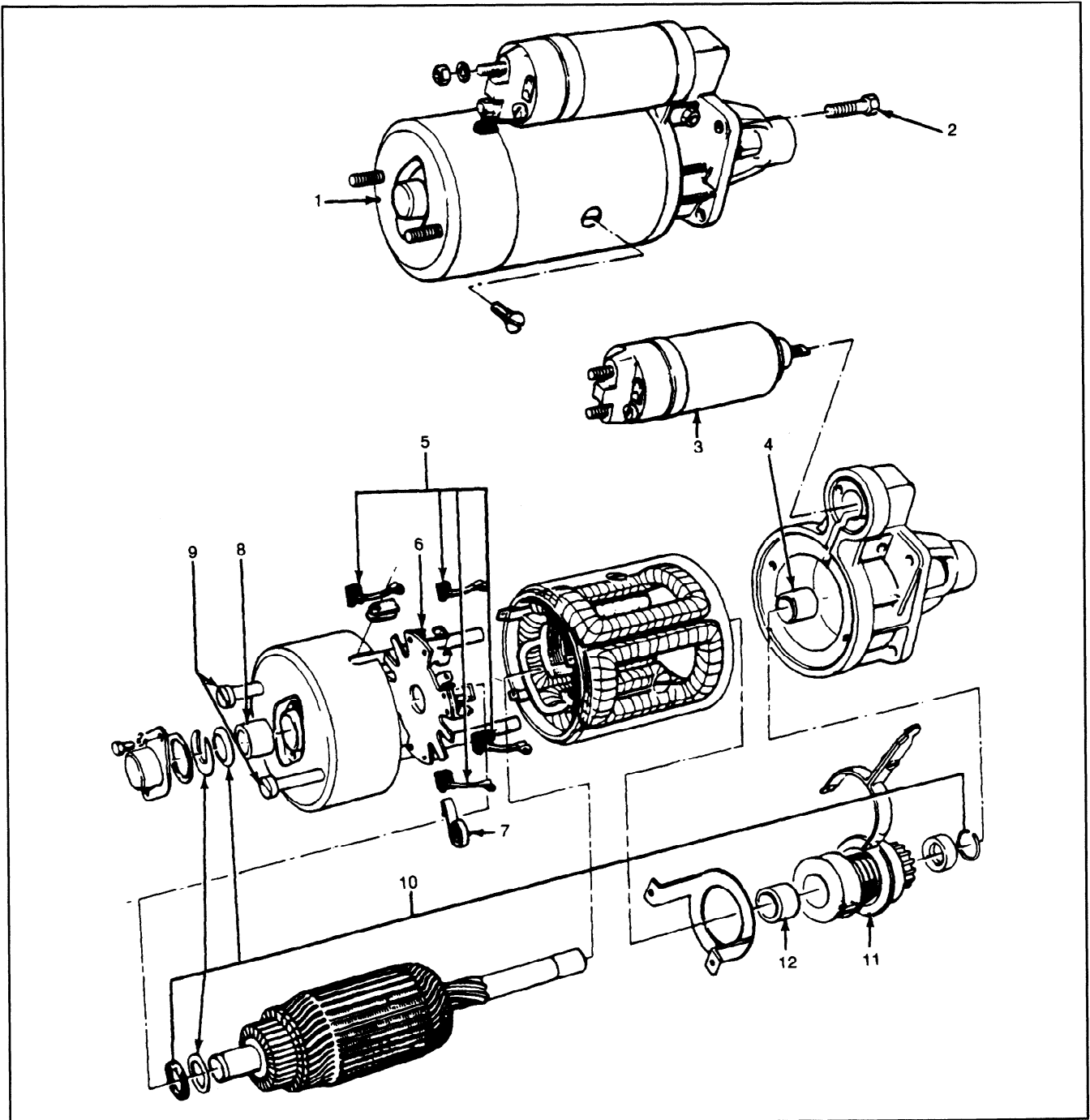
10. To remove drive pinion assembly from armature shaft use a suitably dimensioned tube to separate thrust collar from over "C" clip. Remove "C" clip from its groove and slide thrust collar and drive pinion assembly off armature shaft.



Cleaning and Inspection

1. **Do not wash the drive because the solvent will wash out the lubricant, causing the drive to slip.** Use a brush or compressed air to clean the drive, field coils, armature, commutator, armature shaft front end plate, and rear end housing. Wash all other parts in solvent and dry the parts.
2. Inspect the armature windings for broken or burned insulation and unsoldered connections.
3. Check the armature for open circuits and grounds.
4. Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, turn it.
5. Check the brush holders for broken springs and the insulated holder for shorts to ground. Replace the brushes if worn.
6. Check the brush spring tension.
7. Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation. A brush kit is available. All other assemblies are to be replaced rather than repaired.
8. Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than 1/2 the ring gear tooth depth (to eliminate premature ring gear and starter drive failure).
9. Replace starter drives and ring gears that have milled, pitted or broken teeth or that show evidence of inadequate engagement.

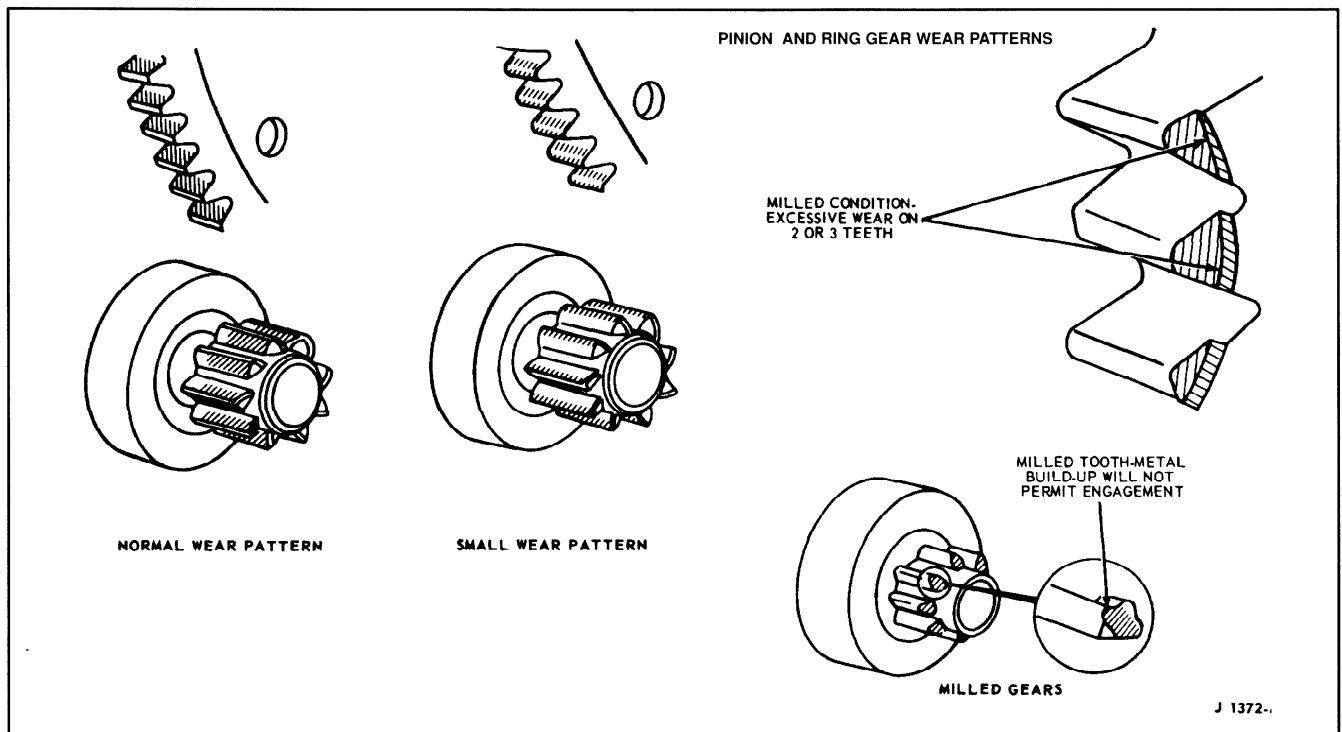
OVERHAUL (Continued)



Item	Description
1	Starter motor
2	Bolt
3	Solenoid
4	Bushing
5	Brush set
6	Brushholder

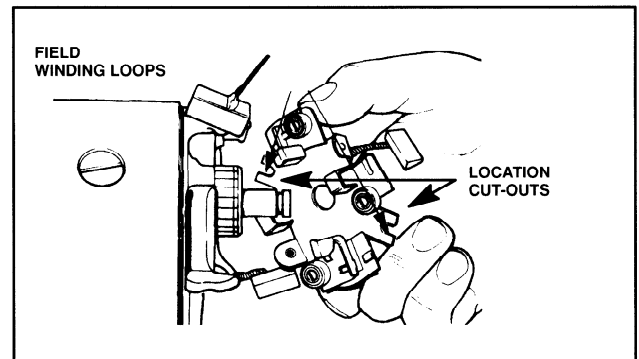
Item	Description
7	Brush spring
8	Brush end bushing
9	Through bolt kit
10	Armature installation kit
11	Drive assembly
12	Bushing

OVERHAUL (Continued)



Assembly

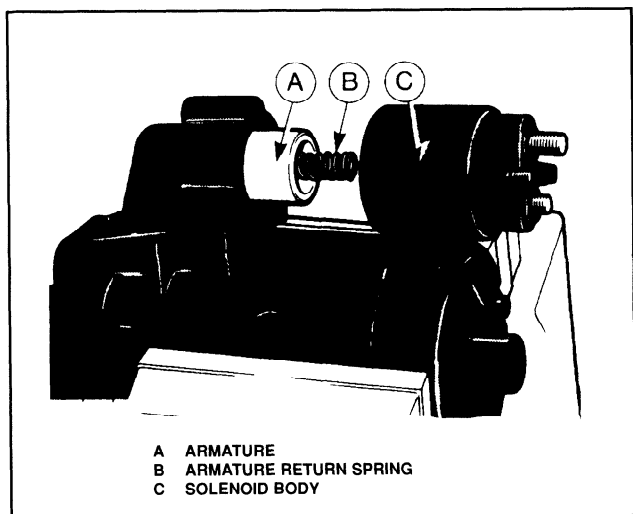
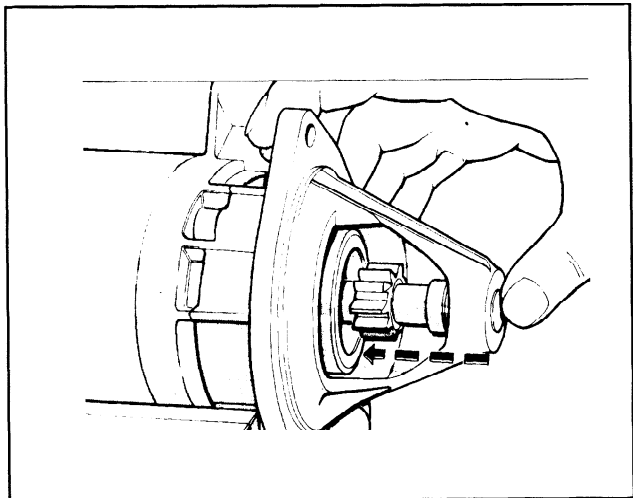
- Slide drive pinion assembly and thrust collar on to armature shaft. Fit "C" clip into its groove in armature shaft and then draw thrust collar over "C" clip.
- Connect actuating arm on to drive pinion flange. Align armature and actuating arm to drive end housing and couple up components. Install actuating arm pin and secure with retaining nut.
- Install rubber insert into drive end housing.
- Guide frame over armature and abut to drive end housing and tap home.
- Position brush holder over end of armature. Align location "cut-out" in brush holder with "loop" in field windings. Brush will be positively located when through bolts are installed.
- Position four brushes in their respective brush holder locations and retain with brush springs.
- Guide commutator end housing into position, sliding rubber insulator into commutator housing "cut-out", and locating two through bolts through housing holes. Secure commutator end housing with two nuts and washers or two through bolts as applicable.
- Slide armature in its bearings, to obtain maximum possible protrusion of armature shaft at commutator bearing end. Install sufficient shims on armature end play when "C" clip is in place. Fit "C" clip.
- Place bearing cap seal in position on commutator housing, smear a small quantity of lithium based grease on end of armature shaft and refit bearing cap, securing with two screws.



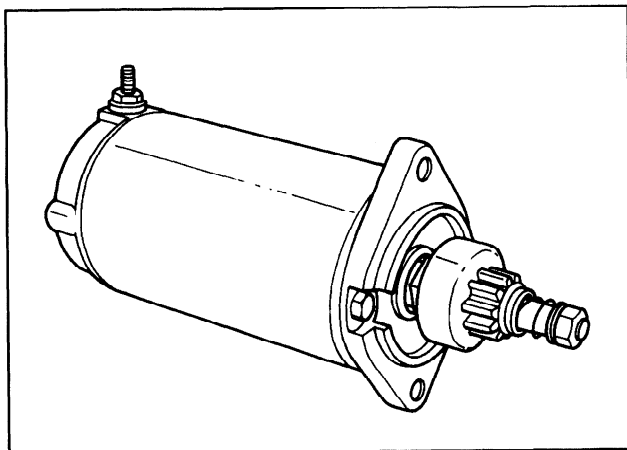
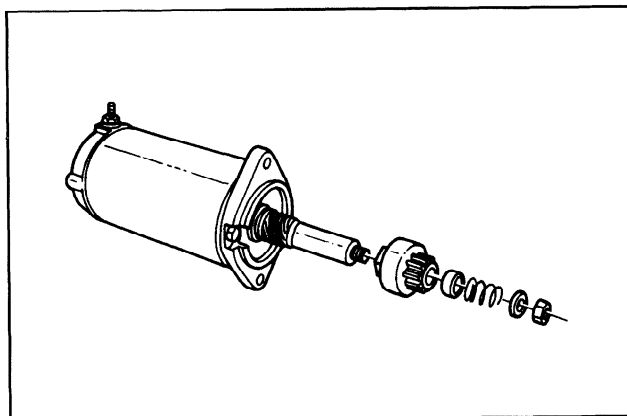
- Smear lithium based grease onto solenoid armature hook and then locate hook onto actuating arm in drive end housing. Ensure solenoid armature return spring is correctly positioned and then guide solenoid body over armature. Align body with drive end housing and install retaining screws.

OVERHAUL (Continued)

11. Reconnect field winding cable to solenoid and install retaining nut.

**Permanent-Magnet Starter**

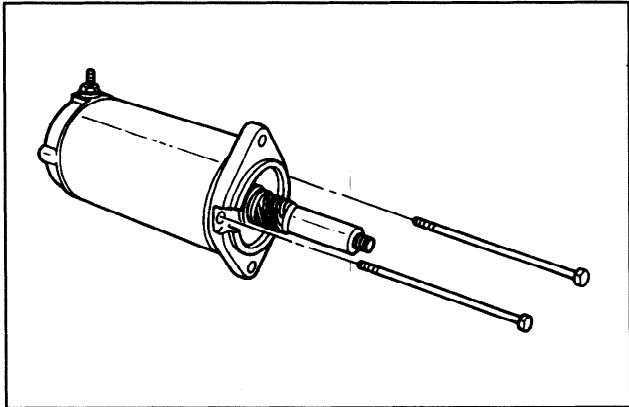
Some engines in the VSG range are equipped with the United Technologies permanent-magnet starter. This starter has a pinion gear which is actuated by inertial force in place of a starter solenoid. When the starter is energized, inertia causes the pinion gear to move out along a spirally-threaded shaft and engage the flywheel. When the engine has started, the starter motor is de-energized and spring tension causes the pinion gear to move away from the flywheel and back to its original position.

**Overhaul
Disassembly**

1. Remove the hex nut.
2. Remove the flat washer.
3. Remove the spring.

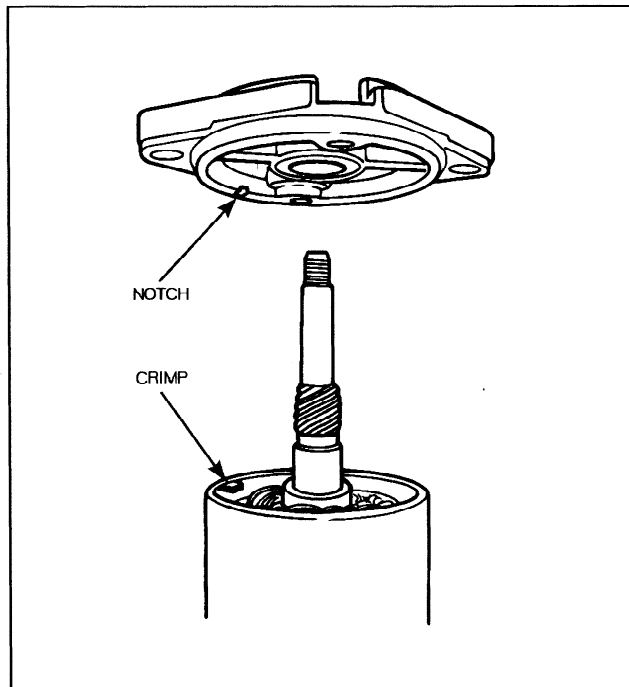
OVERHAUL (Continued)

4. Remove the spring retainer.
5. Remove the pinion.
6. Remove the through bolts.
7. Remove the drive end plate.

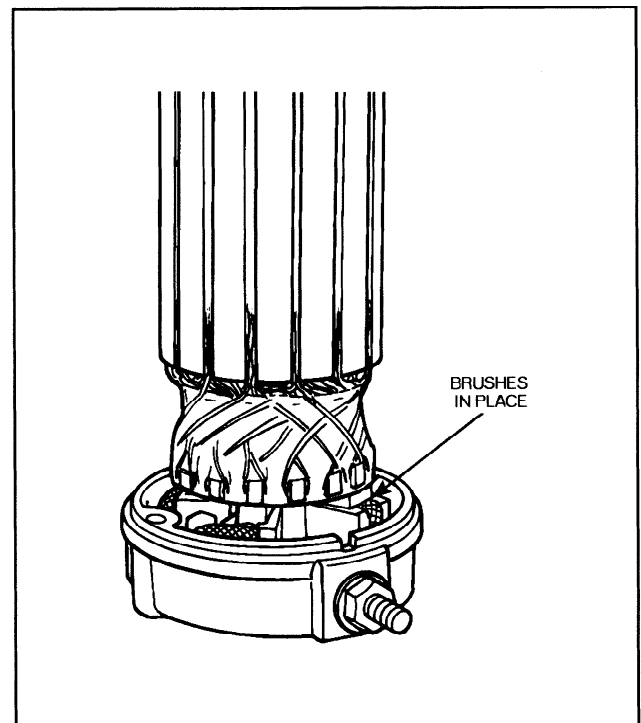
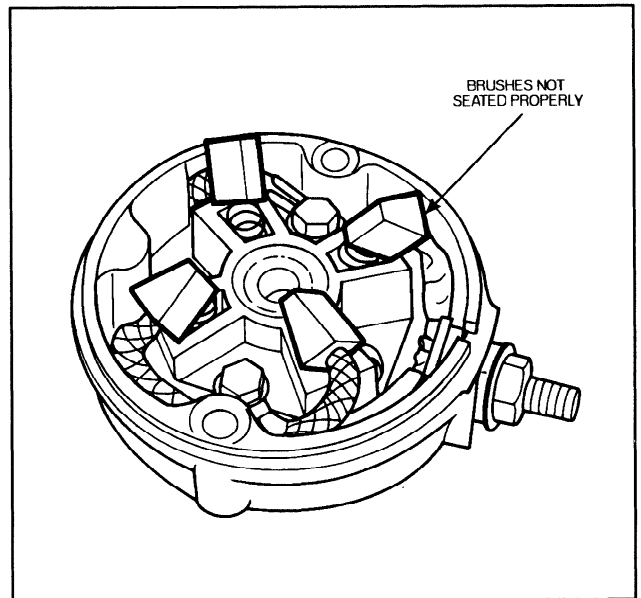


Assembly

1. Install the drive end plate onto the starter body. Make sure the notch in the drive end plate matches the raised crimp on the inside edge of the starter body. This alignment is also shown on the outside of the starter by a raised line on the drive end plate and a corresponding mark on the starter body.

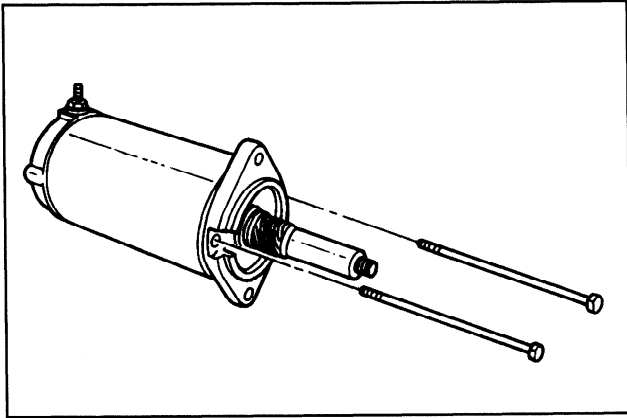


If the armature has been partially or totally removed from the starter body, make sure the brushes are properly seated before re-installing the armature.



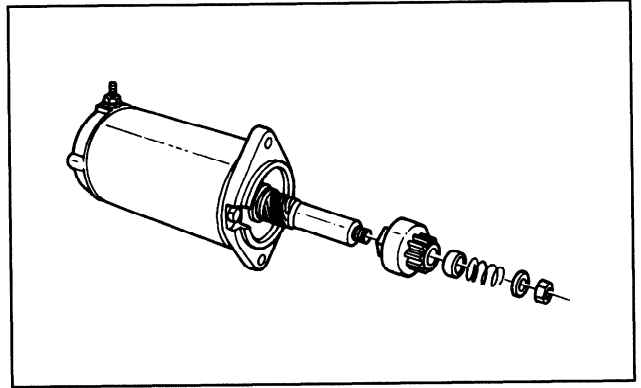
OVERHAUL (Continued)

2. Install the through bolts.



NOTE: The through bolts pass between two powerful magnets and will be attracted to them. A firm side-to-side wiggle near the heads of the bolts may be necessary in order to engage the bolts with their threaded holes.

3. Install the pinion.
4. Install the spring retainer.
5. Install the spring.
6. Install the flat washer.
7. Install the hex nut.



SECTION TITLE	PAGE	SECTION TITLE	PAGE
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SECTION 06 — Governor

SUBJECT	PAGE	SUBJECT	PAGE
DESCRIPTION AND OPERATION	06-3	Increase Spread	06-4
ADJUSTMENTS	06-4	Decrease Spread	06-5
Preliminary Checks	06-4	Low Speed	06-5
Oil Level	06-4	No-Load Surge	06-5
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Throttle Control Rod	06-4	ELECTRONIC DESCRIPTION AND OPERATION	06-7
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Spread or Sensitivity	06-4		

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DESCRIPTION AND OPERATION

A mechanical flyweight-type governor and an electronic governor are available for this engine. The mechanical governor is mounted on the right front of the engine and is belt driven from the engine accessory pulley.

A direct mechanical linkage from the governor throttle control lever to the carburetor throttle lever limits carburetor action to the governor setting. As the engine speed

increases, the rotation of the governor shaft increases. Centrifugal force causes the weights to move outward as the rotation of the governor shaft increases. However, a spring retards or limits the movement of the weights until centrifugal force overcomes the spring tension. At this time the weights are forced outward closing the throttle plates through the linkage to the throttle shaft.

ADJUSTMENTS

Preliminary Checks

Three preliminary checks must be made on the mechanical governor before attempting any repair adjustments. These are the governor oil level, drive belt tension and the throttle control rod length.

Oil Level

Clean the body of the governor in the area of the fill plug. Remove the oil level plug. If oil drips out, the level is full. If oil doesn't drip out, remove the oil fill plug and add 10W-30 or 10W-40 engine oil into the fill hole until it starts dripping out of the oil level hole. Install the oil level and oil fill plugs.

Belt Tension

Belt tension should be checked on a cold belt only.

1. Install belt tension tool (T63L-8620-A) on the drive belt and check the tension.

BELT TENSION

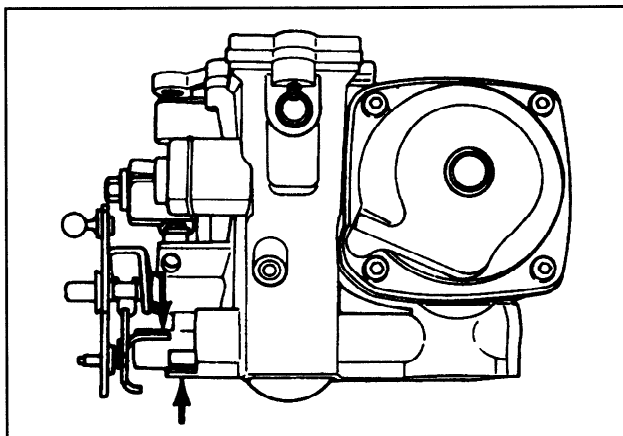
New	95 N•m (70 lb-ft)
Used	68 N•m (50 lb-ft)
(A used belt is one that has been in operation for 10 minutes or more.)	

2. If adjustment is required, loosen the governor adjusting bolts and move the governor until the correct tension is obtained.
3. Remove the gauge. Tighten the governor adjusting bolts. Install the tension gauge and recheck the belt tension.

Throttle Control Rod

1. Manually move the governor throttle lever to the maximum open throttle with spring tension on the governor.
2. Check the gap between the carburetor throttle shaft lever and its maximum open position stop. It should be 0.8-1.6mm (1/32 to 1/16 inch) wide.
3. If adjustment is necessary, loosen the control rod ball joint locknuts, remove the rod from the carburetor throttle lever and adjust the length of the rod with the ball joints.
4. Install the throttle control rod on the carburetor throttle lever and recheck the gap. Tighten the locknuts.

CAUTION: Be sure the throttle control rod is properly installed with the long end at the governor to prevent binding on the ignition wires.



RPM Adjustments

High Speed

First attach a tachometer to the engine, then run the engine until it reaches normal operating temperature.

1. Loosen the locknut on the high-speed stop screw.
2. Disengage engine load.
3. Slowly pull the throttle to desired maximum engine speed.
4. Adjust the high-speed stop screw on the governor to attain the desired maximum engine speed. Do not exceed the recommended maximum rpm.
5. Tighten the locknut.

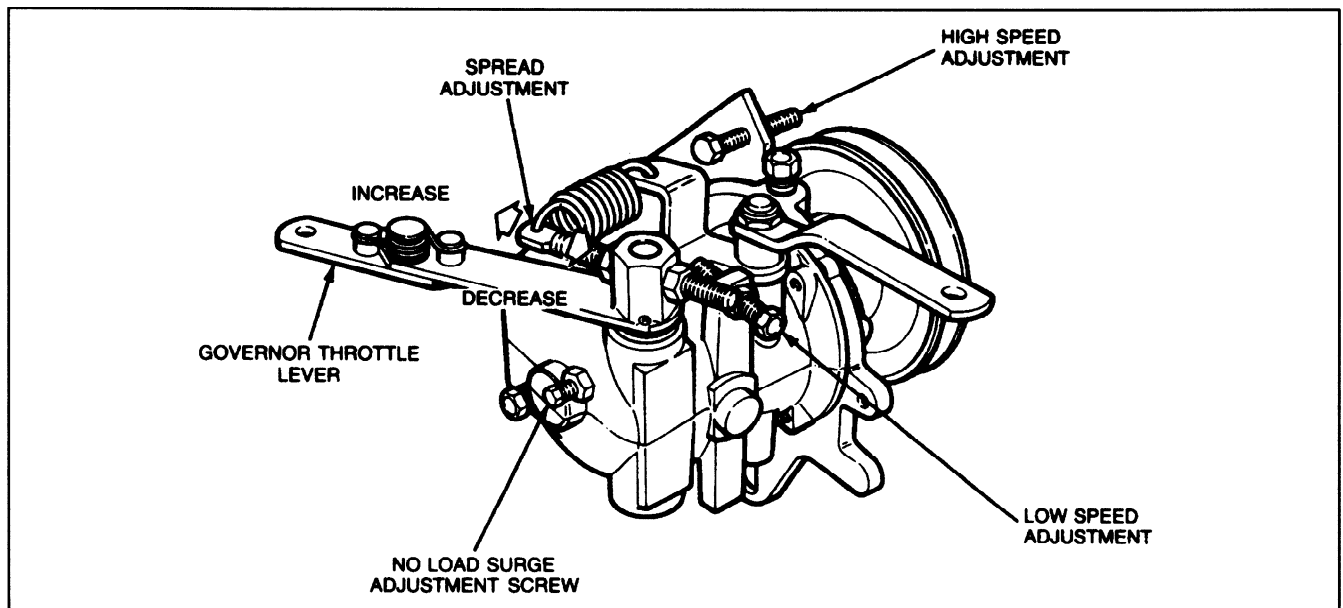
Spread or Sensitivity

Proper governor operation requires a difference between full-load and no-load governed speed. Too small an rpm spread between the two speeds will cause governor hunting and surging. Too large a spread will cause low response. For this governor, normal rpm spread is approximately 250 rpm with the full-load speed range of 2000-2800 rpm.

Increase Spread

1. With the engine running under no-load at maximum governed speed, loosen the locknuts and adjust the screw to move the spring away from the lever hub. Tighten the locknuts.
2. Recheck governor operation under full-load and no-load conditions to determine if operation is stabilized and sensitivity is satisfactory.
3. Readjust the governor high-speed stop screw to maintain the correct high speed under load.

ADJUSTMENTS (Continued)



Decrease Spread

1. With the engine under no-load at maximum governed speed, loosen the locknuts and adjust the screw to move the spring towards the lever hub. Tighten the locknuts.
2. Recheck governor operation under load and no-load conditions.
3. Readjust the governor high-speed stop screw to maintain the correct high speed under load.

Low Speed

1. Attach a tachometer and move the hand throttle or variable speed lever to the closed position.
2. Adjust the carburetor idle speed screw to obtain the desired idle speed.

No-Load Surge

The no-load surge adjustment is set at the factory and rarely requires adjustment. If necessary, this adjustment can be used to prevent hunting and surging and **no-load speeds**, provided the rpm spread adjustment is set properly.

1. Make the adjustment with the tachometer installed. Increase the engine speed with the hand throttle or variable speed lever to 75 rpm lower than the maximum no-load desired control rpm.
2. Loosen the no-load surge adjustment screw locknut and turn the screw inward until the rpm increases to the desired control rpm.

CAUTION: Do not turn the screw in all the way. It will interfere with proper governor operation and prevent the governor from returning the engine to idle speed.

3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

REMOVAL AND INSTALLATION

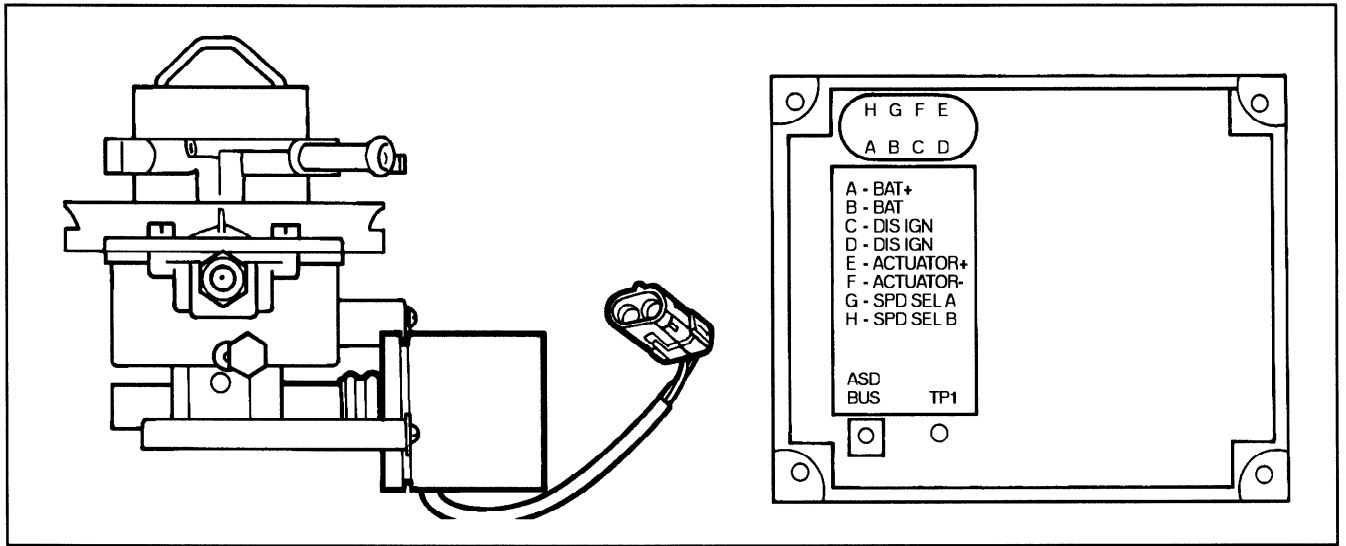
Removal

1. Disconnect hand throttle connection at governor variable speed lever.
2. Disconnect governor to carburetor throttle control rod at governor.
3. Loosen governor mounting nuts and bolts and move governor towards engine to loosen drive belt.
4. Remove drive belt from governor pulley.
5. Remove governor to bracket attaching bolts and remove governor.

Installation

1. Position the governor to the mounting bracket and install the attaching bolts snugly.
2. Position drive belt to governor pulley and move the governor away from the engine to tighten the belt. Tighten the attaching bolts.
3. Adjust the belt tension.
4. Connect the governor to carburetor throttle control rod. Adjust the rod as described previously.
5. Connect hand throttle cable to governor variable speed lever. Adjust cable as necessary to permit operation from idle to maximum speed.

ELECTRONIC DESCRIPTION AND OPERATION



The Barber Colman electronic governor consists of three main components:

- a controller
- an actuator
- a carburetor

The controller is a Barber Colman model 10851 digital unit. This controller allows up to four engine speeds to be used on one application. The operator changes the engine speeds via a run speed select switch, mounted on the control panel of the machine.

These governors are isochronous in operation; there is no governor droop. The governor maintains the same engine speed from no-load to full-load operation. Each controller

can be programmed with up to four separate engine speeds. The carburetor and actuator are integrated into one unit.

The carburetor is a Zenith model 33, offered with either a manual or automatic choke. It is spring loaded to keep carburetor at its minimum fuel position when no power is applied. The feature causes the carburetor to go fully closed in the event of governor power failure.

The rotary actuator is mounted directly to the end of the throttle shaft. This feature eliminates any need for throttle linkage. The actuator is electrically connected to the controller through a two-wire Packard connector. If the governor is used with any other fuel system, such as LPG, then a linear actuator is available.

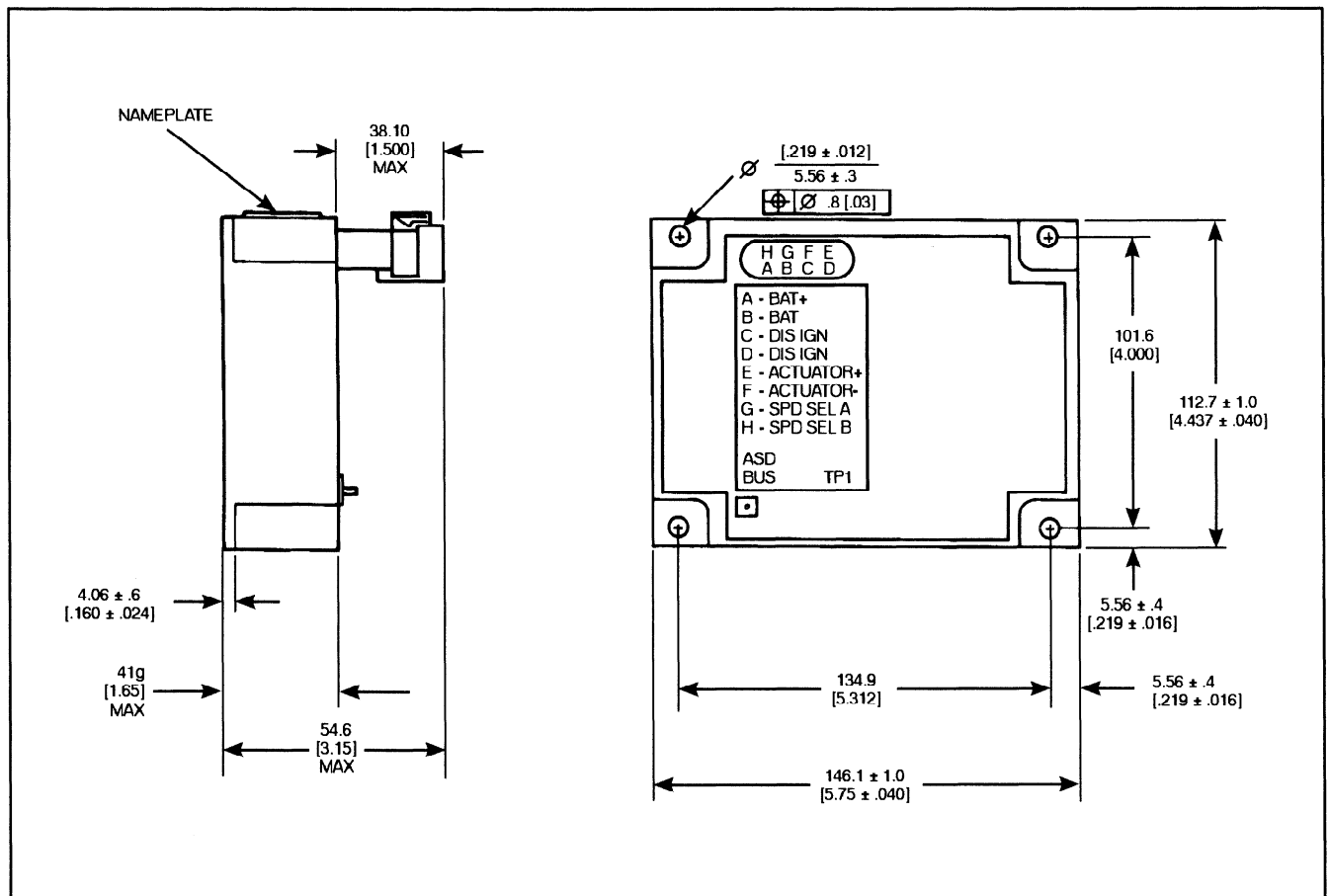
ELECTRONIC DIAGNOSIS AND TESTING

This governor system is comprised of three major components: the carburetor, actuator and controller. The objective of this document is to help a technician identify which component is creating a problem so it can be fixed or replaced.

CONDITION	POSSIBLE SOURCE	ACTION
I. Governor appears dead.	1. Battery power is not supplied to controller.	Remove the connector from the controller and with a voltmeter check for battery power across pins A & B of the wiring harness connector.
		If battery power is not present, check wiring to the controller.
	2. Controller is not receiving the speed signal NOTE: This controller receives its speed signal from the ignition.	If the controller is connected to an engine with a distributor, pins C & D should both be connected to the negative side of the coil, or the tachometer output.
		If the controller is connected to an engine with a DIS ignition, pin C should be connected to one of the two tachometer outputs, and pin D should be connected to the other tachometer output. The DIS ignition utilizes two coils. NOTE: Do not short the tach leads; doing so could damage the spark controller.
		Using an ohmmeter, check continuity from pins C & D to the termination points. If continuity is not present, repair the wiring.
	3. Actuator fails to operate.	Remove the 2-pin connector at the actuator. With a DC voltmeter, check between the purple wire and chassis (battery) ground. The voltmeter should read 12 volts, \pm 2 volts.
If the voltage is low, disconnect the 8-pin connector from the controller, and check continuity between the wiring harness pins E & F, to their respective actuator terminals. If there is no continuity, check for openings in the wires.		
Using a voltmeter, check for battery voltage from controller terminal E to chassis (battery) ground. If battery power is not found, replace the controller and check the actuator and actuator wiring for grounds and shorts. NOTE: Check wiring before replacing controller. Bad wiring might destroy the new controller.		
Check continuity across actuator wires. 2 ohms \pm .5 ohm should be measured. Check the continuity of actuator wires to the case. The ohms measured should be 1M or greater. If these values are out of tolerance, replace actuator.		
II. Engine doesn't change speeds.	1. Incorrect engine speed.	With the engine running, connect battery power to pin H. This will select Run 2. If Run 2 is set a higher speed than Run 1 and the speed does not change, replace the controller. Contact OEM for speed settings.
		With the engine running, connect battery power to pin G. This will select Run 3. If Run 3 is set higher than the previous speed and the speed does not change, replace the controller. Contact OEM for speed settings.
		With the engine running, connect battery power to pins G & H. This will select Run 4. If Run 4 is set higher than the previous speed and the speed does not change, replace the controller. Contact OEM for speed settings.

ELECTRONIC DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE SOURCE	ACTION
III. Engine is hunting.	1. Engine is misfiring due to idle mixture mis-adjustment. This causes engine hunt at no-load condition.	Disconnect the connector from the controller. The governor is now disabled and a warm engine should be running at a mechanical idle of approximately 600 RPM.
		If the engine is not running at the mechanical idle and is governed by an integrated carburetor, loosen the three actuator fasteners and rotate the actuator to achieve an idle of 600 RPM. If the engine is governed by a linear actuator, adjust the idle speed screw to achieve 600 RPM.
		Slowly rotate the idle mixture screw clockwise (CW) until the engine speed begins to decrease. Slowly turn the idle mixture screw counterclockwise (CCW) until the engine speed begins to decrease. Now, turn the idle mixture screw clockwise (CW) until maximum idle speed is achieved. The idle mixture is now adjusted.
	2. Engine is misfiring.	Disconnect the connector from the controller and consult the engine repair manual.

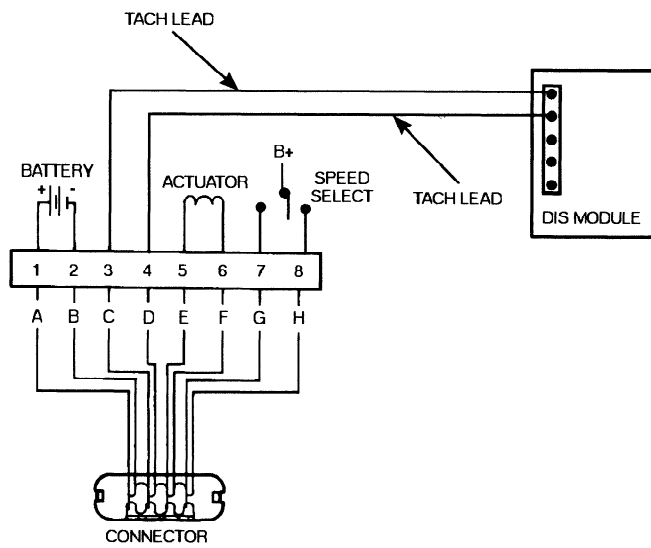
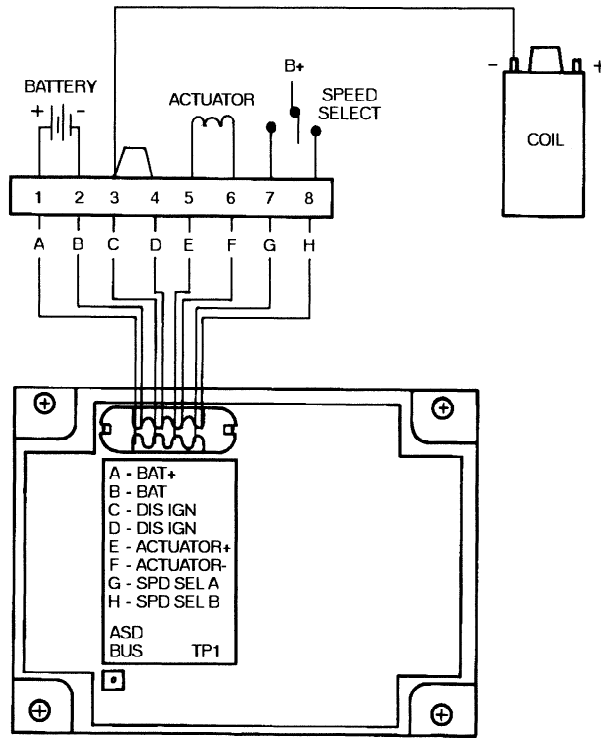


Calibration

Initial speed settings, as well as other parameters, can be set using a special interface connector, and an IBM compatible PC 286 minimum with 640K RAM, of which

512K of conventional RAM must be available. Also required is a 1.44 Meg High Density floppy drive and a VGA graphic display. Programming of the controller is covered in a separate publication.

ELECTRONIC DIAGNOSIS AND TESTING (Continued)



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SECTION 07 — Cooling System

SUBJECT	PAGE	SUBJECT	PAGE
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		Drive Belt	07-4
		Belt Tension	07-4

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DESCRIPTION AND OPERATION

The system is of the full flow type with a centrifugal pump. The thermostat, located in the cylinder head, controls the flow through the system maintaining the proper temperature.

The coolant flow is from the bottom of the radiator to the pump which delivers it to the cylinder block. It then flows through the cored passages to cool the entire length of each cylinder wall. Upon reaching the rear of the cylinder block, the coolant is directed upward into the cylinder head

where it cools the combustion chambers, valves and valve seats.

The coolant from the cylinder head flows past the thermostat, if it is open, through the coolant outlet housing and into the top of the radiator.

Another passage in the head routes the warm coolant through the intake manifold to help atomize the fuel mixture, and then through a hose to the inlet hose of the water pump.

ADJUSTMENTS

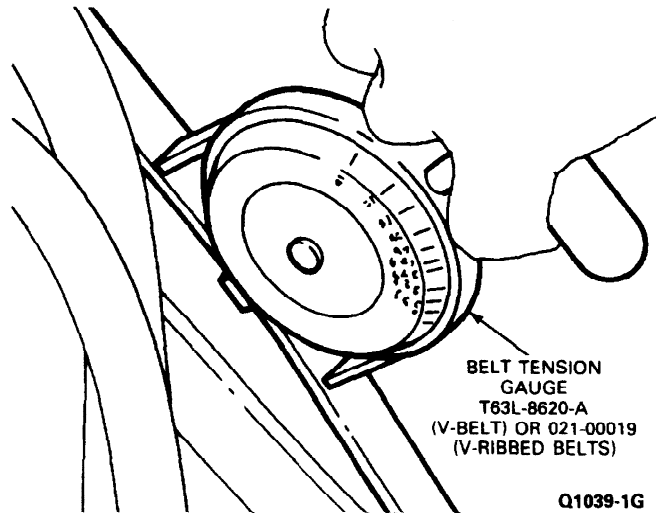
Drive Belt

The fan drive belt should be properly adjusted at all times. A loose drive belt can cause improper generator, fan and water pump operation. A belt that is too tight places a severe strain on the water pump and the generator bearings.

A properly tensioned drive belt minimizes noise and also prolongs the service life of the belt. Therefore, it is recommended that a belt tension gauge be used to check and adjust the belt tension. **Any belt that has been operated for a minimum of 10 minutes is considered a used belt, and when adjusted, it must be adjusted to the used tension shown in the specifications.**

Belt Tension

1. Install the belt tension tool on the drive belt and check the tension.
2. If adjustment is necessary, loosen the generator mounting and adjusting arm bolts. Move the generator toward or away from the engine until the correct tension is obtained. Remove the gauge.
3. Tighten the generator adjusting arm and mounting bolts. Install the tension gauge and recheck the belt tension.



SECTION TITLE	PAGE	SECTION TITLE	PAGE
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SECTION 08 — Specifications

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		Torque Specifications	08-8

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SPECIFICATIONS

ENGINE MODEL YEARS 1993+

General Specifications	
VSG-411	4 Cylinder — 1.1 Liter
VSG-413	4 Cylinder — 1.3 Liter
Bore and Stroke 1.1L	68.68 and 75.48 mm (2.704 and 2.971 in)
1.3L	73.96 and 75.48 mm (2.912 and 2.971 in)
Firing Order	1-2-4-3
Idle Speed	700-800 rpm
Rated Engine Speed — Maximum	Full Load 2800 rpm
	No Load 3050 rpm
Cylinder Block	
Number of Main Bearings	5
Cast Marks 1.1L	93BM-6015-AA
1.3L	89BM-6015-FA
Cylinder Bore Diameter 1.1L	68.680-68.710 mm (2.7039-2.7051 in)
1.3L	73.94-73.97 mm (2.9110-2.9122 in)
Out-of-Round Maximum	0.038 mm (0.0015 in)
Wear Limit	0.127 mm (0.005 in)
Taper Maximum	0.0254 mm (0.0010 in)
Wear Limit	0.254 mm (0.010 in)
Main Bearing Bore Standard	60.623-60.636 mm (2.3868-2.3872 in)
Oversize	61.003-61.016 mm (2.4017-2.4022 in)
Camshaft Bearing Bore Standard	42.888-42.918 mm (1.6886-1.6896 in)
Oversize	43.396-43.420 mm (1.7086-1.7094 in)
Cylinder Block Liner Bore Diameter 1.1L	71.826-71.852 mm (2.8278-2.8288 in)
1.3L	77.086-77.112 mm (3.0349-3.0359 in)
Deck Height (Oil Pan Rail to Head Deck) 1.1L	194.6 ± 0.065 mm (7.6614 ± 0.0026 in)
1.3L	194.6 ± 0.065 mm (7.6614 ± 0.0026 in)
℄ of Crankshaft Above Oil Pan Rail 1.1L & 1.3L	2.578 ± 0.115 mm (0.1015 ± 0.0045 in)

All specifications are in millimeters (inches).

For Conversion Factors see page 5.

SPECIFICATIONS (Continued)

ENGINE MODEL YEARS 1993+

Crankshaft	
Main Bearing Journal Dia. 1.1L Standard	56.99-57.00 mm (2.2437-2.2441 in)
Yellow	56.98-56.99 mm (2.2433-2.2437 in)
Main Bearing Journal Dia. 1.3L Standard	56.980-57.000 mm (2.2433-2.2441 in)
Yellow	—
Main Bearing Clearance 1.1L	0.009-0.046 mm (0.0004-0.0018 in)
Main Bearing Clearance 1.3L	0.009-0.056 mm (0.0004-0.0022 in)
Rod Bearing Journal Dia. 1.1L Standard	40.99-41.01 mm (1.6138-1.6145 in)
Green	40.74-40.76 mm (1.6039-1.6047 in)
Rod Bearing Journal Dia. 1.3L Standard	42.99-43.01 mm (1.6926-1.6933 in)
Green	42.74-42.76 mm (1.6827-1.6834 in)
Rod Bearing Clearance 1.1L and 1.3L	0.006-0.060 mm (0.0003-0.0023 in)
End Play 1.1L and 1.3L	0.075-0.285 mm (0.003-0.011 in)
Camshaft	
Journal Diameter 1.1L and 1.3L	39.615-39.636 mm (1.5596-1.5605 in)
Bearing I.D. 1.1L and 1.3L	39.662-39.713 mm (1.5615-1.5635 in)
Bearing Clearance (Standard Bearing) 1.1 and 1.3L	0.026-0.067 mm (0.001-0.002 in)
Wear Limit	0.0762 mm (0.003 in)
Camshaft Thrust Plate Thickness 1.1L and 1.3L	4.457-4.508 mm (0.1754-0.1774 in)
End Play	0.02-0.19 mm (0.0008-0.0075 in)
Cam Lift 1.1L Intake	5.15 mm (0.203 in)
Exhaust	4.92 mm (0.194 in)
Camshaft Lift 1.3L Intake	5.70 mm (0.224 in)
Exhaust	5.76 mm (0.227 in)
Drive 1.1L and 1.3L	Chain
Connecting Rod	
Piston Pin Bore 1.1L and 1.3L	17.990-18.010 mm (0.7083-0.7091 in)
Rod Bearing Bore 1.1L and 1.3L	43.990-44.010 mm (1.7319-1.7327 in)
Maximum Twist or Bend	0.10 mm (0.004 in)
End Play 1.1 and 1.3L	0.10-0.25 mm (0.004-0.010 in)
Piston	
Diameter 1.1L	68.670-68.700 mm (2.7035-2.7047 in)
Diameter 1.3L	73.930-73.955 mm (2.9107-2.9116 in)
Piston to Bore Clearance	0.015-0.050 mm (0.0006-0.0019 in)

All specifications are in millimeters (inches).
For Conversion Factors see page 8.

SPECIFICATIONS (Continued)

ENGINE MODEL YEARS 1993+

Piston Pin	
Diameter 1.1L and 1.3L	18.026-18.029 mm (0.7097-0.7098 in)
Length 1.1L	58.6-59.4 mm (2.31-2.33 in)
1.3L	63.6-64.4 mm (2.51-2.53 in)
Interference Fit in Rod at 21°C 1.1L and 1.3L	0.016-0.048 mm (0.0006-0.0018 in)
Clearance in Piston at 21°C 1.1L and 1.3L	0.008-0.014 mm (0.0003-0.0006 in)
Piston Rings	
Top Compression Ring Thickness 1.1L and 1.3L	1.503-1.505 mm (0.05918-0.05925 in)
Bottom Compression Ring Thickness 1.1L and 1.3L	1.728-1.740 mm (0.0680-0.0685 in)
Top Compression Ring Side Clearance 1.1L and 1.3L	.013-.027 mm (0.0005-0.0011 in)
Bottom Compression Ring Side Clearance 1.1L and 1.3L	.005-.042 mm (0.0002-0.0017 in)
Compression Ring Side Clearance — Wear Limit	0.15 mm (0.006 in)
Oil Ring Thickness 1.1L and 1.3L	2.978-2.990 mm (0.1172-0.1177 in)
Oil Ring Side Clearance 1.1L and 1.3L	0-.032 mm (0-0.0012 in)
Top Compression Ring — Standard Bore — Ring Gap ^{b/}	0.25-0.45 mm (0.010-0.017 in)
Bottom Compression Ring — Standard Bore — Ring Gap ^{b/}	0.25-0.45 mm (0.010-0.017 in)
Oil Ring — Standard Bore — Ring Gap ^{b/}	0.20-0.40 mm (0.008-0.015 in)
Cylinder Head	
Maximum permissible cylinder head distortion 1.1L and 1.3L: Measured over a distance of 26 mm	0.04 mm (0.0015 in)
Measured over a distance of 152 mm	0.08 mm (0.003 in)
Measured over the entire length	0.15 mm (0.006 in)
Valve Stem Bore 1.1L and 1.3L	7.063-7.094 (0.2781-0.2793 in)
Valve Seat Angle	45°
Valve Seat Insert — Exhaust, Outside Diameter ^{c/} 1.1L and 1.3L	31.500-31.515 mm (1.2402-1.2407 in)
Combustion Chamber Volume 1.1L	27.24-29.24 cc (4.22-4.53 cu in)
1.3L	31.79-33.79 cc (4.93-5.24 cu in)
Reface cylinder head mating surface: The following minimum combustion chamber depth must be left after skimming — 1.1L and 1.3L	14.4 mm ± 0.15 mm (0.567 in ± 0.006 in)

All specifications are in millimeters (inches).

For Conversion Factors see page 8.

^{b/} Ring Gap may exceed these specifications by 0.15 mm (0.006 in) when measurement is made in the block.

^{c/} Insert must be chilled in liquid nitrogen or dry ice prior to assembly.

SPECIFICATIONS (Continued)

ENGINE MODEL YEARS 1993+

Valve Mechanism	
Lash Intake — Cold	0.22 mm (0.009 in)
Exhaust — Cold	0.32 mm (0.013 in)
Stem Diameter Intake	7.025-7.043 mm (0.2766-0.2772 in)
Exhaust	6.999-7.017 mm (0.2756-0.2762 in)
Stem to Guide Clearance Intake	0.021-0.069 mm (0.0008-0.0027 in)
Exhaust 1.1L	0.046-0.095 mm (0.0018-0.0037 in)
1.3L	0.043-0.091 mm (0.0017-0.0036 in)
Length Intake	103.70-104.40 mm (4.083-4.110 in)
Exhaust	104.02-104.72 mm (4.096-4.122 in)
Head Diameter 1.1L Intake	32.90-33.10 mm (1.296-1.303 in)
Exhaust	28.90-29.10 mm (1.138-1.145 in)
Head Diameter 1.3L Intake	34.40-34.60 mm (1.355-1.362 in)
Exhaust	28.90-29.10 mm (1.138-1.145 in)
Seat Angle 1.1L and 1.3L	44.0°-44.5°
Spring Free Length 1.1L and 1.3L, Intake/Exhaust	41.0 mm (1.61 in)
Spring Assembled Height (Pad to Retainer)	33.22 mm (1.308 in)
Spring Load at Assembled Height	270 newtons (60.7 lb)
Tappet Diameter	13.081-13.094 mm (0.5150-0.5155 in)
Block Bore	13.110-13.143 mm (0.5162-0.5174 in)
Clearance to Block	0.016-0.062 mm (0.007-0.0024 in)
Rocker Shaft — Diameter	15.82-15.85 mm (0.6229-0.6240 in)
Rocker Bore	15.875-15.913 mm (0.6250-0.6264 in)
Shaft Clearance in Rocker	0.02-0.09 mm (0.0008-0.0035 in)
Lubrication	
Oil Type	Motorcraft Super Engine Oil, API SG
Oil Capacity With Filter (FL 400)	3.25 Liters (3.5 qts)
Without Filter	2.75 Liters (2.9 qts)
Oil Pressure — Hot at 2000 rpm (minimum)	1.5 Bars (22 psi)
Relief Valve Opens	2.41-2.75 Bars (35-40 psi)
Oil Pump Outer Rotor to Housing Clearance	0.14-0.26 mm (0.006-0.010 in)
Inner to Outer Rotor Gap	0.051-0.127 mm (0.002-0.005 in)
End Play — Rotors to Pump Cover	0.025-0.06 mm (0.0010-0.0023 in)

All specifications are in millimeters (inches).
For Conversion Factors see page 8.

SPECIFICATIONS (Continued)

ENGINE MODEL YEARS 1993+

Ignition System	
Firing Order	1-2-4-3
DIS ^{d/} (with 87 Octane Unleaded Gasoline) 1.1L and 1.3L	Fixed
Spark Plugs — AGRF 22 C1 (Gap)	1.0 mm (0.040 in)
Distributorless Type	
Coil Type	High Output DIS Coil
Coil Output	37.0 KV Minimum
Primary Resistance (at the Coil Tower)	0.50-1.00 Ohm
High Tension Leads	30,000 Ohms Max. per Lead
Belt Tension	
Alternator New	351-449 N (79-101 lbs)
Used-Reset (Minimum)	249-334 N (56-75 lbs)
Governor New	334 N (75 lbs)
Used-Reset (Minimum)	222 N (50 lbs)
Fuel System	
1.1L and 1.3L Unleaded 1986-	87 Octane
Pump Delivery Pressure	0.24-0.38 Bar (3.5-5.5 psi)
Starter — Current Draw	
Normal Engine Cranking	175 amps
Maximum Load — at Stall	410 amps
No Load	35 to 55 amps

All specifications are in millimeters (inches).

For Conversion Factors see page 8.

^{d/} Distributorless Ignition System.

SPECIFICATIONS (Continued)

SPECIAL SERVICE TOOLS

Description	Tool Number
Installer – Valve Stem Seal – Intake	21-007
Installer – Crankshaft Seal – Front Timing Cover	21-046
Installer – Rear Crankshaft Seal	21-059A
Remover – Crankshaft Oil Seals	21-096
Valve Spring Compressor	T81P-6513-A

Call Owatonna Tool Company

1-800-533-5338

Ask for Ford Order Desk

CONVERSION FACTORS

Pounds per Square Inch	Bars x 14.5
Cubic Inches	Cubic Centimeter x 0.061
Newton•Meter (Torque)	Ft-lbs x 1.3558
Millimeter	Inches x 25.4
Pounds	Kilogram (Force) x 2.2046
Cubic Inches	Liter x 61.024
Quarts	Liter x 1.0567
Inches	Millimeter x 0.03937
Pounds	Newton x 0.2248
Ft-lbs (Torque)	Newton•Meter x 0.7376

TORQUE SPECIFICATIONS

Item	Nm	Ft-Lb
Main Bearing Cap	88-102	64-75
Connecting Rod Bolts	1	
Rear Oil Seal Carrier	16 to 20	12-15
Flywheel	64 to 70	47-52
Clutch Pressure Plate	24 to 35	17.6-25.7
Chain Tensioner	24 to 25	17-18
Camshaft Thrust Plate	7 to 9	5-7
Camshaft Sprocket	16 to 20	12-15

TORQUE SPECIFICATIONS (Continued)

Item	Nm	Ft-Lb
Timing Cover	7 to 10	5-7.5
Water Pump	7 to 10	5-7.5
Crankshaft Pulley 1.1 and 1.3L 89/M.Y. and later	100 to 120	73.4-88
Water Pump Pulley	100-120	73.4-88
Starter Motor	35 to 45	26-33
Fuel Pump	16 to 20	12-15
Distributor Retaining Bolt	7 to 10	5-7.5
Distributor Clamp Bolt	3 to 4	2-2.5
Oil Pump	16 to 20	12-15
Oil Pump Cover	8 to 12	6-9
Oil Pump Pickup Tube Bracket	20 to 25	15-18
Oil Pan — Step 1 Alphabetical	6 to 8	5-6
— Step 2 Numerical	8 to 11	6-8
— Step 3 Alphabetical	8 to 11	6-8
Retorque after engine has warmed up (15 minutes at 1000 rpm)		
Oil Pan Plug	21 to 28	15-20
Oil Pressure Switch	13 to 15	10-11
Temperature Sender	4 to 8	3-6
Rocker Shaft Pedestals	40 to 46	30-34
Cylinder Head Bolts — Step 1	STEP 1-30	22
— Step 2	STEP 2-Turn	90° More
— Step 3	STEP 3-Turn	90° More
Rocker Cover	4 to 5	3-4
Exhaust Manifold	21 to 25	15-18
Inlet Manifold	16 to 20	12-15
Carburetor	17 to 21	12.5-15
Thermostat Housing	17 to 21	12.5-15
Spark Plugs	15 to 20	11-15
EGR Valve Bolts	16 to 20	12-15
EGR Hose	34 to 47	25-35

¹ **Step One** Torque to 4 N•m (3 Ft-lbs), **Step Two** Turn 90° more.